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Draft Regional Management Plan for red coral

ADAPTIVE MANAGEMENT PLAN FOR RED CORAL (Corallium rubrum) IN THE GFCM COMPETENCE AREA

FIRST PART – BACKGROUND INFORMATION

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SUMMARY

The present document has been prepared to gather together all the available information useful for the first preliminary draft of a regional management plan (RMP) for red coral (*Corallium rubrum*) in the GFCM competence area.

It is prepared according to the Recommendation GFCM/35/2011/2 on the exploitation of red coral in the GFCM Competence Area that states:

"Scientific and technical knowledge acquired through the actions stipulated under paragraphs 3 (c), 5, 7 and 9 above shall be taken into account by SAC with a view to develop an adaptive regional management plan" (Paragraph 10)

and the Recommendation GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area that states:

"In addition to substantiate the Terms of Reference provided in the 2012 Work Plan of its Sub-Committee for Marine Environment and Ecosystems, and pending the development of a regional management plan for red coral, as requested by the Recommendation GFCM/35/2011/2..." (Paragraph 6)

"The GFCM Secretariat is requested to take actions in support of the SAC with a view to put into operation, not later than 31 May 2013, the adaptive regional management plan." (Paragraph 7)

It is composed by three parts:

'FIRST PART – BACKGROUND INFORMATION' contains data related to the distribution, biology, fishery, and legal instruments dealing with red coral

'SECOND PART – SOCIO-ECONOMIC ASPECTS' summarizes the main socio-economic data related to the red coral fishery

'THIRD PART – MANAGEMENT of red coral' contains the proposed the management for red coral

The first and second parts complement each other, only the combination of the two can give a complete picture of the past and present aspects concerning *C. rubrum*.

The first part is divided in five sections:

BIOLOGY OF RED CORAL
FISHERY OF RED CORAL
NATIONAL LEGAL INSTRUMENTS FOR RED CORAL
INTERNATIONAL LEGAL INSTRUMENTS FOR RED CORAL
INTERNATIONAL LEGAL FRAMEWORK FOR MANAGEMENT OF RED CORAL

The first section summarizes all the scientific information concerning the biology of the species including the main threats and environmental issues related to red coral and more in general gorgonian corals of the coralligenous biocoenosis. A brief discussion on the data available for management and how to improve them in terms of quantity and quality is provided.

The second section contains the description of the fishing methods, providing historical as well as current data on harvesting retrieved from the FAO and GFCM databases.

The third and fourth sections collect laws, both at the international and the national level, dealing with *C. rubrum* conservation and more in general management of fishery resources, and management of red coral at the national level.

Finally, the fifth section describes the international legal framework under which the red coral resource can be managed.

BIOLOGY, ECOLOGY AND CONSERVATION OF RED CORAL

The biology of the red coral *Corallium rubrum*, differs in many aspects from that of other commercially exploited marine organisms.

Many of its peculiar features can have important implications for the effectiveness of management plans. In a certain way red coral poses a harder challenge to fishery managers also because they are accustomed to deal with demersal resources, the vast majority of which, contrary to red coral, are pelagic, short-lived, and hence fast growing.

CLASSIFICATION AND TAXONOMIC ISSUES IN THE FAMILY CORALLIDAE

According to the information found in the WoRMS databases (van Ofwegen 2012), the current accepted classification for the Mediterranean red coral (known also with the common name of Sardinian coral) is as follows:

Phylum	Cnidaria Hatschek, 1888**;**
Class	Anthozoa Ehrenberg, 1834;
Subclass	Octocorallia Haeckel, 1866;
Order	Alcyonacea Lamouroux, 1816;
Suborder	Scleraxonia Studer, 1887;
Family	Coralliidae Lamouroux, 1812;
Genus	*Corallium* Cuvier, 1798;
Species	*Corallium rubrum* (Linnaeus, 1758)

Along with *C. rubrum*, the family Coralliidae comprises some other 35 species distributed in two genera (in bold are shown the species of commercial interest):

1. Genus *Corallium* Cuvier, 1798 including the following species:
    - *Corallium abyssale* Bayer, 1956
    - *Corallium borneanse* Bayer
    - *Corallium boshuense* Kishinouye, 1903
    - *Corallium carusrubrum* Tu, Dai & Jeng, 2012
    - *Corallium ducale* Bayer
    - ***Corallium elatius* Ridley, 1882**
    - *Corallium gotoense* Nonaka, Muzik & Iwasaki, 2012
    - *Corallium halmaheirense* Hickson, 1907
    - *Corallium imperiale* Bayer
    - *Corallium johnsoni* Gray, 1860
    - *Corallium kishinouyei* Bayer, 1996
    - ***Corallium konojoi Kishinouye, 1903***
    - ***Corallium laauense Bayer, 1956***
    - *Corallium maderense* (Johnson, 1899)
    - *Corallium medea* Bayer, 1964

- *Corallium niobe* Bayer, 1964
- *Corallium niveum* Bayer, 1956
- *Corallium porcellanum* Pasternak, 1981
- *Corallium pusillum* Kishinouye, 1903
- *Corallium reginae* Hickson, 1907
- ***Corallium regale Bayer, 1956***
- *Corallium rubrum* ***(Linnaeus, 1758)***
- ***Corallium secundum Dana, 1846***
- *Corallium* ***sp. nov***
- *Corallium sulcatum* Kishinouye, 1903
- *Corallium taiwanicum* Tu, Dai & Jeng, 2012
- *Corallium tricolor* (Johnson, 1899)
- *Corallium uchidai* Nonaka, Muzik & Iwasaki, 2012
- *Corallium vanderbilti* Boone, 1933
- *Corallium variabile* (Thomson & Henderson, 1906)

2. Genus Para*Corallium* Bayer & Cairns, 2003 including the following species:
   - *ParaCorallium inutile* (Kishinouye, 1903)
   - ***ParaCorallium japonicum (Kishinouyi, 1903)***
   - *ParaCorallium nix* (Bayer, 1996)
   - *ParaCorallium salomonense* (Thomson & Mackinnon, 1910)
   - *ParaCorallium stylasteroides* (Ridley, 1882)
   - *ParaCorallium thrinax* (Bayer & Stefani in Bayer, 1996)
   - *ParaCorallium tortuosum* (Bayer, 1956)
   -

Several undescribed species are reported to exist within the Coralliidae, the taxonomy of the undescribed Midway coral listed as *Corallium sp. nov* has not yet been clarified and it may actually represent several species of the family Coralliidae (Grigg 2001). Moreover, the basis for its inclusion in the genus *Corallium* or the family *Coralliidae* remains unpublished (IUCN/TRAFFIC 2009).

C. lauuense and *C. regale* are listed as separate species even if sometimes they are considered to be synonymous (CITES 2009).

Four species have been described and formally named only in 2012 (Nonaka *et al.,* 2012; Tu *et al.,* 2012). Nevertheless, the phylogenetic relationships within the precious coral family Coralliidae remain largely unexplored and their taxonomy somehow controversial. For instance, according to mitochondrial data of the recent paper of Ardila *et al.,* (2012), *ParaCorallium* should not be a valid taxon, given that its species were all nested within *Corallium*. The only recognized genus should remain therefore *Corallium*, and *ParaCorallium* as its junior synonym. However, some species (*C. johnsoni, C. abyssale, C. laauense, C. imperiale, C. niobe, C. sulcatum, C. ducale, C. halmaheirense, C. tricolor, C. maderense*), clustered together and they were proposed by Ardila *et al.,* (2012) to be included in the re-erect genus *HemiCorallium*.

DISTRIBUTION

Corallium rubrum is a sciaphilous endemic species to the Mediterranean and the neighbouring Atlantic coasts that occurs primarily around the central and

western basin (5-350 m, although more commonly at 30-200 m) with smaller populations in deeper water in the eastern basin (60-200 m) and off the coast of Africa around the Canary Islands, southern Portugal and around the Cape Verde Island (Chintiroglou *et al.,* 1989; Marchetti 1965; Weinberg 1976; Zibrowius *et al.,* 1984). Recently the bathymetric limits of red coral distribution have been greatly expanded: from 350 to 600-800 meter depth in the Central Mediterranean (Strait of Sicily) (Costantini *et al.,* 2010; Freiwald *et al.,* 2009; Taviani *et al.,* 2010).

In the Mediterranean, *C. rubrum* inhabits subtidal rocky substrates and is one of the dominant and important components of Mediterranean "coralligenous" species assemblages (Ballesteros 2006), coexisting with other gorgonians, large sponges, and other benthic invertebrates.

The coralligenous biocoenosis (Habitat identification code EUR27:1170; BARCON IV.3.1; EUNIS A4.26 and A4.32) is classified as a 'Priority habitat for conservation', that is a habitat whose conservation is mandatory, because of its vulnerability, heritage value, rarity, aesthetic and economic values (Relini and Giaccone 2009).

The precious red coral is found also outside the coralligenous, in the semi-dark caves (and upper enclaves) with the facies with *C. rubrum* (BARCON IV.3.2.2).

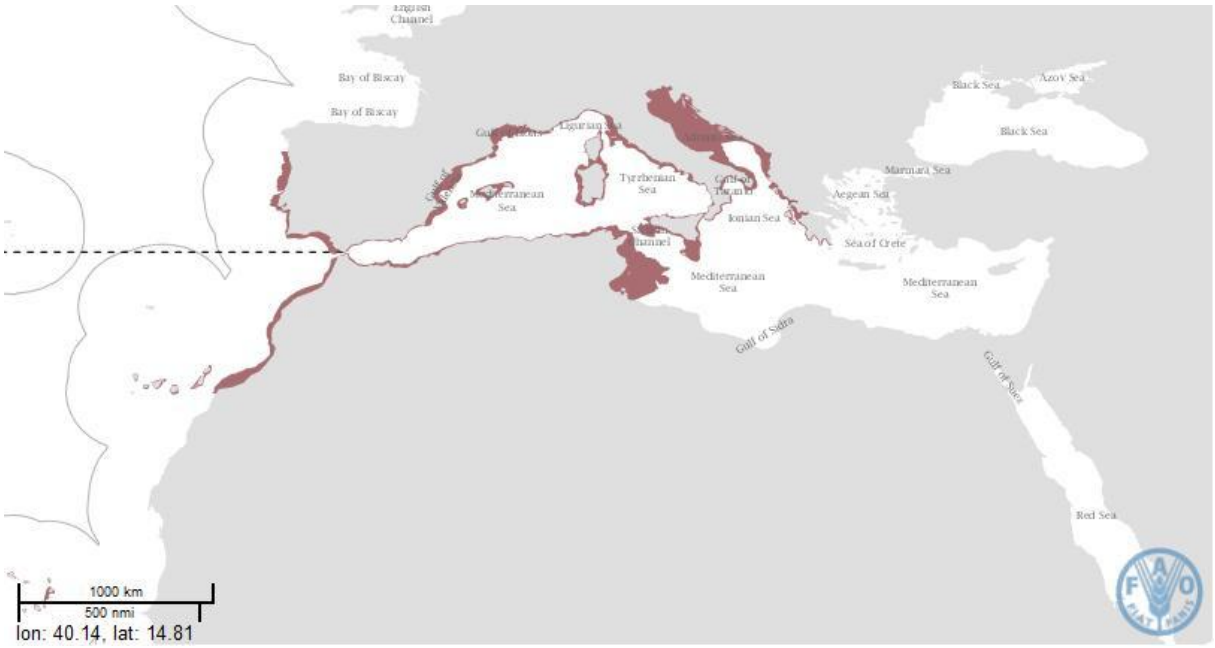

Figure1 FAO Figis web page (2012), the square represent the maximum extension of the geographical distribution of red coral.

Several studies (see the following sections) concordantly suggest the occurrence of different typologies of *C. rubrum* populations:

- **<u>shallow-water populations</u>** (depth range between 15 and about 50 m), dwelling on caves, crevices, overhangs and protected

interstices. Many of them are reported to be over-exploited, in consequence of the heavy pressure exerted by SCUBA diving since the 1950s, able to picking of red coral in areas inaccessible to dredges. According to the Recommendation GFCM/35/2011/2 Paragraph 8, they are being fully protected from exploitation, to allow for their recovery.

- **deep-water populations** (depth range of between 50 and about 130 m), typically dwelling on open surfaces. The commercial harvesting was/is mainly focused on these populations. In the past, they were harvested by the use of dredging gears, nowadays, by divers down up to depths of 100-130 meters. They are the populations to be managed through the provisions of the Regional Management Plan (RMP) for red coral and the National Management Plans (NMPs).
- **deepest-water populations** (depth range 130 to about 800 m); poorly known. No legal harvesting is realized on those populations, but considering they are very sparse (very low densities) they are said of not commercial interest (not permitting any profitable exploitation). They should not be harvested in the future, as they could provide refugia for the species.

THREATS AND ENVIRONMENTAL ISSUES

The red coral is considered one of the most vulnerable resources in the Mediterranean Sea because it is a long- lived species, with a slow growth, low fecundity and limited dispersal capabilities and consequently strong genetic differentiation of populations at spatial scales of 10s of meters (see following sections dealing with biology, ecology and genetics of red coral).

On account of its high economic value, the red coral has long been heavily exploited since ancient times (see the following sections on harvesting, both dealing with past and current aspects).

Besides harvesting, other types of anthropogenic disturbances threat red coral populations: pollution, tourism, recreational diving, incidental take or habitat degradation associated with long-line fishing and bottom trawling (Coma *et al.,* 2004; Garrabou *et al.,* 1998; Linares *et al.,* 2003; Linares *et al.,* 2010b). Furthermore, mass mortality events have been observed in shallow waters populations

Fishing impacts are worsened by natural stressors and climate change, especially in shallow water where also mass mortality events have been documented since the late 1990s, attributed to a fungal and protozoan disease and linked to temperature anomalies (Bramanti *et al.,* 2005; Cerrano *et al.,* 1999; Garrabou *et al.,* 2009; Garrabou *et al.,* 2001; Perez *et al.,* 2000; Romano *et al.,* 2000). In particular, the Mediterranean red coral (*Corallium rubrum*) is expected to be particularly susceptible to acidification effects linked to climate change, due to the elevated solubility of its Mg-calcite skeleton. Recent experimental studies have shown, for the first time, evidence of

detrimental ocean acidification effects on this valuable and endangered coral species (Bramanti *et al.,* 2013).

More in general, the habitat that hosts most of red coral populations, the Mediterranean coralligenous, is considered a benthic habitat of high conservation interest (Ballesteros 2006; UNEP/MAP 2009). In fact, coralligenous outcrops are of special interest, as they represent one of the hotspot for species diversity, and also of special concern, as they are increasingly suffering impacts of a range of anthropogenic disturbances. In particular, the gorgonian corals play a very important role within the coralligenous biocoenosis as ecosystem engineers by providing structural complexity and biodiversity.

Currently, the most destructive impact affecting coralligenous communities is the action of trawling gear (Cinelli and Tunesi 2009). In the past, special trawling used to collect the precious red coral by the so-called "Italian Bar" or "Saint Andrew Cross" proved to be highly destructive, causing degradation of large areas of coralligenous (RAC/SPA 2008). Negative impacts on the coralligenous can be also caused by traditional artisanal fishing (long-lines, trammel nets, pots for catching lobsters), recreational fishing, diving activities and anchoring (RAC/SPA 2008).

As most of the builder species (and red coral as well) are particularly long-lived, have low recruitment and complex demographic patterns, destruction of the coralligenous structure is critical as their recovery will probably take several decades or even centuries (Ballesteros 2006; RAC/SPA 2008).

For instance, after 20 to 30 yr of protection within French and Spanish MPAs, red coral colony sizes did not reach the values of pristine populations (Garrabou and Harmelin 2002; Linares *et al.,* 2010a; Tsounis *et al.,* 2006) suggesting that full recovery will require decades of effective protection (Linares *et al.,* 2010a; Torrents and Garrabou 2011; Tsounis *et al.,* 2006).

Given the longevity of this species (more than 100 yr, (Garrabou and Harmelin 2002; Marschal *et al.,* 2004; Tsounis *et al.,* 2007), it seems reasonable to speculate that 20 yr of protection are not sufficient to reach the size of pristine populations.

REPRODUCTIVE BIOLOGY

Aspects of reproductive biology have been studied for the red coral *Corallium rubrum*, but they are still lacking. To date, except for the historical work of Lacaze-Duthiers (Lacaze-Duthiers 1864), a few reports on red coral reproduction are published for shallow water colonies (Santangelo *et al.,* 2003; Torrents *et al.,* 2005; Tsounis 2005; Tsounis *et al.,* 2006a; Vighi 1970; Weinberg 1979). Since 2013, new knowledge on the fecundity of deep colonies is available for the Tyrrhenian Sea (Italy) (Priori *et al.,* 2013).

C. rubrum presents a limited capability for asexual reproduction. The sexual status of the population appears completely gonochoric at both the colony and the polyp level (Santangelo *et al.,* 2003; Tsounis *et al.,* 2006a; Vighi 1970). Red coral is an iteroparous species, undergoes internal fertilization and broods larvae internally (planulator). Gonadal development follows an annual cycle with a synchronized release in summer (Santangelo *et al.,* 2003; Tsounis *et al.,* 2006a; Vighi 1970). The embryonic period lasts about 30 days (Lacaze-Duthiers 1864; Vighi 1970). Colonies do not fuse together (in nature) and each adult colony therefore is likely to have originated from a singular planula (Stiller *et al.,* 1984; Weinberg 1979). Larvae exist in the water column for a few hours to days before setting in close proximity to parent's colonies. It is therefore very likely that most populations are genetically isolated.

Data on fecundity is summarized in Table 1. Fertile female polyp of shallow water colonies produced from 1 to 4 mature oocytes per year, while each fertile male polyp produced 6±3.5 spermiaries on average (Santangelo *et al.,* 2003). Female fecundity and fertility are constant over time, but decrease after March, despite the fact that oocytes do not turn into planulae during this period (Santangelo *et al.,* 2003). Female's fecundity ranged between 0.05-3 mature oocytes per year has been found for the deep water colonies (Priori *et al.,* 2013).

Table 1 - Colonies fecundity in several Mediterranean shallow- and deep-water populations; fecundity is expressed as number of oocytes/ polyp /year.

COLONIES	Fecundity/sex	Substrate	Population examined	Reference
SHALLOW	3-6/female	-	Italy (Liguria)	Vighi, (1970,1972)
	0.87/female	-	Italy (Calafuria)	Santangelo *et al.,* 2003
	0.9-1.6/female	-	Spain (Medes islands)	Tsounis *et al.,* 2006 a,b
	1.0-3.2 / female	-	France (Provence)	Torrents and Garrabou, 2011
	2.1±1.5 / female	39-42 m	France (Provence)	Torrents and Garrabou, 2011
	2.7±1.6 / female	15-22 m	France (Provence)	Torrents and Garrabou, 2011
	2.7±1.6/ female	Cave entrance	France (Provence)	Torrents and Garrabou, 2011
	1-12/male	-	Italy (Liguria)	Vighi, (1970,1972)
	6/male	-	Italy (Calafuria)	Santangelo *et al.,* 2003
	1.9-3.9/male	-	Spain (Medes islands)	Tsounis *et al.,* 2006 a,b
	5.0±1.7/ male	39-42 m	France (Provence)	Torrents and Garrabou, 2011
	5.7±3.0/ male	15-22 m	France (Provence)	Torrents and Garrabou, 2011
	5.7±3.0 / male	Cave	France (Provence)	Torrents and

		entrance		Garrabou, 2011
DEEP	0.05-3/female	50-130 m	Italy(Tyrrhenian sea)	Priori *et al.,* 2013

The size has positive effect on reproductive potential. The reproductive output increases exponentially with colony size. Generally, large colony contained more oocytes and sperm sacs and may produce a hundred or more of planulae than the small ones (some tens of planulae) (Santangelo *et al.,* 2003; Torrents *et al.,* 2005; Tsounis *et al.,* 2006a).

The actual age of first reproduction is probably 7-10 years corresponding to colonies about 24.0 mm in eight, 3.6 mm in basal diameter and 0.6 g in wet weight (Torrents *et al.,* 2005). Female colonies reach fertility at a minimum age of approximately 10 years (corresponding to a diameter of 2 mm), although reproductive parameters (percentage of fertile colonies and fertility) are significantly lower in small size than in medium and large colonies (Torrents *et al.,* 2005). Male colonies, on the other hand, may develop gametes much earlier. The youngest fertile male colony of the sample with a basal diameter of 1.2 mm is supposed to be not older than six years (Gallmetzer *et al.,* 2010).

RECRUITMENT

Recruitment is one of the main process determining both population structure and dynamics (Caley *et al.,* 1996). The rate of recruitment can greatly vary in space and time. It could be different if it occurs in natural or artificial substrates. There are few studies on the recruitment process in red coral populations (Table 2)

Table 2 Recruitment rate measured in different time and areas of the Mediterranean

COLONIES	Recruitment rate	Substrate	Population examined	Reference
SHALLOW	0-32 recruits/m2	Shallow waters (40 m depth)	Spain (Medes Islands)	Linares *et al.,* 2000
	1.6±1.96 recruits/dm2	Semi natural substrate on a vertical cliff	Spain (Medes Island)	Bramanti *et al.,* 2007
	0.4-0.6 recruits/dm2	Semi natural substrate on a vertical cliff	France (Monaco)	Cerrano *et al.,* 1999
	0-12 recruits/m2	Semi natural substrate on lateral wall	France (Marseille)	Garrabou and Harmelin, 2001
	1.3 recruits/dm2	Semi natural substrate in a cave	France (Marseille)	Garrabou and Harmelin, 2002
	0.178 recruits/dm2	Semi natural substrate in a	France (Marseille)	Garrabou and Harmelin, 2002

	cave		
6.24±4.26 recruits/dm2	Semi natural substrate on a vertical cliff	Italy (Calafuria)	Bramanti *et al.,* 2005
1.1±1.4 recruits/dm2	Semi natural substrate on a vertical cliff	Italy (Elba Island)	Bramanti *et al.,* 2007
3.88±0.68 recruits/dm2	Semi natural substrate on marble tiles	mean (Medes I., Elba, Calafuria)	Santangelo *et al.,* 2012
0.56±0.21 recruits/dm2	Semi natural substrate on marble tiles	Spain (Medes Island)	Santangelo *et al.,* 2012
6.06±1.75 recruits/dm2	Semi natural substrate on marble tiles	Italy (Calafuria)	Santangelo *et al.,* 2012
4.66±1.01 recruits/dm2	Semi natural substrate on marble tiles	Italy (Elba Island)	Santangelo *et al.,* 2012

Saturation of space and interference competition appears to be a major controlling factor in red coral recruitment (Garrabou *et al.,* 2001; Santangelo *et al.,* 1988). This could explain why recruitment rates were higher after harvesting events (Linares *et al.,* 2000; Santangelo *et al.,* 1997).

GROWTH RATE

Corallium rubrum is long-lived but how "long" its life span can be is still controversial and object of research. Some researches talk about >100 years (Garrabou *et al.,* 2002; Roark *et al.,* 2006) but this data has to be already confirmed. Up to now three different methods have been applied to determine the age of coral colonies:

Petrographic method (Abbiati *et al.,* 1992; Garcia-Rodriguez and Massò 1986a; Santangelo *et al.,* 1993a);

Organic matrix staining of thin sections from the base of colonies (Marshal *et al.,* 2004), which allows one to read annual growth rings;

Direct measurements of new settled colonies of known age, a not destructive approach to the study of colony growth rate, based on artificial or semi-natural substrates on which new settled colonies can be followed during their growth for a determined time interval (Bramanti *et al.,* 2005; Cerrano *et al.,* 1999; Garrabou and Harmelin 2002).

Unfortunately, the dark bands highlighted with the first method (Petrographic method) were not annual, so colony age was underestimated. Only "organic matrix staining method" allowed reading growth rings which were checked to be annual by calcein labelling in vivo (Caley *et al.,* 1996). In general, colonies

exhibit low growth rate which varies among location, depths, and habitats (Abbiati *et al.,* 1992; Bramanti *et al.,* 2005; Cerrano *et al.,* 1999; Garcia-Rodriguez and Massò 1986b; Garrabou and Harmelin 2002) (Table 2).

Table 3 - Growth rates (mm yr-1) in several Mediterranean shallow- and deep-water populations of *C. rubrum*

COLONIES	Growth rate (mm yr-1)	Method used*	Population examined	Reference
SHALLOW	1.32	P	Spain (Gerona)	(Garcia-Rodriguez and Massò 1986a)
	0.24±0.06	OMS	Spain (Cape de Creus)	(Vielmini *et al.*, 2010)
	0.35±0.15	OMS	France (Marseille)	(Marschal *et al.*, 2004)
	0.24±0.05	D (semi natural substrate in a cave)	France (Marseillle)	(Garrabou and Harmelin 2002)
	0.91	P	Italy (Calafuria, Livorno)	(Abbiati *et al.*, 1992)
	0.62±0.19	D (semi natural substrate in vertical cliff)	Italy (Calafuria, Livorno)	(Bramanti *et al.*, 2005)
	0.62	D (natural substrate in a cave)	Italy (Portofino)	(Cerrano *et al.*, 1999)
	0.22±0.04	OMS	Italy (Portofino)	(Vielmini *et al.*, 2010)
	0.2	OMS	Italy (Ligurian Sea)	(Gallmetzer *et al.*, 2010)
	0.68±0.02**	D (marble tiles)	Italy (Calafuria, Livorno)	(Santangelo *et al.*, 2012)
	0.59±0.02**	D (marble tiles)	Italy (Elba, Tuscany)	(Santangelo *et al.*, 2012)
DEEP	0.26	OMS	Italy (Tyrrhenian Sea)	(Priori *et al.*, 2013)

* OMS = Organic matrix staining; D = Direct measure; P = Petrographic; ** first year of life

After settlement, the growth rate of shallow water colonies is about 1 mm year^{-1} for the base diameter, and 10 mm year^{-1} for the height (Cattaneo-Vietti and Bavestrello 1994) but after 4-5 years, the growth virtually stops and become negligible (Bavestrello *et al.*, 2010). The growth rate of deep water colonies seems to be narrower (0.26 mm) (Priori *et al.*, 2013)

POPULATION STRUCTURE AND DENSITY

Red coral population density varies from place to place, according to depth and exploitation (Rossi *et al.*, 2008; Tsounis *et al.*, 2006b). Schematically, we can distinguish two different spatial situations: 1) coastal populations, occurring up to 50 m depth, characterized by high density (up to 1000 colony/m^2) and small colony size (until 5 cm of height); 2) deeper populations, extending up to 200 m depth and more, characterized by low

density and high colony size. At this depth range, colonies are characterized by more extensive branching patterns (Santangelo *et al.,* 2007) forming small aggregates on individual banks and hard ground areas, where colonies are concentrated on the exposed surface facing into high-current areas (Cannas *et al.,* 2010; Rossi *et al.,* 2008) (Table 4).

Table 4 - Adult colonies densities (colonies m-2) at different depths in several Mediterranean areas.

POPULATIONS	Country	Density (colonies m^{-2})	Depth (m)	Reference
SHALLOW	France (Scandola)	70	19-22	(Linares *et al.,* 2010)
	France (Banylus)	137	23-25	(Linares *et al.,* 2010)
	France (Carry)	47	24-25	(Linares *et al.,* 2010)
	France (NW Mediterranean)	228-606	25	(Garrabou *et al.,* 2001)
	Spain (Costa Brava)	3.42±4.39	20-50	(Tsounis 2006)
	Spain (Palma de Mallorca)	55	40	(GFCM 1984)
	Spain (Costa Brava)	20	60	(GFCM 1984)
	Italy (Calafuria)	4322±3358	20-45	(Santangelo *et al.,* 1993)
	Italy (Ligurian Sea)	1050 ± 7.39; 212.5±10.38	22-40	(Santangelo *et al.,* 1988)
	Italy (Eastern Ligurian Sea)	2493±1299.5	30-50	(Santangelo and Abbiati 1989)
DEEP	Spain (Cap de Creus)	43±53	45-85	(Rossi *et al.,* 2008)
	Italy (Calabrian coast, South)	18.04±23.6	50-105	(Angiolillo *et al.,* 2009)
	Italy (Calabrian coast, South)	6.42±4.6	70-130	(Angiolillo *et al.,* 2009)
	Italy (Calabrian coast, South)	96.57±7.5	50-200	(Angiolillo *et al.,* 2009)
	Italy (Tyrrhenian Sea)	12.9±7.9	50-130	(Priori *et al..,* 2013)

GENETICS AND GENETIC STOCK IDENTIFICATION

The main bulk of available genetic knowledge refers to the more accessible shallow-water populations (15-60 m of depth) (Abbiati *et al.,* 1992,1993, 1997; Aurelle *et al.,* 2011; Calderon *et al.,* 2006; Casu *et al.,* 2008; Costantini *et al.,* 2003, 2007a,b,2011; Del Gaudio *et al.,* 2004; Ledoux *et al.,* 2010a,b). These studies found evidence of breeding isolation and population sub-structuring suggesting that larval dispersal could not be able to ensure sufficient gene flow to preserve genetic homogeneity of the species. Several studies confirmed the occurrence of genetic differentiation at spatial scales of 10s of meters (that is the effective larval dispersal range may be restricted to < 10 m). The strong genetic differentiation between nearby samples implies that the recovery of over-exploited populations should be mainly due to self-recruitment.

Moreover, a pattern of Isolation by Distance was described in Ledoux *et al.,* (2010a), that is the more distant the more different populations are. All studies revealed, through the use of differentially powerful markers, significant deviations from Hardy-Weinberg equilibrium due to elevated heterozygote deficiencies, consistent with the occurrence of inbreeding (mating between consanguineous).

As regards deep-water populations, the number of genetic studies dealing with them is very limited.

Costantini *et al.,* (2011) analysed colonies along a depth gradient (from 20 to 70 m) and showed strong patterns of genetic structuring among the samples both within and between two study sites (Catalan and Ligurian Sea), with a pattern of reduction in genetic variability with depth. A threshold in connectivity was observed among the samples collected across 40–50 m depth, supporting the hypothesis that discrete shallow- and deep-water red coral populations occur. This finding could have major implications for management strategies and the conservation of commercially exploited deep red coral populations (Costantini *et al.,* 2011)

The only genetic data available on populations >-80 m comes from Sardinian commercially exploited banks (Cannas *et al.,* 2010, 2011). In Sardinian populations high level of genetic differentiation was measured, over different spatial scales from hundreds to less than 1 km. First preliminary results seems indicate the existence of a strong genetic differentiation among populations over the different depths (banks from 30-60 meters vs. banks from 80-120 m), further underlying possible restrictions to gene flow along the depth gradient and hence possible local adaptations to the two different environments, the deep- and shallow-waters (Cau *et al.,* in preparation).

As concerns the deepest red coral populations, a few colonies (a total of 12 fragments from 5 sites from Malta and Linosa shelves) from the lower limit of red coral depth range in the Mediterranean Sea (up to 819 m of depth) were genetically characterized by Costantini *et al.,* (2010b). The authors found differences between shallow and deep-water samples, but the small sample size of the deep-water collections does not allow the authors to make final considerations on their degree of isolation (Costantini *et al.,* 2010).

Finally, an interesting experiment was recently performed combining transplant and genetic analyses (Ledoux *et al.,* 2010b). Two populations dwelling in contrasted temperature regimes and depths (-20 m and -40 m) were reciprocally transplanted. The population from -20 m showed a significant decrease in growth rate when transplanted at -40 m. Since previous genetic analyzed indicated significant differentiation among the studied populations, the authors concluded that different genotype*environment interactions could exist and hence local adaptation in these populations of *C. rubrum*.

On the overall the genetic studies performed so far highlight a strong genetic heterogeneity even at very small spatial scales, and suggest that management of red coral has to be planned on a local base. Individual harvesting plans for each bank should also to be considered, that is each commercial stock should be previously characterized from the genetic point of view to identify population boundaries and define Management Units.

MORTALITY

The high commercial value of red coral involves that this vulnerable species is subject not only to natural mortality but also to harvesting mortality.

Natural mortality of red coral includes completion of space with sponges and other sessile biota, dislodgement from the substrate due to the action of boring species (Harmelin *et al.,* 1984) or seismic movement (Di Geronimo *et al.,* 1994), predation by the small gastropod *Pseudosimnia carnea* and the crustacean *Balssia gasti* (Abbiati *et al.,* 1992) and sedimentation increase. Mortality in *C. rubrum* had a different impact, depending on the colony size. Large colonies are more resilient to natural stressors. On the contrary, small colonies prevalently suffer of higher virulence, showing higher whole-colony mortality rates. A large number of species (mainly sponges, crustaceans, brachiopods, molluscs and echinoderms) have been documented living on/in or in strict association with red coral colonies (Calcinai *et al.,* 2010; Crocetta and Spanu 2008) and references therein). Some of these species, especially the parasitic ones, may increase the red coral mortality rate and therefore profoundly affect its population structure (Corriero *et al.,* 1997). Apart from being the main causes of natural mortality, sponges have the ability to damage colonies and thus reduce the commercial value of red coral (Calcinai *et al.,* 2010).

Phenomena of mass mortality events have been observed in shallow waters populations since the late 1990s, including several mass-mortality events linked to elevated temperature anomalies (Bramanti *et al.,* 2005). A mass mortality event occurred in the NW Mediterranean in summer 1999. The phenomena, in which about 80% of the colonies were affected, was attributed to a fungal and protozoan disease and linked to temperature anomalies (Cerrano *et al.,* 2000; Garrabou *et al.,* 2001; Perez *et al.,* 2000; Romano *et al.,* 2000). In the same year (late summer 1999) some shallow water red coral populations have been affected by mass mortality associated to anomalous temperature increase in the Eastern Ligurian sea (Calafuria, Italy; Bramanti *et al.,* 2005), as well as western Ligurian sea. However, further studies are urgently required to provide basic information regarding red coral population dynamics as a basis for the hypothesis on the actual recovery capability of affected populations.

CONSIDERATIONS ON THE DATA AVAILABLE FOR RED CORAL

Huge differences exist in the availability of data from the different areas, reflecting the different efforts (and economic availability) in studying and monitoring red coral populations.

The aim of these paragraphs is to give an overlook (summary) on the main sources that have been utilized in the past to gather data on red coral populations, as well as indications on which are the sources to be used in the future and how to implement them. The priority actions and future efforts to be made in improving the management and the conservation of this important species are given. Furthermore, a discussion on pros and cons of the main type of data is presented.

FISHERY-DEPENDENT AND INDEPENDENT DATA

The following Table 5 shows the main type of Fishery-dependent data and gives indication priorities in using and collecting them for management or scientific purposes.

Table 6 shows the main type of Fishery-independent data and gives indication priorities in using and collecting them for management or scientific purposes.

Table 5 Fishery-dependent data (task C = completed; H = high priority; M = medium priority; L = low priority; na = not applicable)

Information source	Data on		notes
Fisheries agencies	landings	H	There is the very urgent need to improve the quality of data collected by countries and provided to FAO / GFCM
	fishing effort	H	As above
	Size/branching patterns	H	Through scientific surveys + observer at sea + improvement of fishermen logbooks
Museum / private collections	Size/branching patterns	L	Data on a few individuals cannot give relevant information for the management of the species
	population dynamics and biological data (ancient DNA, isotopic analyses)	L	Scientifically relevant, but low priority for management
Fishermen (logbooks + ad hoc interviews)	Landings	H	There is the very urgent need to improve the quality of collected data (Logbook) e.g. not only gross weight but also number of colonies, if possible also individual weights and sizes (basal diameter)
	fishing effort (length of dive/harvested coral)	H	
	position of banks	H	
	Size/branching pattern	M	Better if collected through scientific surveys + observer at sea
	Trade (amount and prices)	H	
Manufacturers/traders	Trade (amount and prices)	H	Market is the major driver of harvesting
	Stockpiles (amounts)	M	As above
	Stockpiles (biological data, DNA, isotopic analyses)	L	Scientifically relevant, but low utility for management
Independent observers (Random e/o systematic assessment of fishing activities)	biometric data (diameter, height, weight, branches, etc)	H	There is the very urgent need to improve the quality/quantity of data, especially in some areas and depths
	Fishing effort (length of dive/harvested coral)	H	
	%dead, %broken corals, %infested by sponges	M	Scientifically relevant, but low priority for management
	Samples collection (reproduction, genetics, physiology etc)	H	Scientifically relevant, relevant for management
	Monitoring of habitat and environment	M	Scientifically relevant, especially for conservation issues

Table 6 Fishery-independent data (e.g. through observer programs / scientific surveys)

Data on	priority	Notes
Size/branching pattern	H (De)	Comparison **Ha/Pr** pops and over time monitoring give indications of the effects of fishing on the studied populations; for **Sh** populations data are available (some areas only)
Density, abundance, biomass	M/L (De)	Difficulties in measuring, comparing and interpreting the data; for **Sh** populations data are available (some areas only)
Recruitment, growth	H (De)	To measure recovery time that is responses to disturbances (fishing but also climate changes etc.); for **Sh** populations data are partially available (some areas only)
Reproduction, genetics, physiology etc.	H (De)	To measure reproductive output, connectivity, resilience to disturbances (fishing but also climate changes, etc.); for **Sh** populations data are partially available (some areas only)
Environmental parameters (temperature, currents, pH etc)	H	monitoring effects of emerging threats (e.g. global warming) in **Sh** pops; data on **De** are completely lacking
Habitat and biodiversity surveys (associated species)	M/L	Scientifically very relevant (conservation purposes), but not strictly linked to the acquisition of data for management purposes

Codes: Priority (H = high priority; M = medium priority; L = low priority); banks (Deep: De; Shallow: Sh); populations (Harvested: Ha; Protected: Pr)

COMPARISON AMONG INFORMATION OBTAINED THROUGH DIFFERENT TYPES OF DATA

SIZE

Size of the colony is a major determinant of first reproduction, reproductive output, and colony survival. The size of colonies is principally measured through**: height of the colony, basal diameter, and branching pattern**.

In general, as the height increases with age, the diameter also increases. However, the growth pattern could vary among different areas and according to environmental parameters. For a given height, in different areas, colonies could have very diverse basal diameter values and ages. Therefore, to a more accurate description of populations, **local estimates** should be preferable.

BRANCHING PATTERN

The size (and branching pattern) are related to the number of polyps in the colony and hence to its reproductive output.

Small colonies have not developed a branching morphology and consist in relatively few reproduction polyps which produce only low numbers of gamete once per year.

The increase in polyps is partially related to size (larger colonies have more polyps overall), polyp number also increases in proportion to the degree of branching, which is much more extensive in large colonies. However, large colonies lack polyps at the basal portions and polyps may be more dense but smaller at the branch tips.

DENSITY

Numbers of colonies per unit area are unlikely to provide an indication of the population status or trends. This is because these measures differ depending on how they are assessed (colony density measured over the entire suitable habitat is much less than the density of small patches occupied by the coral within this habitat), and the life stage of the population. In fact, higher values are found in populations composed of smaller colonies: they tend to occur in large aggregates because they settle relatively close to their parent; these smaller-sized colonies lack a branching morphology. As they increase in size, and in branching pattern, they require more space. When they reach a large size, populations will ultimately become less dense, with a lower overall abundance throughout a bed.

In general in red coral, high abundance and density values, such as those present in Mediterranean shallow waters, are an indication of frequent continuing perturbations responsible for rapid turnover of populations and a persistent state of early-stage recovery.

However, it should be considered that for sessile colonial organism, such as *C. rubrum*, successful reproduction is critically dependent on the density (a minimum density is required for successful reproduction). Therefore, very low levels of density, associated with the selective removal of the largest colonies on a coral bed, should be avoided since they may alter the reproductive potential due to the well known Allee effect.

ABUNDANCE AND BIOMASS

Abundance data must be combined with knowledge on the entire size of the bed suitable for colonization, and abundance must be normalized over the entire bed.

Abundance data are associated with high standard deviations due to patchy distribution of corals. Abundance data cannot be directly compared among

populations or within individual beds over time, due to their patchy occurrence within these beds, differences in the available habitat within an area occupied by this coral, and highly variable features such as crevices and outcrops that are not uniformly distributed throughout the habitat.

Furthermore, identifying population biomass decline requires a time series of comparison or comparison with unharvested populations, and this kind of data is lacking for red coral. In the case of red corals a precise estimate of decline will probably never be possible because the lack of natural baseline. In any case population decline in colonial animals must be identified by analyzing polyp numbers, not colony numbers, because polyps are the reproductive modules. For colonial organisms, change in population structure (size frequency distribution) is a more suitable measure of decline than changes in the absolute numbers of colonies.

POPULATION STRUCTURE

Data on the population structure are the most useful data in identifying monitoring population status, in identifying changing proportion of mature/immature colonies, which is more functional as a basis for management decisions that need to ensure minimum recruitment, especially for sessile animals that require a certain density to ensure fertilization success (Bruckner and Hill 2009)

Furthermore, shifts in the size structure of populations due to fishing pressure can be directly compared, while density and abundance cannot.

A recent study (Linares *et al.,* 2010) documented as the demographic structure of red coral populations from 3 of the oldest Mediterranean MPAs (all in France: Scandola Nature Reserve, Cèrbere-Banyuls Nature Reserve and Carry-le Rouet Marine Protected Zone) has changed with time and it is now significant different from unprotected populations (Linares *et al.,* 2010). Within the MPAs the size values are higher than those reported for most of the shallow populations and deep-dwelling populations. Differences in the observed size distributions are more closely related to the structure at the beginning of the reserve than to the number of years of protection. Despite these positive effects, colony sizes did not reach characteristic values of pristine populations estimated from museum specimens (Garrabou and Harmelin 2002), most likely as a result of other impacts such as poaching and diving, which do not allow their total recovery (Linares *et al.,* 2003). The percentages of colonies with basal diameter greater than 7 mm or colony height greater than 100 mm has been proposed as useful descriptors for evaluating the conservation status of each population.

USING DATA IN MODELS

Developing a quantitative model for an exploited population which reflects its main demographic features is a standard precondition for drawing up a management plan for the resource (Caddy 1993).

According to Caddy (1993) four aspects of modelling a red coral population emerge from the biology of this species in which it differs significantly from, for example, the more commonly modelled finfish populations, namely:

1) Populations are sedentary, and their density varies from place to place.

2) Because they are sedentary, the effects of past local harvesting remain local, at least until the population regenerates itself. In other words, the dynamic pool assumption must be rejected (Caddy, 1975).

3) Like other high-value sedentary or semisedentary organisms, harvesting (especially by scuba) tends to be in a 'pulse' fishing mode, in which local patches are cleaned out selectively, leaving only inaccessible or non-commercial individuals, before another patch is located and harvested in turn.

4) Growth of corals, and hence regeneration of exploited populations, is very slow, and as such, harvested areas are effectively removed from production for a significant period. Periods of up to 50 years have been mentioned as recovery times in Pacific fisheries (Grigg 1984).

Furthermore, developing a population model for precious coral resources has to take into account the fact that population parameters are often not precisely known and are likely to show wide variation from place to place; nor is usually the size of the population, the rates of recruitment and growth, or the death rates due to natural causes and fishing (Caddy 1993).

The question of modelling red coral resources has been discussed and examined the first time during the first GFCM Technical Consultation on red coral resources of the western Mediterranean (GFCM 1984): three types of models have been compared, as proposed by Garcia (GFCM 1984): 1) Models that assume a ‘mining’ strategy (curve of exhaustion models), 2) global or production models, and 3) analytical, structural or yield-per-recruit models.

According to Garcia (in GFCM 1984) the deposit exhaustion model can be used to analyse the reaction to exploitation of a small, isolated coral bed, as in this case the growth rate and natural mortality are insignificant with respect to the fishing mortality (the only actually affecting the biomass). It allows calculate the theoretical time needed to reduce the bed to certain percentage of its initial biomass for different extraction rates (Table 7).

Table 7 'life span' of the coral bed in years for different exploitation rates (form 1% to 75% biomass/year) and final abundances (5, 10, 50% of the initial biomass) (from Garcia in GFCM 1984).

	extraction rate / year					
	1%	5%	10%	25%	50%	75%
fishing mortality F	0,01	0,051	0,105	0,287	0,699	1,386
t50% (years)	69	14	6,6	2,4	1	0,5
t10%(years)	nc	nc	nc	8	3	1,5
t5% (years)	nc	nc	nc	10	4	2

The global production models are applicable only on a large geographical scale if the concepts of average exploitation pattern, average size of colonies, average abundances, etc are to have a minimum sense (Garcia in GFCM 1984). These models, despite their limitations, make it possible to perceive the economic problems.

The analytical model underlines the importance of the size of the coral colonies, when first exploited.

In order to simulate population growth and exploitation, two different kind of models have been applied to red coral: Beverton and Holt model (or "yield per recruit model" Beverton and Holt 1957) and life-history table and Leslie-Lewis matrix model (Caswell 2001).

The Beverton-Holt (BH) model provides a useful estimator of the age/size at which colonies should be harvested, and provides a conservative estimate of harvest yields.

Data requirement for using this model are: i) natural mortality rate; ii) age/size at recruitment to fishery - selectivity of gear for different age/size classes; mean size at sexual maturity.

Main assumptions of the model are: i) it assumes knife edge selectivity and constant fishing mortality and natural mortality for all ages; ii) it assumes the stock is in equilibrium i.e. that the biomass and age –structure are constant from year to year; iii) it assumes that recruitment is constant from year to year, which is likely to be false at high fishing mortalities when low spawning biomass may reduce recruitment.

One the main advantages is that data can be collected only once (in a single survey) (Santangelo *et al.,* 2010).

However, the assumption that red coral recruitment is constant in time cannot be taken for granted, because it has been demonstrated that, depending on the studied area and habitat, red coral recruitment may be discontinuous over time (Garrabou and Harmelin 2002; Bramanti *et al.,* 2005). Furthermore, a

precise estimate for natural mortality, the most critical parameter in the BH model, by using the population structure of natural populations is not possible in red corals as no untouched populations are known or accessible. Moreover, the size classes (colony diameter) conversion to age classes, as well as the correlation growth and age, are not easily done. Other limitations to the original model are that it assumes that all the colonies above a determined (age) size will be completely removed and it does not take into account the effects of reproduction and density-dependence on biomass growth (Santangelo *et al.,* 2010).

The BH model has been applied to *C. rubrum* by Garcia (in GFMC 1984), Garcia-Rodriquez and Massò (1986) and Tsounis *et al.,* (2007) and to other coral species in Hawaii (Grigg 1976, 2002, 2004).

Based on these models a range of estimates has been made for continuous harvesting in a sustainable way (i.e., without depleting the resource). According to Massò *et al.,* (l986a) it would necessitate very low levels of annual harvest (1.3%) with respect to the stock size, if populations were not to be depleted. Figures of the order of 5% are in Garcia (1984) while Grigg (1984) mentions values of 3.5% of the stock size harvested annually as corresponding to the Maximum Sustainable Yield (MSY).

The age at MSY calculated for red coral using the Beverton and Holt 'yield per recruit' ranged from 80 years (Garcia-Rodriguez and Massò 1986) and 98 years (Tsounis *et al.,* 2007). Different ages at MSY can be found according to the different growth and mortality rates applied, that can vary for different geographical areas and environments. According to Tsounis *et al.,* (2007), the current practise of harvesting red coral with a basal diameter of 7 mm (about 11 year old) results in a yield of only 6% of what would be reached by harvesting coral colonies of 98 years.

Estimates of maximum sustainable yield (MSY) and OY (optimum yield) are used in the fishery management plan for precious corals in the Hawaii Archipelago for the definition of harvest quotas.

MSY has been estimated using a Beverton and Holt model for *Corallium secundum*, for a single bank for which biological data were available (Grigg 1976). For the Makapu'u Bed the age at MSY has been estimated at 34 years and the harvest quota at MSY has been identified to be 1185 kg/year (Grigg 1976).

The same author using the BH model estimated black coral MSYs of 6174 kg/yr for the Auau Channel and 1480 kg/year for the area around Kauai (Grigg 1976). More recently, Grigg discovered a greater impact to the black coral resource from an invasive soft coral, Carijoa riisei, and based on that, coupled with harvesting impacts, estimated a reduced MSY of 3,750 kg/yr for the Auau Channel (Grigg 2004).

To estimate MSY for gold and bamboo corals the Gulland Model was used (Gulland 1970), because information on population dynamics was lacking (Grigg 2002).

Actually, the harvest quotas are based on extrapolations from "rounded down MSY values" for the ecological and economic reasons (OY). All the beds for which OY has been determined are called 'Established Beds'. For all the other bed known to contain precious but in which biological data are not available ('Conditional Bed'), the OY is prorated based on the area of the Conditional Bed relative to the area of established beds.

In particular, the dynamic pool yield-per-recruit models has been considered not particularly well adapted to a sedentary species, unless the spatial nature of the resource is taken into account (e.g. Caddy, 1975; Gales and Caddy, 1975; Sluczanowsky, 1983). They may be useful, however, for a first treatment of an open-access resource in which we wish to know the effects of a minimum size limit and a particular level of fishing effort on the resource (Caddy 1993).

Finally, the compilation of **life-history tables** (describing the demography of a population, gathering data for density, fertility, fecundity, sex ratio, recruitment, population structure, mortality), and the inclusion of those data in Leslie–Lewis transition matrix were used to simulate the trends of red coral populations over time (Bramanti *et al.,* 2009; Santangelo *et al.,* 2007).

They link reproduction, growth, mortality and demographic structure into one model and can take density dependence into account as well. Furthermore, the contribution of each cohort to population growth rate by reproduction and survival is included.

These models allow predictions of harvest effects based on every possible variation in fishing effort, and selective harvesting affecting the different age classes in a different way (Santangelo *et al.,* 2010).

However, they are highly-demand model in terms of data requirement.

A SPECIAL CASE: THE ROTATING HARVEST REGIME

According to Caddy (1993) for sedentary species an alternative 'ideal' management scheme is the Rotating harvest regime: the stock is divided into subareas, whose harvesting is staggered over a period of years, thus allowing depleted stocks to recover before restart harvesting.

A 9-year rotating closure period was apparently also practiced by Arab fishermen in the 10th Century (Grigg, 1988). Several countries and regions already had closures of coral fisheries in their fisheries legislation; notably, a 5-year closure established for coral fisheries in Sardinia in the 1970s (GFCM 1984, 1989) and a 25 year closure provided for in Spanish legislation (GFCM

1984, 1989). Nowadays, harvesting based on rotating areas is in place in Morocco and Greece.

Rotating harvest regimes for sedentary organisms can be represented using yield-per-recruit *(Y/R)* models with spatial components (Caddy, 1975, 1993). Based on these models estimates can be made for continuous harvesting in a sustainable way (i.e., without depleting the resource (Caddy 1993). It has been proposed also by the same author that some fraction (B') of the total biomass (B) could be excluded from the rotation scheme, or two or more unit areas could be opened simultaneously to harvesting. For instance, areas of fringe population can be excluded from the rotation scheme and left open to harvesting full time. Alternatively, some areas where reproduction occurs more regularly (Caddy, 1988) could be closed indefinitely as "mother lodes" or stock conservation areas (Caddy 1993).

Advantages and disadvantages of this approach, when compared to the principal alternative management approach, namely a quota scheme, are described in the paper by Caddy (1993).

In summary, firstly considerable information on population parameters are required for the application of these models, which are not yet available for red coral populations in many areas.

Moreover, this management scheme, providing for the closure of a coral fishery for a long time (several decades can be necessary for juveniles to grow to adequate size), imposes very high surveillance costs and leads to an increasing incentive for illegal fishing (Garcia, 1984). There is the need for control of fishing operations at sea, to ensure that fishing is not occurring in unauthorized areas; and also, a precise control of the location of fishing will be needed (today technically feasible using VMS systems). Fisheries surveillance, which is supposed to increase progressively as the biomass on the grounds builds up.

Furthermore, this practice could disrupt the gene flow through coral populations itself, and also potentially interrupt migrations of other species that take refuge in coral populations, or benefit otherwise from its presence (Tsounis *et al.,* 2009).

STANDARDIZED DATA COLLECTION PROGRAM WITHIN THE GFCM AREA FOR RED CORAL

Considering that valid scientific information is essential to develop meaningful management measures, a standardized data-collection program for red coral in the GFCM area should be urgently implemented.

A long-term monitoring program is important both to understand the fishery and to facilitate adaptive management.

Information should be collected in different ways through:

- simple, regular and standardized record from logbook or landings (catch data),
- sampling at landing sites and/or on board (size data),
- scientific surveys or focused studies as part of in-depth scientific research programmes (biological data for stock assessment, ecological data in view of the EAF approach)

To obtain valid data it should be stressed that:

- Methods of data collection should be standardized and kept consistent over time to allow comparisons across years.
- funding for monitoring should be adequate
- staff personnel should be well trained and motivated

FISHERY OF RED CORAL

FISHING METHODS

FREE DIVING

Thousands of years ago red coral was collected as fragments or branches, washed up on shores by wave action after heavy storms. Afterwards, about 5000 years ago, Greek fishermen began to look for it by breath-held diving. Harvested was performed by free diving by using iron hooks (called 'kouraliò') and Japanese goggles to harvest red coral (Bruckner 2009; Tsounis *et al.,* 2009).

DRAGGING GEARS

Gears that can be employed from boats dated to the fourth to third centuries BC (Tsounis *et al.,* 2010b). These gears changed very little with time, just modifying the materials or dimensions. The dredge mainly used in Mediterranean was the "St. Andrew Cross". It was made up by two beams in a cross shape with some weight to the junction. Some hooks and pieces of nets were put at the tip of the cross. During the Industrial Age, the Saint Andrews cross was abandoned in favour of a modified metal version called "ingegno" ("barra italiana"): a wooden or iron bar with pieces of nets and chains on it.

These gears were used to dredge the bottom of the sea; while moving, they broke the coral branches that remained entangled in the net and could be collected (Cicogna 2000; Bruckner 2009; Liverino 1998; Tescione 1973). They are known to have caused extensive habitat impacts to the coralligenous in Mediterranean (Chessa and Cudoni 1989). Dredges exclusively accessed exposed banks and removed the vast majority of coral on the rocks, down to the limit of 100/200 m of depth (Tsounis *et al.,* 2010a). Coral dredge are also extremely inefficient, as only about 40% of the detached colonies are entangled and retrieved (Grigg 1984; WPCouncil 2007).

Since the mid-1980s coral dredging was banned in many countries (e.g. 1977 in Algeria, 1985 in the former-Yugoslavia and Tunisia, in 1989 in Sardinia [Italy], and in 1994 in European Union waters); scuba-diving using advanced technology remains the unique legal exploitation method today.

SCUBA DIVING

At the end of the 1950s SCUBA diving became a common tool for surveying hard bottom communities and the way of harvesting the red coral has completely changed toward a less destructive and more selective way of harvesting (Harmelin 2010). Scuba divers were so able to access colonies

hidden in caves, overhangs and crevices that dredges cannot reach (Rossi *et al.,* 2008; Tsounis *et al.,* 2010a)

From the first use of the SCUBA diving for harvesting red coral, divers have been moving to deeper and deeper depths; in 1956 divers worked at 30–35 m, in 1958 at 40–45 m, by 1964 an at depths of 72 m (Liverino 1983). Inevitably a growing number of accidents were recorded as the result of the spreading 'coral fever' among the divers (Liverino 1983). Others similarly documented that by the late 1950s divers in France and Italy already had to descend to depths of 80 m, and at times to even more than 100 m, to find coral (Galasso 2000). In 1974, helium-based mixed-gas diving techniques started to spread among coral divers, permitting them to work at 120 m for 20 min without the dangers of nitrogen narcosis (Liverino 1983).

They use a pick to break the chosen branches, leaving untouched the rest. Scuba harvesting inflicts little direct damage to non-target species in the same habitat. Responsible divers cut the red coral base instead of extracting the whole colony; leaving the base in place leaves a chance that this colony might re-growth as sporadically observed (Rossi *et al.,* 2008). Studies on catches confiscated to poachers confirmed that up to 60-70% were entire colonies with the substratum still attached to their base (Hereu *et al.,* 2002; Linares *et al.,* 2003; Tsounis *et al.,* 2010b). However, as regards the selectivity of this fishing method, it is absolute only theoretically. In the '80s divers have been reported to make a "clean sweep" of an entire precious coral population at one site, and recently poachers have been harvesting young corals in shallow waters (GFCM 1989).

The dive at high depths is a very dangerous activity and it needs a very long decompression, after which the divers usually go into a hyperbaric chamber for 6-9 hours (Cicogna 2000). Furthermore, the considerable time, pressure and difficulty in working underwater and at those depth is quite incapacitating, so that red coral divers may not be able to consistently perform a precise size selection or partial harvest of corals (Tsounis *et al.,* 2010b).

SUBMARINES

To our best knowledge until 1997 the Isla de Alboran was the only area, off the Spanish coast, where submarines were used to collect the red coral (Paracuellos *et al.,* 2006). A total of two submarines were authorized: the Neree 201 and the 66 Tours DGK 300. These type of submarine were transported to the area of work by support vessels, Cote de Nacre and Boreal. The first one began operating in the Alboran Island in 1989, and had an uninterrupted harvesting license until 1997. It could dive as deep as 180 m and had a great manoeuvrability thanks to its five engines. The submersibles were equipped with manipulator arms or baskets of recovery and could work

for long periods in the extraction of coral at great depth, bound by ropes to the support vessels on the surface.

These devices were permitted only at depths exceeding 120 m, with a fixed quota of a maximum of 1500 kg of coral per year and engine. However, the average catches of the submarine Neree 201 were 503.6 kg/year during the period 1990-1995. As regards the other submergible, the 66 Tours, no harvesting data are known and there are doubts about that it never became operationally active. The sum of divers and submarine, 677.8 kg, was very close to the 700 kg/year that were obtained using the barra Italiana.

ROVS

Nowadays robotic extraction is not practical and not permitted in many fisheries. ROV (Remote Operating Vehicles) are increasingly employed to scout a potential bed, improving the yield per dive. Basic ROV consist of motorized real-time video camera that is controlled from the boat via a cable that also transmits the video signal to a topside monitor and recorder.

ROV can also be equipped with a robotic arm that permits remote-controlled harvesting, although this option raises the acquisition cost considerably.

Remote harvesting is still considered impractical compared with manual methods. Currents, nets and the topography of coral habitats make it difficult to handle the tethered machines, and without a dedicated technician a minor malfunction may easily render an ROV unusable for an entire expedition (Tsounis *et al.,* 2010b). Furthermore, according to the experimental uses in the Pacific, ROV tether may damage precious corals if not carefully used (WPCOUNCIL 2007).

In recent years in the Mediterranean ROVs have proven to be very useful for habitat mapping, studying biocoenosis and quantifying the distribution, structure, abundance, status of benthic biocoenosis, especially in areas that could not be sampled using traditional methods (scuba, trawl) due to the depth or the roughness of the terrain. ROV surveys have also been applied to red coral studies, to describe the occurrence, spatial distribution and population structure (Angiolillo *et al.,* 2009; Bo *et al.,* 2011a; Rossi *et al.,* 2008; Taviani *et al.,* 2010). Similarly, ROV videos permitted to obtained data on spatial distribution and structure of commercial banks (from -80 to -130 m) around Sardinia seas (Cannas *et al.,* 2010; Cannas *et al.,* 2011).

However, as pointed out in the two transversal Workshops on red coral organized by the GFCM in 2010 and 2011, many different problems can arise from the use of ROV for harvesting red coral.

Considering the peculiarities of this machines (not limited by the physical constraints of divers, and hence capable of diving deeper and longer than

humans) the number of ROV licenses, its operational time/day, the season length, the depth limits etc. should be attentively defined before the gear is massively employed to avoid the risk that its unregulated (mis)use will lead to a sudden and unsustainable increase in the amount of coral harvested (Cau in GFCM 2010). Last but not least, according to the experimental uses in the Pacific, ROV may damage precious corals if not carefully used because currents, nets and the topography of coral habitats make difficult to handle these tethered machines (WPCOUNCIL 2007); consequently long lasting damages to the ecosystems (the coralligenous communities) are also to be considered (Cau in GFCM 2010).

Considering the high risk to legalise a new harvesting methodology (robotic harvesting) without comprehensive knowledge of the fishing effort and the sustainability of the gear, since 2011 according to Recommendation GFCM/35/2011/2the use of the Remotely Operated underwater Vehicles (ROVs) in the GFCM Competence Area for the exploitation of red coral; ROV is authorized only for reasons of observation and prospection and provided that ROV models cannot be equipped with manipulator arms or any other device allowing the cutting and harvesting of red coral. The use of ROV is allowed for scientific experimental campaigns both for observation and harvesting during a limited period not extending beyond 2015, to evaluate impact and the advisability of using ROV for direct harvesting of red coral.

In this context, in Italy two important projects using ROVs have been financed by the Government.

- Prospection
- An interdisciplinary research project on red coral deep-dwelling populations was promoted by the Italian Environmental Ministry (GFCM 2011). This project involved researchers of several institutions working on red coral, cooperating within the "Italian Red Coral Research Group". A first survey cruise was carried out during early Summer 2010 in the Tyrrhenian Sea between 60 and 130 meter depth to investigate the following topics: 1) the demographic structure (in terms of size/age, spatial and sexual structure); 2) the population genetic structure; 3) the associated community with particular interest in epi and endobionts (which greatly affect colony economic value); 4) the microbial community associated to red coral colonies. A second survey cruise was carried out during summer 2011 to complete the project.
- Harvesting
- A second project was promoted by the Ministry of Agricultural, Food and Forestry Policies (Italian - Ministero delle Politiche Agricole, Alimentari e Forestali, or MiPAAF) in the framework of a national three-year program on fishery and aquaculture: "Use of ROV (Remotely Operated Vehicle) in the applicative definition of management plans for red coral (*Corallium rubrum*). Management Strategies for the conservation of the species and assessment of the compatibility of the resource with a potential commercial exploitation

along the north-central Tyrrhenian Sea Italian coasts." The project is ongoing.

At the time of writing, it was no possible to gather additional information on other projects using ROV within the GFCM competence area.

HISTORICAL FISHING DATA

Red coral has been a precious good since Prehistoric times. It has been found among archaeological finds of prehistoric graves of both Mediterranean marine people and European inland ones (Marini and Ferru 1989; Tescione 1965). Antique vestiges found at Marseilles, the oldest port in France, state that red coral was already collected there 26 centuries ago (Harmelin 2010).

In XII and XIII century the most exploited areas were located in Tunisia and Algeria. Here Catalan, Genoese and Marseillaise were used to compete for coral banks. At about 1400, Marseillaise moved also along the coasts of Naples (Italy) and Alghero (North-Western Sardinia, Italy).

In 1451 a company was founded by Genoese people was authorized to collect red coral in the western coasts of the Reign of Tunis, for 20 years (Berti 2003). At the beginning of 1500, Genoese people moved to Tabarka and in 1542 they obtained there the exclusive right of fishing coral. Here they caught an average of about 105.7 quintals (225 canthari).

With time, a lot of companies were created to exploit red coral banks. One of the most important was established in 1553 by Marseillaise, the "Grande Compagnie du Corail des mers de Bône", having the monopoly of fishing along 250 km of Northern African coasts ("Barberia"), but also used to collect coral in Corsica, Sardinia, Tunisia and the isle of Scarpanto (Aegean Sea). They were very capable and organized, it is reported that they caught high amount of red coral: 40000 quintals in 15 years (from 1575 to 1591) (Berti 2003).

In 1500 fishermen from Torre del Greco (Italy) moved towards Corsica and Sardinia to collect red coral, and in 1688 they had more than 400 boats to fish it. They reached the African coasts in 1780, becoming the more expert coral harvester in the Mediterranean Sea.

The coral fisheries in XIX and XX century underwent fluctuating periods of prosperity and decline (Tsounis *et al.,* 2007). For instance in Algeria, in 1876 almost 250 vessels were fishing by the cross; landings during this period were some 250-300 t/vessel/y for the eastern coast (El Kala) (GFCM 1989). After a period of stasis, following the independence from France (1962) fishing was resumed (1975-1977) totalling some 10 t. In Tunisia from 1885 to 1895, the production was about 7000 kg/year, while from 1920 to 1925, despite the technical improvement, it did not reached 1200 kg /year.

In Italy, in the 1880s the discovery of the Sciacca banks, off Sicily (wide banks of dead fossilized coral) led to a 'coral rush' of 2000 vessels into the small area and quickly depleted those grounds, while lowering prices and reducing fishing in other areas (Tsounis *et al.,* 2010). Coral fishing stopped completely during the WWI in 1914–1918. At about the same time, imports of Japanese coral started to reduce demand, and thus fishing, dramatically. Demand for Mediterranean coral increased again, and apart from another pause during WWII (in 1941, there were only 5 boats active, which increased to 31 in 1947), larger-scale coral fishing was resumed. A major event it has been the spread of Scuba-diving in coral harvesting, soon after its invention in the early 1940s', because it allowed divers to pick corals in protected crevices that were inaccessible to dredging. Since the 1954, many Italian sport divers became professional scuba coral harvesters working on banks in Southern Italy (Palinuro), Sardinia, Elba and Corsica (Liverino 1983). The 14-mile long Scherchi Channel from Sicily to Tunisia was regarded as a coral 'el Dorado', with 80 divers from Italy, France and Spain harvesting 70–120 t in 1978. In 1979, there were 366 boats at work (283 of them were registered in Italy) and 150 divers (Liverino 1983).

PRESENT DATA: FAO DATABASE

FAO (FAO FIGIS) started compiling continuous yield statistics in the 1970s. Differently from the other catch statistics included in the database, which are usually submitted by national official sources, data on red coral are consistently provided since mid-1980s by a major red coral import-export and production of jewellery wholesaler (Garibaldi in GFCM 2010, 2011). Although the data available in the FAO database present some shortcomings (i.e. possible conflict of interest for an industry data provider, data may refer in some cases to trade information rather than to actual annual harvest), the constant provision by the same source ensure consistent information for trend analysis (Garibaldi in GFCM 2010, 2011).

The FAO data certainly underestimate the overall Mediterranean yield since illegal fishing and black-market trade are said to be common (Santangelo *et al.,* 2009). Poaching has been confirmed at the Costa Brava (Spain), Italy and Greece, and is probably common throughout the Mediterranean. Unofficial estimates by fishermen themselves quote that there are as many or more poachers active in Spain than licensed divers. In some cases it seems that poachers sell their harvest through licensed divers (Tsounis *et al.,* 2009).

Today's main stocks are located at the Costa Brava (Spain), Corsica (France), Sardinia (Italy), Morocco and Algeria, although harvesting occurs as well in Sicily (Italy), Mallorca (Spain) and to a lesser extent in some other locations (Croatia, Albania, Greece) (Tsounis *et al.,* 2009).

FAO data since 1978 (Figure 2) show a sharp decline in landings over 20 years. The last major peak recorded lists 98 t of *C. rubrum* in 1978. Coral landings decreased in the period 1978-2010: from 98 t in 1978 to the minimum of 18.9 (1998). Later, the reported yields slightly increased again but in general remained below 40 t (Figure 2, 3).

The global production reaches nowadays the value of 54.11 t (2010). The countries with the largest catches in 2010 are Italy (10.3 t), Tunisia (10.1 t) and France (9.3 t).

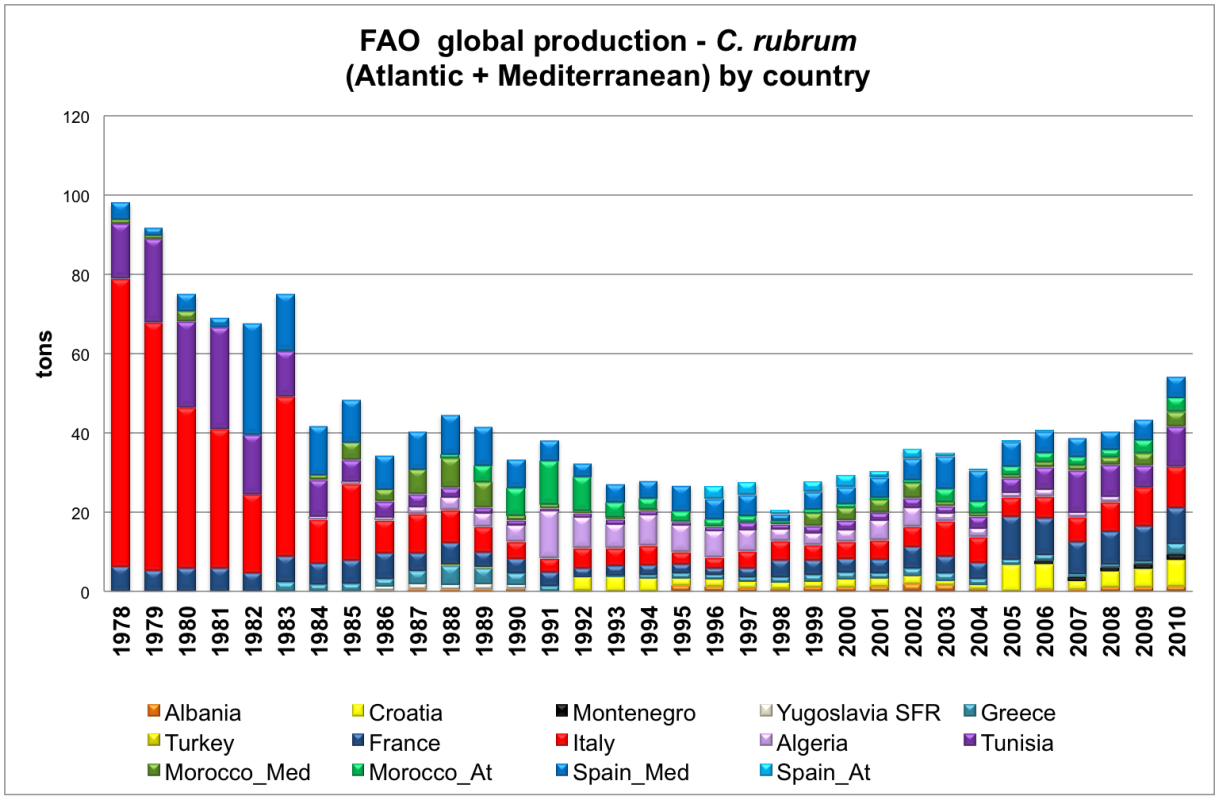

Figure 2. FAO FIGIS data for *Corallium rubrum*.

Apart from minor amounts from the Atlantic coast off Morocco and Spain, all red corals were harvested in the Mediterranean Sea (Figure2).

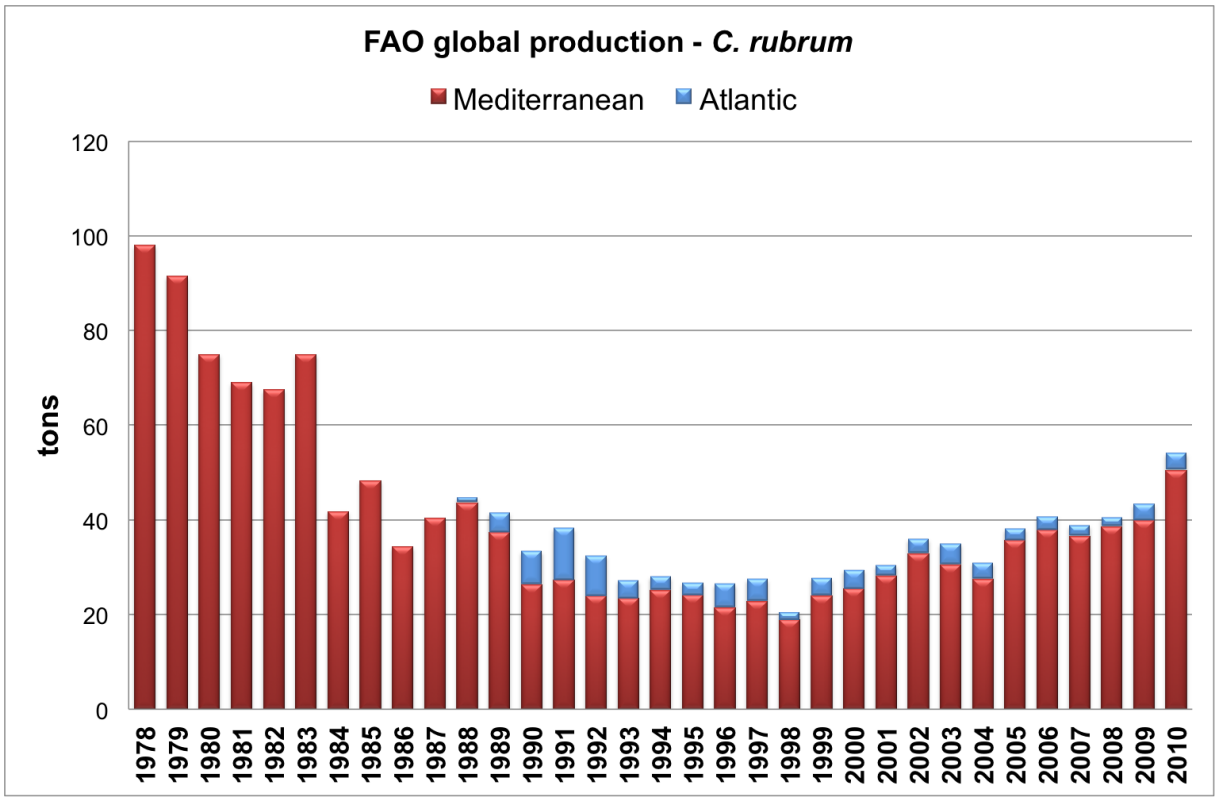

Figure 3. FAO FIGIS data for *Corallium rubrum*.

The decrease in landings is mainly due to the change in harvesting techniques (from the destructive dredging to the selective diving) that has greatly reduced the fishing effort exerted on the species.

In fact, in the light of the immense ecological damage that dredging inflicts on coral habitats (Thrush & Dayton 2002), coral dredging in European Union waters was banned in 1994. Actually, dredging was phased out even earlier in some countries (see section on gears and countries profiles for further details).

Since inception of SCUBA fishing, landings reported by individual countries have continued to show sharp peaks and declines, which are suggestive of the discovery of large aggregations of coral in a particular area, followed by rapid overexploitation of these populations. Individual peaks in landings during a single year reflect the pulse fishing mode associated with SCUBA harvest, where individual beds are selectively cleared of large colonies, then a new area is targeted. SCUBA fishing was originally concentrated in shallow water, extracting corals from areas that were largely inaccessible to dredges. Over the last two decades, SCUBA fishing has been progressively moving into deeper areas, in response to a depletion of corals in shallow water.

According to a recent publication (Tsounis *et al.,* 2013) in the last decade the yield has been able to remain stable or even increase thanks to 1) the harvesting of ever-smaller corals after depleting larger size classes; 2) the harvesting in ever-deeper waters, and 3) the use of ROV technology for scouting (legal) and harvesting (illegal).Furthermore, the fear to the listing in CITES and the incoming GFCM FMP seems to have pushed coral divers to collect as much as possible, before the possible stricter regulations on trade and harvesting become implemented (Tsounis *et al.,* 2013).

COUNTRY PROFILES ON PRODUCTION

Hereinafter, Figure 4-13 report FAO data by countries.

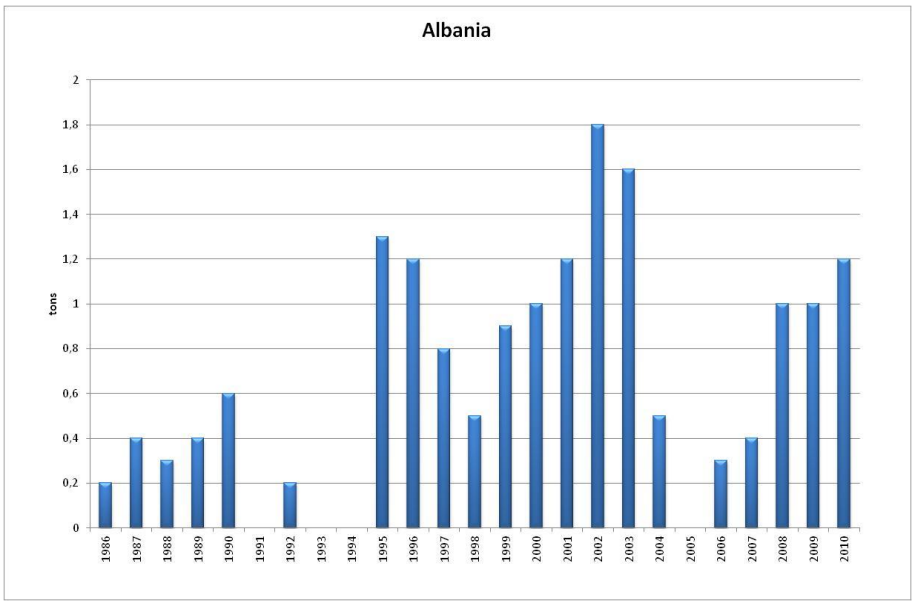

Figure 4. FAO FIGIS data for *Corallium rubrum* in Albania.

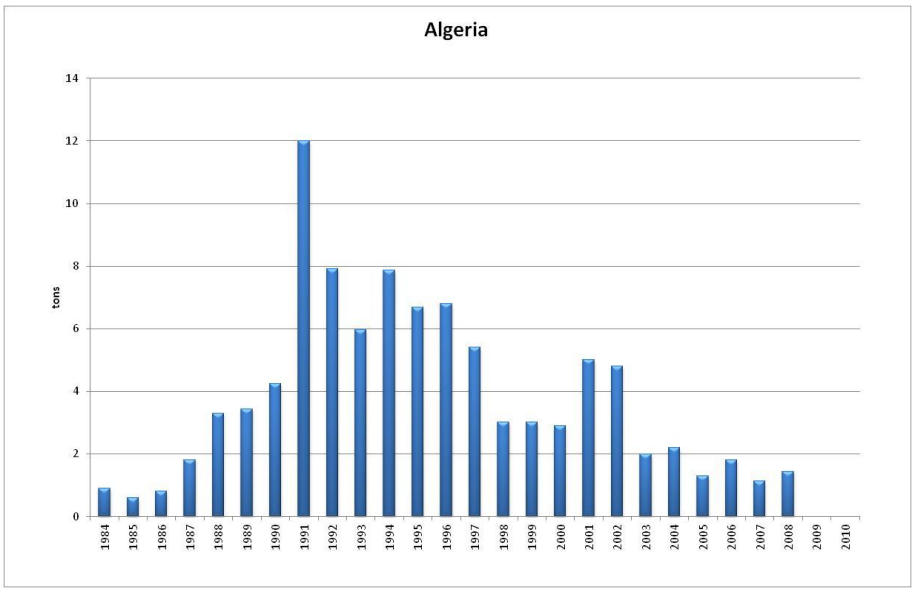

Figure 5 FAO FIGIS data for *Corallium rubrum* in Algeria.

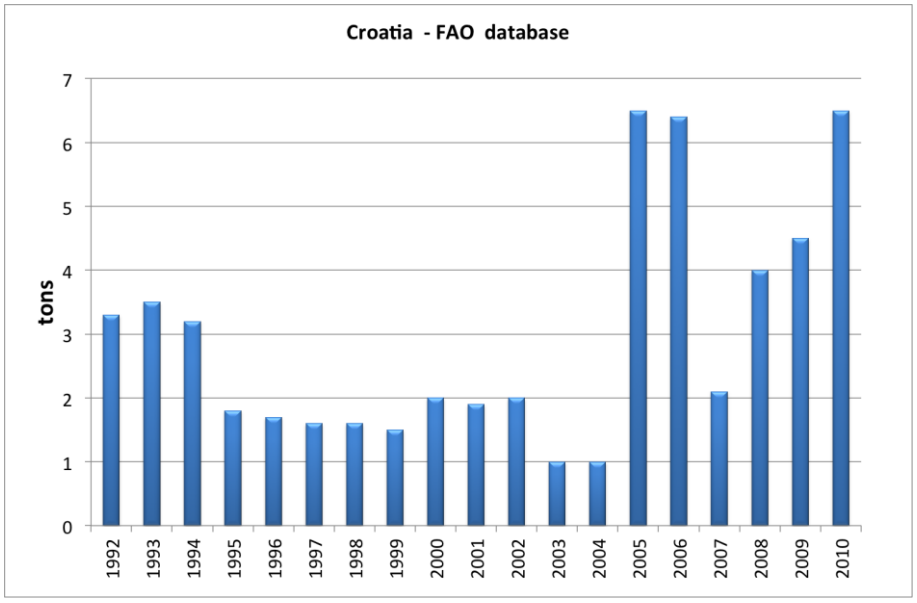

Figure 6 FAO FIGIS data for *Corallium rubrum* in Croatia

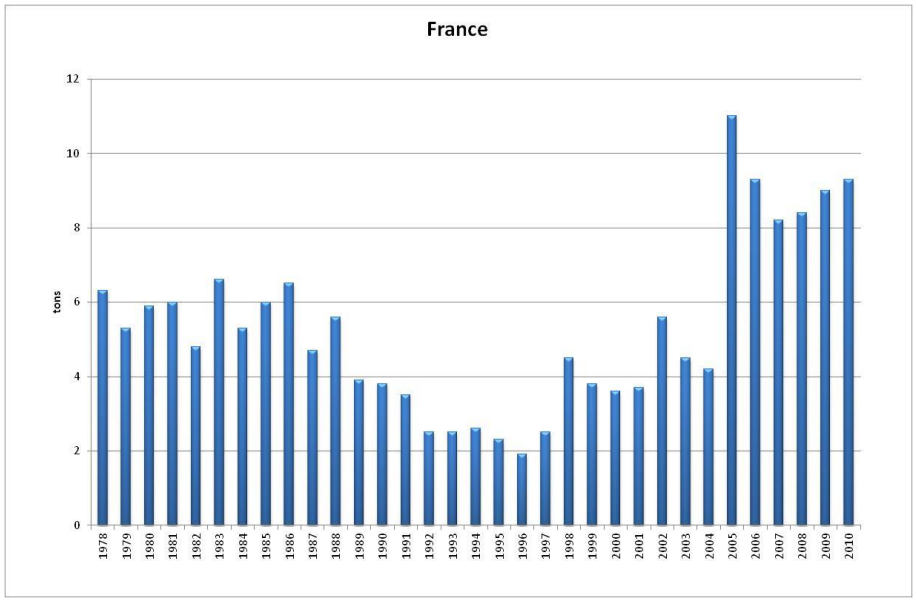

Figure 7 FAO FIGIS data for *Corallium rubrum* in France.

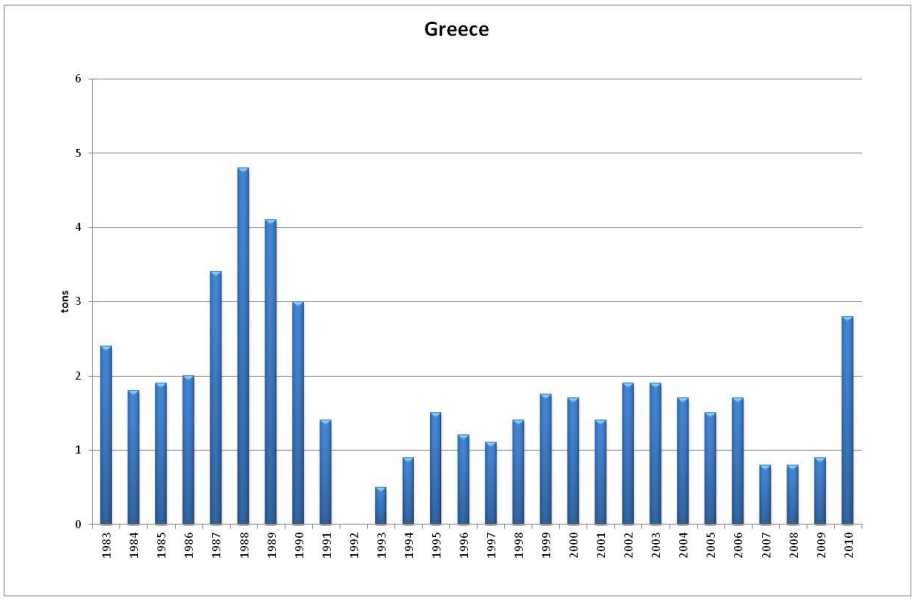

Figure 8 FAO FIGIS data for *Corallium rubrum* in Greece.

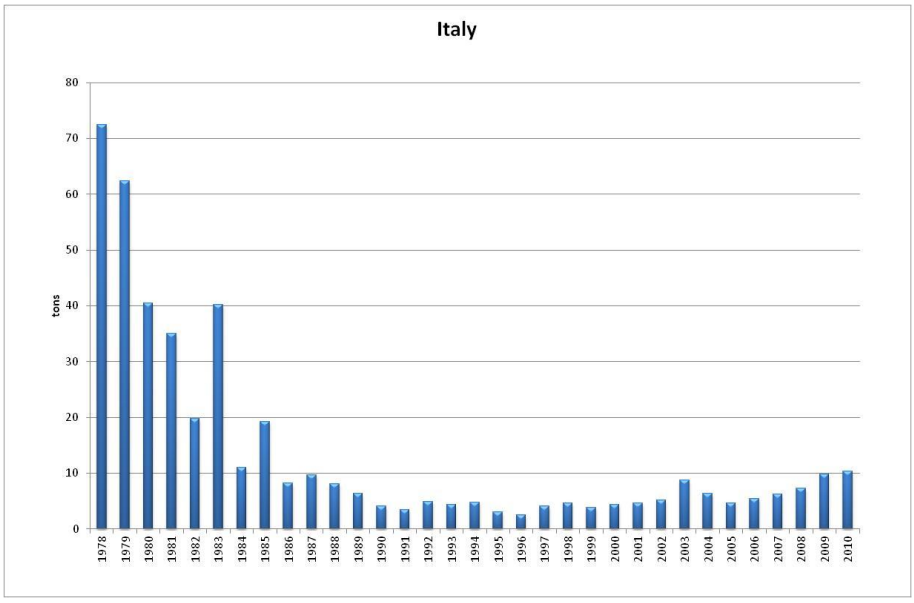

Figure 9 FAO FIGIS data for *Corallium rubrum* in Italy.

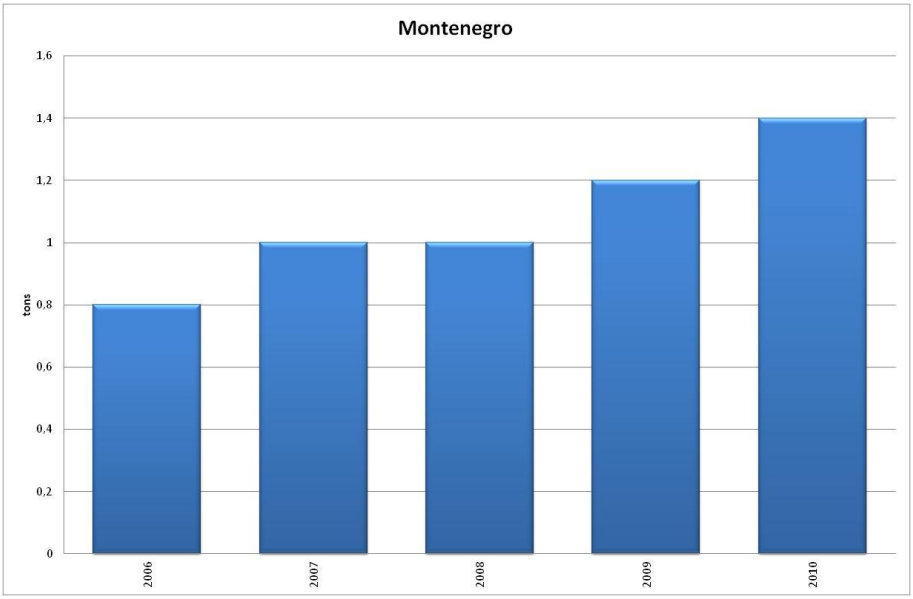

Figure 10 FAO FIGIS data for *Corallium rubrum* in Montenegro.

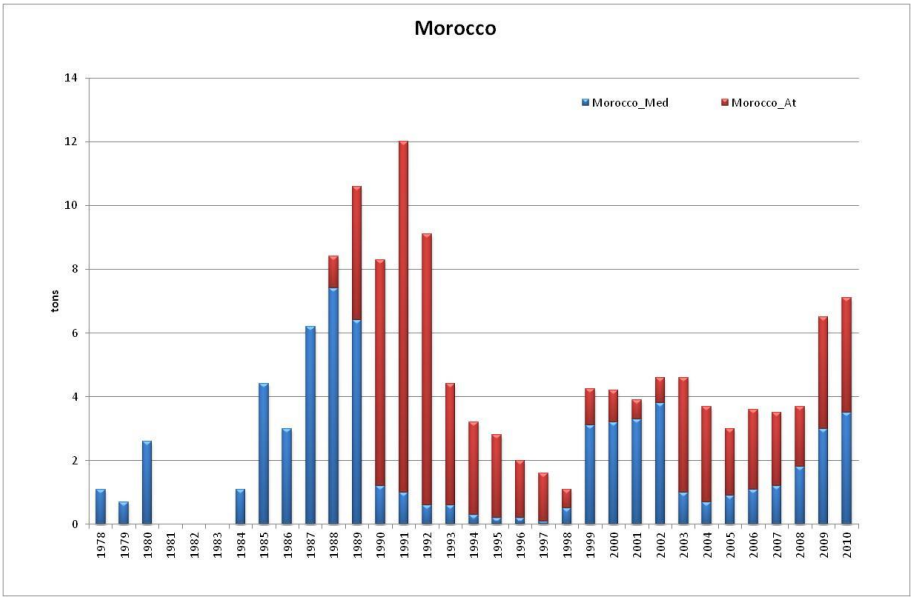

Figure 11 FAO FIGIS data for *Corallium rubrum* in Morocco.

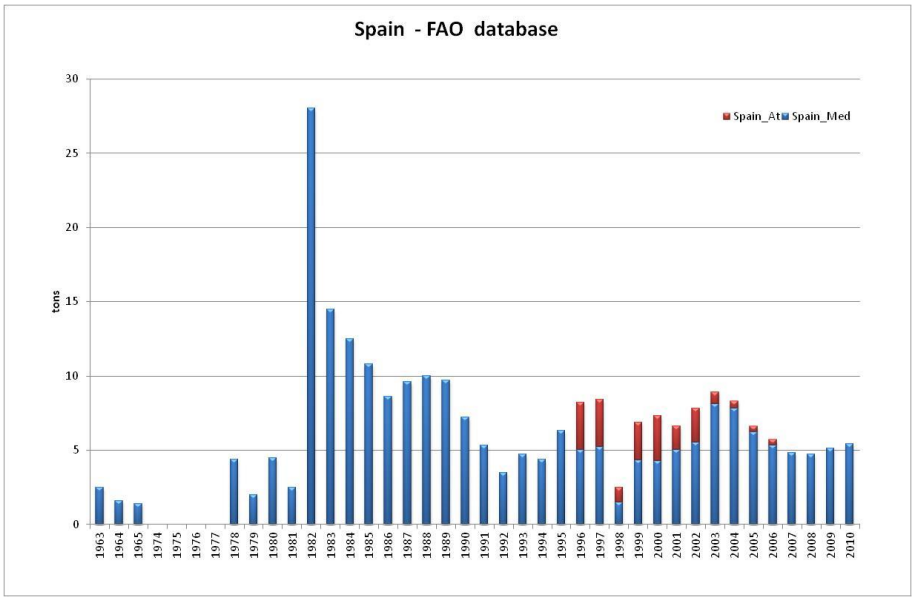

Figure 12 FAO FIGIS data for *Corallium rubrum* in Spain.

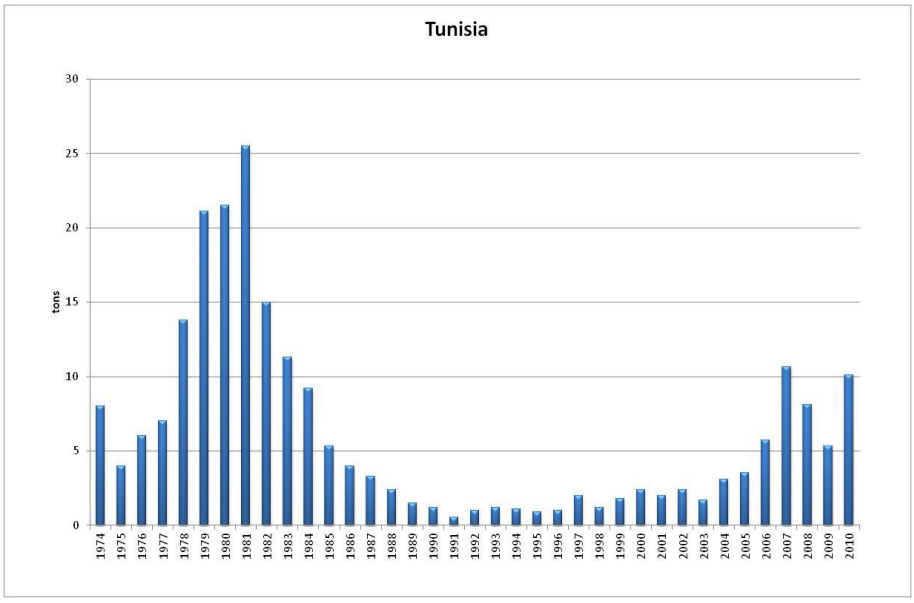

Figure 13 FAO FIGIS data for *Corallium rubrum* in Tunisia

NATIONAL LEGAL INSTRUMENTS FOR RED CORAL

Apart from being part of the international convention (see International legal instruments on this document), several country have enacted specific laws related to *C. rubrum*.

Actually, only the banks of *C. rubrum* within the limit of the 12 nautical miles from the coast (territorial waters) can be regulated by national laws. The following paragraphs are not to be regarded as containing all the existing information on the subject; the exhaustive lists of all laws, decrees or decisions made by the different countries on red coral is out of the scope of this document.

The information was collected by non-experts and it is reported here for documentation purpose only, with the idea of giving a picture of the different approaches adopted by the different countries.

All the 'best possible and updated' legislative instruments, that were accessible through the FAO-lex database and the WebPages of Governments, Ministries and agencies, are summarized. However, the difficulties in retrieving the documents (especially at the local level) and the involvement of so many different countries and so many different languages could have led to incompleteness and errors due to misunderstandings during the translation.

Further information on management of red coral can be retrieved from the answers of the technical questionnaires (Appendix C) and the document by Cannas *et al.,* (Appendix D) included in the Report of the Transversal workshop on red coral held in Alghero (Sardinia, Italy) in 2010 (Document GFCM: SAC13/2011/Inf.12).

COUNTRY PROFILES – NATIONAL LEGAL INSTRUMENTS

ALBANIA

Despite the fact that the taking of corals and sponges is prohibited at any time throughout Albanian waters (except for scientific research purposes (Article 22 of Law No. 7908 of 1995) the FAO global production database record data from 1986 to 2010.

ALGERIA (PAST REGULATIONS)

Starting from 1977 the Saint Andrew cross was prohibited (GFCM 1989b). Coral fishing was banned from 1977 to at least 1982 considering the opportunity of regulating the fishery (Akrour 1989). Then, in 1982 the State Secretariat allowed the exploitation of this resource by the Entreprise Nationale des pêches (ENAPECHES); from 1982 to 1987 only two vessels equipped for scuba-diving were active in this fishery in the El Kala area but

their number seems to have increased later on (Akrour 1989). Since 1995 (Décret exécutif n° 95-323 du 21 Octobre 1995 réglementant l'exploitation des ressources corallifères), red coral harvesting was allowed only if in possession of a personal permit, strictly linked to a specific area. Eight areas are identified for exploitation with an annual maximum quota and number of licenses per area, defined as follows:

area	From to	Maximum quota per area (Kg/year)	N° licenses
A	Ras Roux - Ras Rosa	850	20
B	Ras Rosa - Ras EI-Hadid	850	20
C	Ras EI-Hadid - Ras Bougarouni	1200	10
D	Ras Bougarouni - Ras Corbelin	1200	10
E	Ras Corbelin - Ras Cascine	1200	10
F	Ras Cascine - Ras Ténès	1200	10
G	Ras Ténès à Ras Falcon	1200	10
H	Ras Falcon à la frontière Algéro-Marocaine	1200	10
Total		8900	100

Each area can be harvested for not more than five (5) consecutive years, and then it is closed for a minimum period of fifteen (15) years, to allow for the natural regeneration of beds.

The size limit for the harvesting is fixed at 8 mm of basal diameter. The cut should be realized at a minimum of 3 cm from the base. To allow for the emission of gametes, the colonies should be kept submerged for at least two hours from the time if the cut. At the harbour the colonies are checked and weighted in presence of officers (coast guard, customs etc).

Since 1998 the harvest of red coral was again completely interdict, this ban is formally implemented by a later executive decree (Décret exécutif N° 01-56 15 February 2001) that provides for the suspension of the red coral fishery until studies on the evaluation of resource had been finished.

CROATIA (AND FORMER YUGOSLAVIA)

The **ban of dredges** could date back to 1985 when the former Yugoslavia seems to have limited the harvesting of red coral in the Croatian coasts to scuba divers (article 51 and 53 Regulation of 19 June 1985).

The harvesting is permitted and regulated by the Ministry of Agriculture, Fisheries and Rural Development.

The Ministry of Agriculture, Fisheries and Rural Development **regulates *C. rubrum* fishery** imposing a license (around 15 license have been released for 2010), a seasonal closure (the collection of corals is prohibited from 1 December to 31st March), a quota (maximum of 200 kg per year per license), the collection can be done by hand with or without diving gear and other tools

only powered by human strength and a maximum 2 axes for the detachment of the coral; fishing zones open to license holder have to be indicated in the license. No new licenses will be issued for commercial fishing (including coral extraction) until scientifically based indicators of their status are available. *(Regulation on commercial fishing on the sea (Official Gazette 6/06, 46/06, 66/07, 121/08, 146/08) Regulation on fishing gear* (*Official Gazette 6/06, 46/06, 93/06*) *Regulation on licenses for commercial fishing on the sea and license register (OG 155/05, 135/06, 133/07) Regulation on commercial fishing on the sea (Official Gazette 6/06, 46/06, 66/07, 121/08, 146/08).*

Recently, pursuant the **Nature Protection Act** (NPA) (Official Gazette Official Gazette NN 70/05, 139/08) and **Ordinance on the proclamation of protected and strictly protected wild taxa** (Official Gazette NN 06/07and99/09 Annex III 'protected native species' corresponding to the Annex V of the EU Habitats Directive) *Corallium rubrum* has been declared a protected wild taxa in Croatia. It is listed as a critically endangered species on the Red list of corals of Croatia (Anonymous, 2009, Cites CoP15 Proposal 21).

FRANCE

The practice of fishing for coral requires the immersion of a diver and ranks in the activity "pêche sous-marine". However, fishing using a breathing apparatus without rising to the surface is prohibited in the France. Therefore, permission to coral harvesting requires derogation from the provisions of Ministerial Decree of 01.12.1960. To this is added the Administrative Decree (DAM) No 85 of 11.4.1980 laying down the conditions for granting authorizations to collect coral diving underwater with breathing apparatus. Fishermen should be in possession of medical and professional documented skills (certificat d'aptitude à l'hyperbarie classe II ou III mention B option pêche au corail). Their license is subject to annual renewal. Furthermore, they must fill a harvest logbook and should be assisted on board by a fisherman with the same hyperbaric certification.

The issuance of permits and the conditions governing the exercise in the waters of the French Mediterranean continental (thus excluding Corsica) is regulated each year of a decision of the Prefect of the Provence-Alpes-Côte d'Azur (PACA). By delegation, the Regional Director of Maritime Affairs in PACA can take such a decision (Decree No. 90-95 of 25.01.1990 as amended). The last decision that was possible to find date back to 09.01.2003; it grants permits for one year to 17 fishermen. This decision does not mention any restriction in relation to sampling (colony size, quantity) and do not excludes any area of the coast. However, according to the Arrêté n °2012157-0001 du 05 Juin 2012, as a precaution for a period of one year from the publication of the decree the harvesting of red coral in the waters bordering the 'department des Pyrénée Orientales' is authorized from the 1St of May to the 30th of September each year except in the Reserve of Cerbère-Banyuls where it is

interdicted. The harvesting of red coral is interdicted from 0 to 50 m as well as the use of ROV for prospection. The minimum size for collecting colonies is fixed at 8 mm basal diameter. Each authorized fishermen each season can harvest a maximum of 50 kg of red coral (net weight cleaned) and he is obliged to record all the catches in a logbook (with the coordinate, GPS position, date and hour, weight and basal diameter for each colony).

According to the information provided by CRPMEM PACA in 2011, 21 permits were granted for harvesting red coral. This number has changed little during the last ten years, and the idea is to fix this number to a maximum of fisherman licensed to practice this activity of between 22 and 25.However, only 14 of these divers are allowed in the Mediterranean continental French to work beyond 60 meters depth (possessing the Certificat d'Aptitude à l'Hyperbarie (C.A.H.) Class III).It should be noted these figures refers to the fishermen that have a "right" to access to the resource coral not necessarily to those actively harvesting the species. Some of them could exercise another activity (fisherman / sea urchin divers in particular) but renewed still their debit authorization.

Today, red coral fishery in **Corsica** is regulated according to several laws (JORF n°162 du 14 juillet 2006 Texte n°61 and the administrative decrees Decree No. 67-2002, Arrêté N° 06-0358 and 06-0359 du 13 July 2006). The regional administration of Corsica is responsible for determining the number of permits that could be issued, taking particular account of biological capabilities of the areas, market trends and socio-economic issues. Since 2006, in Corsica the number of licenses has been fixed to 10 (art 2 Arrêté N° 06-0358). In case of infraction the license can be retreated and the renewal refused. This decision does not mention any restriction in relation to sampling (colony size, quantity) and excludes no area of the coast. Recently, the Corsican fishermen have agreed to work below 50 m to allow the stocks in shallower waters to recuperate (Arrêté No. 67 / 2002/DRAM; Harmelin, 2007).

GREECE

The Ministry of Agriculture established the first time relevant legislation in 1987 (Greek Law 1740/1987). According to this legislation, harvesting, processing, and trade of the red coral were to be allowed only after the purchase of a special license. Five years later, after scientific data confirmed its presence in large populations in certain areas of the Greek Seas and at depths ranging from 50 to 110 m (Chintiroglou *et al.,* 1989) , two additional laws were enacted in order to further manage the exploitation of *C. rubrum* (Presidential Decree 174/1994; Ministry Decision 240102/1995). A national rotating harvesting system covering five large fishing geographical zones was set up in Greek waters once the legislative framework was in place in 1994. According to this scheme, each area may be harvested on a maximum 5-year rotational basis, which is then followed by a 20-year closure period. The

harvesting period in each zone can vary depending on the density of coral populations. Overall, a maximum of 10 licenses are given each year, each costing 3000 Euros. The harvesting period in each year lasts from April 1 to December 31. Harvesting is allowed only manually by scuba diving using a pick. Whenever professional coral harvesters find coralligenous formations, they must immediately inform the local port authorities before any harvesting can be undertaken. Collection, transportation, processing, selling of red coral (*Corallium rubrum*) is forbidden, without special permission. Permissions are valid for one year but their validity duration cannot be more than 9 months (Dounas *et al.,* 2010).

Until now, only three out of the five geographical zones of the Greek Seas have been harvested (N. Aegean, S. Aegean-Island of Crete, and Ionian Seas) (Dounas *et al.,* 2010).

Figure 13 Greek fishing zones (from Dounas *et al.,* 2010)

According to Sixth session of the Compliance Committee (CoC) held in Marrakesh, Morocco in 2012 the document COC:VI/2012/2 related to the Status of implementation of GFCM decisions by the members states that in Greece in 2011 no special licence for exploitation of red coral has been issued.

ITALY

Since 1965, National Law 14th July 1965, n. 963 "Maritime Fishing Regulation," implemented by President of the Republic's Decree (DPR) 2nd October 1968, n. 1639, established specific regulations for the exploitation of discovered coral banks in Italy. In particular the above mentioned Law established that fisherman who finds a new coral bank has to declare the discovery to marine authority in order to be allowed to its exploitation for the next two years (Art. 16). Furthermore, President of the Republic's Decree (DPR) 2nd October 1968, n. 1639, issued for implementation of this Law, specified that discovery declaration of a new bank has to include personal data

of the fisherman, day of discovery, position and extension of the bank (Art. 123) and that fishing season lasts all the year (Art. 124).

In Sardinia red coral fishery is regulated by 2 Regional Laws: n. 59/1979 afterward integrated and modified by the Regional Law 23/1989, that introduce several restrictions in order to improve sustainable exploitation, conservation of coral resources, and protection of marine ecosystems. Since 1989 there is the prohibition (ban) for the *Ingegno* and St. Andrew's Cross towed gears while only manual harvesting with hatchet is permitted, by professional fishermen equipped with scuba-diving devices. All the other fishing methods are banned. Financial aids were provided to sustain transition from destructive dragging methods (Saint Andrew's cross and Ingegno) to allowed gears (hatchet). In 1988 and 1989 contributions (up to 70% of total costs) were given to fishermen to purchase new fishing equipment (non-selective gears).

The regional permit must be renewed annually and is issued or suspended by means of regional councillor's decree. The fishermen can apply for the permit only if they can prove to have effectively collected coral in two distinct harvest seasons in the previous 5 years. Furthermore, annually, within January, in compliance with the Regional Council decision and once the opinion of the Regional Technical Advisory Committee is acquired, the councillor's decree establishes the harvesting effort (harvesting time, maximum daily amounts of coral, allowed areas, the fee amount for license, minimum harvesting size).

Additional harvesting permits can be issued in order to allow scientific research. For ecological and biological protection, requirements the councillor's decree can forbid coral harvesting in specific areas for a minimum period of 3 years.

If a fisherman collects red corals without the due permit, along with the confiscation of the vessel, of the scuba equipment and of the corals, he shall pay a fine (from 2500 to 25000 Euros) and cannot obtain a permit for at least 3 years. If an authorized diver collects coral in a prohibited area, along with the confiscation of the vessel, of the scuba equipment and of the corals, he shall pay a fine and cannot re-obtain the permit for at least 3 years. The permit will be suspended for at least one year if the fisherman, fishes by diving other species.

The 2012 Decrees (N 761GAB/DecA/42; 1374/DecA/94; 1203/DecA/82 and 83) establishes that: the harvesting season lasts from 15th May to 15th November (exceptional prorogation), the minimum harvesting size is 10 mm basal diameter with a tolerance of 20% (the measurement should be done with a caliper at midpoint from the base and the first ramification); a maximum of 25 permits fixed (license fee is fixed at 1000 euro); a maximum of 2.5 kg of harvested red coral per day per fisherman; in each vessel there can be a maximum of two fishermen (both with the regional permit); new-

harvested red coral has to be maintained in sea water for a minimum of 30 minutes in the net (size ≥ 5 mm) in order to allow the dispersion of gametic products; the apices, accidentally broken, should be left in the harvest site immediately after the collection. Every year coral fishermen have to provide daily harvesting data (coral amounts, position, and depths of fishing areas) within 30 days from the end of harvesting season. Since 2008, harvesting is allowed only under 80m depth. The coordinates of the areas closed to fishing are also provided in the decree; they are seven protected areas (5 MPAs and 2 National Parks), an area especially designed for the recovery of the resource in the North-Western coast near Capo Caccia – Alghero, 2 areas in the North-East and East Sardinian coast closed due to the strong impact of towed gears used in the past. The landing of catches is authorized only in 8 designated ports; a special procedure for the traceability of red coral is implemented with the obligation of sealing all the colonies caught during each dive in separate plastic bags, with a unique univocal labelled code. The prohibition to use the ROV for prospection and harvesting, and a special derogation of its use for prospection to divers that are involved in a scientific programme funded by the RAS where the use of ROV is allowed only and monitored by the presence onboard of scientific observers.

In Tuscany the harvesting is regulated by a Regional law n. 66/2005. A recent decree of the 23rd July 2012, n. 42/R, has closed red coral fishing until the 31st December 2013. From 1st January 2014 fishing will be allowed under strict regulations described in the Art.2: harvesting allowed only under 60m depth, minimum basal diameter of 8mm with a tolerance of 5% of overall weight of harvested coral undersized, fishing allowed only by hand with the use of a peak, no ROV allowed onboard.

MALTA

At present, *Corallium rubrum* is strictly protected in Malta, where no exploitation is contemplated. Such a situation has arisen from the verbatim transposition of Habitats Directive species lists into local environmental legislation (Deidun 2010).

MONACO

Since at least 1989 two marine reserves (protected zones) were created, one for fishing and the other for coral protection, off the coastline of Monaco (GFCM 1989).Nowadays, *Corallium rubrum* habitat is protected and no exploitation is allowed (Anonymous, 2009, Cites CoP15 Proposal 21).

MONTENEGRO

Corallium rubrum is protected under the Decree on putting the protection on certain plant and animal species (Official Gazette RM no. 76/06) issued by the Institute for Nature Protection 12.12 2006. No data on specific regulation of the red coral fishery.

MOROCCO

In 2005, the Department of Fisheries promulgated a decree 2-04-26 (January 17, 2005) setting conditions and procedures for harvesting coral. This text fixed the general terms of coral fishing, taking into account the need for rational exploitation of this resource by fixing fishing effort through limitation of the number of ships, harvested quotas by ship, and periods of fishing per zone. Moreover, it stipulates that access to fishing is limited only to ship-owners able to justify the possibility of total treatment in Morocco of the harvested coral, either directly, in a transformation unit, or by a contract of delivery to a third owner or owner of such a unit.

The first gear used in the exploitation of red coral was the cross of Saint Andrew, however during the 1980s this technique was prohibited and replaced by scuba diving; the divers must use a net basket and a sharp marteline which makes it possible to cut the base of the coral colony (Dridi *et al.,* 2010).

In Morocco red coral banks occur mainly in two areas, both along the Mediterranean coasts (Topo and Tofino) and the Atlantic coasts, in particular in the oceanic area ranging from Tangier to Larache but also in other southern areas.

As concerns the Mediterranean banks:

- with the aim of protecting the coral at the level of Topo into the National park of Al Hoceima (Marine Protected Area) the department of marine fisheries closed fishing for 10 years (order n° 1954-05 October 10th, 2005).
- a fishery decree 2.655-06 (November 13, 2006) regulates red coral by quota, but has not set up any size limit, in the marine area named "Tofino", in front of Al Hoceima: fishing boats are limited to a number of 10; every boat has a total annual quota of 500 kg and can have a maximum of 3 divers onboard. The boat has to be smaller than 50 tons gross and fishing is permitted only during daytime (Dridi 2009). The fleet operating in the coral fields is specialized, and consists of small units provided with a decompression box and equipped with a capacity of 50 TJB (Dridi 2009). Later on, according to the decree n° 2409-10 (18 August 2010) the harvesting of red coral is temporary closed in the Tofino area for 10 years.

As concerns the Atlantic banks:

In 2010, a new order is promulgated to regulate the fishing of coral between Larache and Cap Spartel along the Atlantic coasts (order of Minister for Agriculture and Marine Fisheries n° 1566-10 May 14th, 2010 regulating the fishing of red coral in between the Cap Spartel and Larache). In 2011 in the same zone a decree of Minister for Agriculture and Marine Fisheries (n° 1980-11 May 6th, 2011 regulating the fishing of red coral in between the Cap Spartel and Larache) defines the depth limit for harvesting in the depth range between 40 and 80 m.

SLOVENIA

Corallium rubrum probably does not exist in Slovenian waters, and therefore it is not protected under Slovenian laws.

SPAIN

Nowadays the harvesting in external waters is regulated by the Real Decreto 1415/2005 (regulating fisheries and commercialization of the species) and by the Orden APA/1592/2006 (regulating the proceedings for authorizations of this activity).

Coral can be collected in only five areas by a total of a maximum number of 47 authorized divers (Catalonya 12 permits, Illes Balears/Mallorca 10 permits, Illes Balears/Menorca 10 permits, Almería 5 permits, South Atlantic Region ranging from the border with Portugal to Punta Tarifa 10 permits). In 2010, according to the Ministerio de Medio Ambiente y Medio Rural y Marino, only 44 permits were granted (the maximum number was reached in all the over mentioned areas except for Menorca where only 7 permits were granted).

A maximum of 400 kg of coral per fishermen per fishing year is still fixed, allowing a variance of 10%, including the computation of the harvesting quota approved by the autonomous communities in interior waters.

It is forbidden to remove any red coral branch of diameter < 7 mm at the point of fracture. The cutting should be done through the base of central axis. Measurements shall be taken in each and every one of the branches collected and the diameter of the base of each colony collected always above the basal plate fixing the coral to the substrate.

Only manual harvesting by scuba divers using a pick is permitted and only one dive / a day from sunrise to sunset.

The permit to fishermen is issued for one year and for each of the zones and a person may only hold one permit per zone. Authorizations are granted on the basis of seniority at the sole discretion demonstrated in the exercise of authorized activity. If the number of applications exceeds the number of fixed

permits for that year, the permit will be drawn among the candidates who have received the same score.

No permits will be granted to applicants who have been sanctioned in the exercise of that activity by a final decision of any civil service in the 24 months preceding the date of the application.

The authorization is personal and not transferable. Each diver must fill the logbook of red coral harvesting issued by the Ministry of Agriculture, Fisheries and Food, to be submitted to the Fishermen's Association of the harbour of landing with the coral removed to certify the weight of coral collected and the size of the branches in the relevant pages of the book. Data should be referred to the Functional Areas of the Ministry of Agriculture, Fisheries and Food.

At the time of each sale, the seller and the buyer must complete the relevant data sheet of the logbook of red coral harvesting. The seller must send a copy of that, within 48 hours of sale, to the General Secretariat for Maritime Fisheries and the competent organ of the Autonomous Region in the territory of which the sale occurred. The Ministry of Agriculture, Fisheries and Food may request to the divers the transfer of red coral samples harvested with the aim of analyzing their biology or resource status.

As concerns the harvesting of red coral in the interior waters, local communities are allowed to enact their own regulations.

Accordingly, since the mid of 1980s the Baleares (Orden del Consejero de Agricultura y Pesca, de día 10 de mayo de 1985) and Catalona (Decreto 291/1983, de 30 de junio) prohibited dragging gears. Furthermore, other specific regulations are in place in the Balears Islands (Decreto 40/2003, de 25 de abril, por el que se regula la extracción de Coral Rojo en las aguas interiores de las Illes Balears). The harvesting of red coral is permitted in only two interior water areas (North of Mallorca- between cap de Formentor and cap des Freu- maximum number of 4 permits; North of Menorca – between punta Nati and punta de S'Esperó, except for the marine reserve between la punta des Morter, la isla des Porros y el cap Gros- maximum 2 authorizations). Since 2008, the harvesting is forbidden from the 1st of November to the 30th of April of each year, and the number of permits for North Mallorca is increased to 6. According to the Resolución del Consejero de Agricultura, Medio Ambiente y Territorio de 22 de noviembre de 2011 Num. 24241, imposing supplementary means for regulating the harvesting of red coral in the aguas interiores de las Illes Balears no harvesting is allowed in the area called 'Norte de Menorca' while in the area Norte de Mallorca the harvesting is always allowed from the 1st of November 2011 to the 30th of April 2012 to 6 authorized divers.

Similarly, in the Comunidad autonoma de Cataloña the harvesting in the interior waters is regulated by law (Decreto 389/2004, por el que se regula la

pesca de coral rojo (*Corallium rubrum*) en las aguas interiores del litoral catalán).

Two interior water areas were originally opened to fishing (from the French border to the municipality of Roses-10 permits; from the municipality of L'Escala to Cabo de Begur – two permits 2) but the following year the second area was closed and the 2 licensed transferred to the first area. In 2010 (Orden AAR/167/2010) only the first area is declared open to harvesting with a maximum of 10 licenses, the second is still closed.

It could happen that a single fishermen is granted for both a permit for harvesting in exterior waters and another for interior waters, usually in the same zone of Spain (e.g., Costa Brava in Cataloña) (Tsounis *et al.,* 2010).

According to the 'AAM/49/2012, de 27 de febrero, por la que se establece la campaña de pesca de coral rojo (*Corallium rubrum*) para el año 2012 en las aguas interiores del litoral de Cataluña' the harvesting season is fixed from 1st May to 31st October 2012. The minimum size of harvesting red coral colonies is fixed at 7 mm of basal diameter with a maximum of tolerance of 5% in weight for undersized colonies.

The local government has established reserves for the protection of *C. rubrum* disposing that the removal of red coral at any depth and time of year is forbidden in the three partial nature reserves located in the marine natural park of Cap de Creus (Orden MAH/293/2005; Law 4 / 1998 12 March; DOGC. 2611, of 1.4.1998) and in the natural parks of El Montgrí, las Illes Medes and El Baix Ter (Law 15/2010).

In Cataloña the Spanish Divers that discover a new bank are obliged to inform the Directorate General for Fisheries and Maritime Affairs as much detail as possible (location, abundance, quality). Furthermore, they must inform the Directorate General for Fisheries and Maritime Affairs if they observe any irregularities related to extractive industries, conservation status of the resource and the quality decreases (article 11). Where the number of applications exceeds the authorization must be granted in accordance with the following priority criteria (no penalty for final administrative decision during the two years preceding the application date; the senior year of activity and continuous practice, according to data in files or administrative records). The dives must be performed at least in pairs, and each of the fishermen must hold its own authorization.

TUNISIA

In 1982, with the decree of the 26 February 1982, Tunisia decided to not release new permits for the use St. Andrew's cross that can be used only by those who already have the license. Red coral fishery using the cross is allowed in the maritime zone of Tabarka, la Galite and Cap Negro only below

100 m of depth. The cross cannot be used from the 1st of Aprit to the 15th of September of each year. Starting from the 1st of April 1985 this type fishing will be forbidden. Harvesting is prohibited in the areas of Bizerte, from Cap Blanc to Cap Zebit. Moreover, fishing off "Cani" islands has been banned above 50 m of depth.

Tunisian fisheries law requires to professional divers be licensed to exploit coral and sponges; they are not allowed to unroot (eradicate) the colonies. Furthermore, fishermen have to disembark harvested coral in the port indicated by the administration and total amount has to be weighted under the supervision of an agent.

TURKEY

Harvest of corals is prohibited since 1990 according to the Turkish legislation/regulation governing fisheries (Anonymous, 2009, Cites CoP15 Proposal 21). It is prohibited to catch aquatic products by diving, except for sponges (Fisheries Regulation n 22223 10/03/1995, Article 17). According to Sixth session of the Compliance Committee (CoC) held in Marrakesh, Morocco in 2012 the document COC:VI/2012/2 related to the Status of implementation of GFCM decisions by the members states that in Turkey it is prohibited to harvest red coral in accordance with Article 16 of the Notification 2/1 regulation commercial fishing.

OTHER COUNTRIES OUTSIDE GFCM

GERMANY

Corallium rubrum was strictly protected in that country for a decade (from January 1987 to June 1997) through the listing of the species in Annex I of the Germany Federal Ordinance on Species Conservation and resulted in a total prohibition of any commercial trade into Germany both from EU and non-EU Member States. The listing revealed significant (irresolvable) identification problems on the species level for enforcement officials in particular for pre-manufactured products, jewellery or products made of coral dust. Wrong identification lead to wrong declarations of seizures of red coral shipments from countries where the species doesn't occur in the wild (Dietrich 2010).

GIBRALTAR (UK)

Red coral is protected in Gibraltar under the Nature Protection Act 1991 Annex V (Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures). All trade of the species is restricted under the Endangered Species Act 1991 (amendment 113/2003, Schedule 1). The species is now considered very rare in Gibraltar

waters, having disappeared from the shallower waters near the territory. Trade is likewise rare (Anonymous, 2009, Cites CoP15 Proposal 21).

INTERNATIONAL LEGAL INSTRUMENTS FOR RED CORAL

BARCELONA CONVENTION (SAP BIO AND SAP BIO CORALLIGENOUS AP)

CONVENTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT AND THE COASTAL REGION OF THE MEDITERRANEAN known as the **Barcelona Convention** (revised on 10 June 1995, modifying the Convention for the Protection Of The Mediterranean Sea Against Pollution signed 16 February 1976). The Barcelona Convention has given rise to **10 Protocols** addressing specific aspects of Mediterranean environmental conservation, among them the **SPA Protocol #6 SPA and BD Protocol#7(S**pecially **P**rotected **A**reas and **B**iological **D**iversity in the Mediterranean) that includes **3 Annexes**. *Corallium rubrum* is listed in **Annex III** of the SPA/BD protocol (List of 'Species whose exploitation is regulated', last amended in February 2012).

With a view to furthering the implementation of the SPA Protocol the Contracting Parties of the Barcelona Convention established **the RAC SPA** (Regional Activity Centre for Specially Protected Areas) in Tunis in **1985.** RAC/SPA developed a **Strategic Action Programme for the Conservation of Biological Biodiversity in the Mediterranean Region** (**SAP BIO**) which was adopted by the Contracting Parties in 2003. The basic objective of this Strategic Action Plan is to foster the improving of knowledge of marine and coastal biodiversity, improve the management of existing, and favour the creation of new Marine and Coastal Protected Areas, enhance the protection of endangered species and habitats, contribute to the reinforcement of relevant national legislation and national and international capacity building. Regarding marine ecosystems, the SAP BIO, in particular, recognizes special attention to the coralligenous community and emphasizes the negative indirect effects of the use of active gear, particularly trawls, often used illegally at shallow depths, causing the destruction of vast stretches of coralligenous bottoms. Furthermore, it stresses how the uncontrolled recreational activities, such as over-frequentation by divers, could cause erosion of this sensitive ecosystem. More specifically, among the proposed priority actions in **Category III** (ASSESSING AND MITIGATING THE IMPACT OF THREATS ON BIODIVERSITY) the **Priority Action N° 21** (Assessment, control and elaboration of strategies to prevent impact of fisheries on biodiversity) **Objective f** (Mediterranean strategy to eliminate particularly harmful fishing practices) call for the **Geographical identification of priority areas with a significant occurrence of coral fishing using the Saint Andrew Cross**.

Later on, in 2008, a specific **SAP BIO Coralligenous AP (Action Plan)** was adopted by the Contracting Parties in order to propose a work programme aiming to conserve the Coralligenous ecosystem. Although it does not have a binding legal character, this Action plan was adopted as a regional strategy setting priorities and activities to be undertaken. Among the major threats

affecting the Coralligenous community special care is given to the commercial exploitation of red coral (*Corallium rubrum*), whose stocks have strongly declined in most areas, for which an adequate management of this extremely valuable and long-lived species is considered necessary.

BERN CONVENTION

CONVENTION ON THE CONSERVATION OF EUROPEAN WILDLIFE AND NATURAL HABITATS (19.IX.1979) known as the **Bern Convention,** which has the aim to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the co-operation of several States. Particular emphasis is given to endangered and vulnerable species, including endangered and vulnerable migratory species. In particular, *C. rubrum* is listed in Annex III of the Bern Convention (list of the 'PROTECTED FAUNA SPECIES', in force since 1 March 2002 and regularly revised by the Standing Committee). According to Articles **7** and **8,** appropriate and necessary legislative and administrative measures should be taken by the Contracting Party in order to ensure **the protection** and the **regulated exploitation** of the wild fauna species specified in Appendix III. Measures to be taken shall include: closed seasons and/or other procedures regulating the exploitation; the temporary or local prohibition of exploitation, as appropriate, in order to restore satisfactory population levels; the regulation as appropriate of sale, keeping for sale, transport for sale or offering for sale of live and dead wild animals. In respect of the capture or killing of wild fauna species specified in Appendix III Contracting Parties shall prohibit the use of all indiscriminate means of capture and killing and the use of all means capable of causing local disappearance of, or serious disturbance to populations of a species. Among the Contracting Parties, those where red coral is probably present are: Albania, Croatia, Cyprus, France, Greece, Italy, Malta, Monaco, Montenegro, Portugal, Spain, The former Yugoslav Republic of Macedonia, Turkey, Morocco, Tunisia, the European Union.

EU LEGISLATION

The European Union: several laws explicitly call on the conservation of red coral and the protection of the Coralligenous community

HABITATS DIRECTIVE

The COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 (and following amendments Directive 97/62/EC, Regulation (EC) No 1882/2003, Directive 2006/105/EC), known as the **Habitats Directive**, which is intended to help maintain biodiversity in the Member States by defining a common framework for the conservation of wild plants and animals and habitats of Community interest. *Corallium rubrum* is listed in **Annex V** of the European Union Habitats Directive (List of the "Animal and plant species of Community interest whose

taking in the wild and exploitation may be subject to management measures"). On the contrary, despite their recognized importance, the Coralligenous assemblages are not explicitly listed in the Habitats Directive (in a broader sense they can fall under the "Reefs Biogenic concretions" habitat type habitat 1170 and "Caves" habitat 8330, already listed in **Annex I**) but their specific inclusion as a priority natural habitat type is highly encouraged by the RAC/SPA, because this would enable at least EU countries to set up an ecological network of conservation areas in the framework of Natura 2000.

COUNCIL REGULATION (EC) NO 1967/2006

The over-mentioned EU regulation deals with management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94 in **Article 2.12** gives a definition of "coralligenous habitat", **in Article 4.2** states that "Fishing trawl nets, dredges, shore seines or similar nets above coralligenous habitats and maërl beds shall be prohibited" and **Article 4.4** that this prohibition "shall apply to all Natura 2000 sites, all special protected areas and all specially protected areas of Mediterranean interest (SPAMI) which have been designated for the purpose of the conservation of these habitats under either Directive 92/43/EEC or Decision 1999/800/EEC". **Article 8.1e,g** states that 'towed devices for harvesting red coral or other type of corals or coral-like organisms' as well as 'St Andrew's cross and similar grabs for harvesting, in particular, red coral or other type of corals or coral-like organisms' shall not be used for fishing or kept on board. Actually, the ban to use the St. Andrew's cross was already include in the 1994 EC Council Regulation No 1626/94.

Apart from being part of the international convention, several countries have enacted specific laws related to *C. rubrum*. Actually, only the banks of *C. rubrum* within the limit of the 12 nautical miles from the coast (territorial waters) can be regulated by national laws. A summary of the principal laws and regulations has been presented in the country profiles section.

INTERNATIONAL LEGAL FRAMEWORK FOR MANAGEMENT OF RED CORAL

With the growing scarcity of fish resources, ensuring sustainable and equitable management of biodiversity from local to global levels is the objective of many Conventions and Laws.

In fact, the availability of 'good' legal instruments for fisheries management is crucial.

The following paragraphs recall the main international legal instruments dealing with sustainability, precautionary approach, and responsible fishery practices.

For a more exhaustive information and discussion the reading of the IUNC report (2009) titled 'Towards Sustainable Fisheries Law A Comparative Analysis' is highly recommended.

SUSTAINABLE (RESPONSIBLE) FISHERY

United Nations Convention on the Law of the Sea (UNCLOS) (adopted in 1982)

Article 56(1)(a) UNCLOS, coastal states have 'sovereign rights for the purpose of exploring and exploiting, conserving and managing' the living resources

Article 61(1) UNCLOS, the coastal state 'shall determine the total allowable catch of the living resources in its exclusive economic zone'.

Article 61(2) UNCLOS, '[t]he coastal state… shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation'.

Article 61(2) UNCLOS paragraph 3: Proper conservation and management measures shall be 'designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield'.

Article 61(2) UNCLOS coastal state should to take 'into account the best scientific evidence available to it' in determining conservation and management measures, albeit not to base its action solely on such evidence.

Article 62(4) UNCLOS contains a non-exhaustive catalogue of conservation measures and 'other terms and conditions' that the coastal state may establish. It includes the licensing of fishermen and vessels; fees; catch quotas; area, time and gear restrictions; minimum fish sizes; monitoring requirements; and enforcement procedures.

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks ('UN Fish Stocks Agreement') (adopted in 1995).

Its objective is 'to ensure the long-term conservation and sustainable use of straddling fish stocks and highly migratory fish stocks through effective implementation of the relevant provisions of UNCLOS'.

Article 5 provides that, in order to conserve and manage straddling and highly migratory fish stocks, coastal states and states fishing on the high seas shall 'adopt measures to ensure [their] long-term sustainability… and promote the objective of their optimum utilization'.

Annex II on Guidelines for the Application of Precautionary Reference Points in Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks elucidates the role of MSY under the Agreement. The Annex distinguishes (i) conservation, or limit, reference points, which identify safe biological limits for harvesting, and (ii) management, or target, reference points, which define management objectives within safe biological limits. MSY is to be regarded as a 'minimum standard for limit reference points', rather than a management objective. Under the Agreement, management objectives will have to be set below MSY and thus at a lower level than was previously required under UNCLOS.

Article 5 further include the development and use of selective and environmentally safe fishing gear and the limitation of fishing effort to levels commensurate with the sustainable use of fishery resources, as well as monitoring, control and surveillance measures.

Article 5(b) requires that conservation and management measures are based on the best scientific evidence available to the coastal state. Under the Agreement, coastal states must further assess the impacts of fishing, other human activities and environmental factors on target stocks, dependent and associated species, and other species belonging to the same ecosystem, promote and conduct scientific research, and collect and share data and information.

FAO Code of Conduct for Responsible Fisheries ('FAO Code of Conduct' or 'the Code') (adopted by consensus at the Twenty-eighth Session of the FAO Conference on 31 October 1995).

It sets out 19 'general principles' from which the remaining provisions of the Code are derived.

Article 6.1 asserts that '[t]he right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources', and calls upon states and individual users to conserve aquatic ecosystems.

According to Article 6.2, '[f]isheries management should promote the maintenance of the quality, diversity and availability of fishery resources in

sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development'.

According to its Art. 6.2, fisheries management measures 'should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species'. Critical fisheries habitats should be protected and rehabilitated (Art. 6.8); conservation and management decisions should be based on the best scientific evidence available (Art. 6.4).

Art. 7 FAO Code of Conduct specifically address fisheries management. The overriding objective is the long-term conservation and sustainable use of fisheries resources (Art. 7.1.1, 7.2.1). In particular, states 'should ensure that levels of fishing effort are commensurate with the sustainable use of fishery resources' (Art. 7.1.8, Art. 7.6.3).

The Code envisages conservation and management measures 'designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors' (Art. 7.5).

According to Art. 12.1, 'States should ensure that appropriate research is conducted into all aspects of fisheries', so as to provide a sound scientific basis for decision making. In particular, '[i]n the absence of adequate scientific information, appropriate research should be initiated as soon as possible' (Art. 12.3). The actions required to promote such research, as well as the collection and efficient use of data, are concretized through Art. 12.2-20. Paragraphs 5 and 6 of Art. 12 call on states to establish the necessary research capacity, with special provisions on support to developing countries in paragraphs 18 and 20.

The Plan of Implementation of the World Summit on Sustainable Development (JPoI), adopted by the World Summit on Sustainable Development held in Johannesburg in 2002.

It addresses the 'sustainable development of the oceans'.

Actions are asked for 'at all levels' to achieve sustainable fisheries include the maintenance at or restoration of stocks to levels that can produce MSY, 'with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015' (Para. 31(a)).

'the scientific understanding and assessment of marine and coastal ecosystems as a fundamental basis for sound decision making', inter alia through cooperation and promotion of 'the use of environmental impact assessments and environmental evaluation and reporting techniques (Para. 36).

THE PRECAUTIONARY PRINCIPLE

Principle 15 of the Rio Declaration as the most frequently cited formulation provides that '[i]n order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'. In the fisheries management context, however, the precautionary principle or approach has found specific recognition.

UN Fish Stocks Agreement

Article 3(1) Paragraph 1 provides that '[s]tates shall apply the precautionary approach widely to conservation, management and exploitation of straddling and highly migratory fish stocks in order to protect the living marine resources and preserve the marine environment'. Paragraph 2 specifies the content of the precautionary approach by stating that '[s]tates shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures'.

Annex II to the UN fish stock Agreement provides guidelines for the application of 'precautionary reference points'. Precautionary reference points are so-called 'target reference points' defining management objectives, and 'limit reference points' identifying safe biological limits for harvesting. The action to be taken if such reference points are exceeded must be determined in advance. This means that conservation measures will automatically become applicable. Moreover, when precautionary reference points are approached, ongoing fishing activities would have to be characterized as overfishing. It may thus be argued that Article 61(2) UNCLOS itself, laying down the duty of coastal states to ensure that the marine living resources are not endangered by overexploitation, requires a halt to fishing in such instances.

Additionally, states are obligated under the Agreement to 'adopt plans which are necessary' to conserve non-target species and protect habitats of special concern. Article 6(6) requires the adoption of cautious conservation and management measures, including catch and effort limits, for new or exploratory fisheries as soon as possible, which are to remain in force until sufficient data allow assessment of the long-term impact on the stocks.

Besides, the Agreement provides for emergency measures to be taken where natural phenomena adversely affect straddling or highly migratory fish stocks, so as to ensure that fishing does not exacerbate such impacts. Notably, the same applies where fishing activities themselves seriously threaten the sustainability of such stocks.

The FAO Code of Conduct also accords a central role to the precautionary approach:

'States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.'

In broadly the same the Code calls upon states to take into account a number of uncertainties in implementing the precautionary approach; to determine target and limit reference points and the action to be taken when they are approached or exceeded; and to adopt cautious conservation and management measures for new or exploratory fisheries, as well as emergency measures to avert certain detrimental effects of fishing.

Moreover, the **UN General Assembly** Resolution A/RES/61/105 on sustainable fisheries calls upon states 'to apply widely, in accordance with international law and the Code, the precautionary approach… to the conservation, management and exploitation of fish stocks… and also calls upon States parties to the [UN Fish Stocks]. Agreement to fully implement the provisions of article 6 of the Agreement as a matter of priority'.

The precautionary approach to fisheries conservation and management thus qualifies as a general principle of international law within the meaning of Article 38(1) (c) ICJ Statute.

ECOSYSTEM APPROACH TO FISHERY (EAF)

According to Lackey (1999), ecosystem management is "the application of ecological, economic, and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period".

It involves "management decisions which involve a broad awareness of the consequences of fishing or other human actions to an ecosystem….used to infer the necessity of understanding multispecies interactions and questions of altered structure of the biological community" (ecosystem stability)" (FAO-ACMRR, 1979).

It aims at: (1) maintaining viable populations of all native species in situ; (2) representing within protected areas all native ecosystem types across their natural range; (3) maintaining evolutionary and ecological processes; (4) managing over periods of time of sufficient duration to maintain evolutionary potential of species and ecosystems; and (5) accommodating human use and occupancy within these constraints (Grumbine, 1994, cited by Larkin, 1996).

The term "Ecosystem Approach to Fisheries" (EAF) was adopted by the FAO Technical Consultation on Ecosystem-based Fisheries Management held in Reykjavik from 16 to 19 September 2002 (FAO, 2003)

EAF is defined by Ward *et al.,* (2002) as "an extension of conventional fisheries management recognizing more explicitly the interdependence between human well-being and ecosystem health and the need to maintain ecosystems productivity for present and future generations, e.g. conserving critical habitats, reducing pollution and degradation, minimizing waste, protecting endangered species".

In general, the approach is taken as requiring: (1) definition and scientific description of the ecosystem in terms of scale, extent, structure, functioning; (2) assessment of its state in terms of health or integrity as defined by what is acceptable to society; (3) assessment of threats; and (4) maintenance, protection, mitigation, rehabilitation, etc., using (5) adaptive management strategies.

The concepts and principles of an EAF are not new, as they are contained in a number of international instruments, agreements and conference. According to Garcia *et al.,* 2003 these include: • the 1972 World Conference on Human Environment; • the 1982 United Nations Law of the Sea Convention; • the 1992 United Nations Conference on Environment and Development and its Agenda 21; • the 1992 Convention on Biological Diversity; • the 1995 United Nations Fish Stocks Agreement; and • the 1995 FAO Code of Conduct for Responsible Fisheries.

A summary of the content of these instruments as well as further information on this issue can be found in:

Garcia, S.M.; Zerbi, A.; Aliaume, C.; Do Chi, T.; Lasserre, G. The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper. No. 443. Rome, FAO. 2003. 71 p. Annex I

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ADAPTIVE MANAGEMENT PLAN FOR RED CORAL (Corallium rubrum) IN THE GFCM COMPETENCE AREA

SECOND PART - SOCIO-ECONOMIC ASPECTS

26/03/2013

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SUMMARY

The present document has been prepared to gather together all the available information useful for the first preliminary draft of a regional management plan (RMP) for red coral (*Corallium rubrum*) in the GFCM competence area.

It is prepared according to the Recommendation GFCM/35/2011/2 on the exploitation of red coral in the GFCM Competence Area that states:

"Scientific and technical knowledge acquired through the actions stipulated under paragraphs 3 (c), 5, 7 and 9 above shall be taken into account by SAC with a view to develop an adaptive regional management plan" (Paragraph 10)

and the Recommendation GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area that states:

"In addition to substantiate the Terms of Reference provided in the 2012 Work Plan of its Sub-Committee for Marine Environment and Ecosystems, and pending the development of a regional management plan for red coral, as requested by the Recommendation GFCM/35/2011/2..." (Paragraph 6)

"The GFCM Secretariat is requested to take actions in support of the SAC with a view to put into operation, not later than 31 May 2013, the adaptive regional management plan." (Paragraph 7)

It is composed by three parts:

'FIRST PART – BACKGROUND INFORMATION' contains data related to the distribution, biology, fishery, and legal instruments dealing with red coral

'SECOND PART – SOCIO-ECONOMIC ASPECTS' summarizes the main socio-economic data related to the red coral fishery

'THIRD PART – MANAGEMENT of red coral' contains the proposed the management for red coral

The first and second parts complement each other, only the combination of the two can give a complete picture of the past and present aspects concerning *C. rubrum*.

The second part is divided in four main sections:

AT THE SEA (HARVESTING RED CORAL)
AT THE WORKSHOP (PROCESSING RED CORAL)
AT THE (JEWELLERY) STORE
THE GLOBAL MARKET FOR PRECIOUS CORALS

The first three section contain data (figures) on the number of people, companies, and money generated by red coral are given, tentatively tracking its route from the sea to the benches of jewellers.

The last section contains information on other species or precious corals involved in trade. This is especially because in the global market, the 'fates' of precious and semi-precious corals are inextricably intermingled.

PREMISE

Whilst there are thousands of species of corals on Earth, only a few are regarded as precious (or priceless), and harvested for treasures, collections, and precious jewellery; among them the oldest and most well known species is, without doubts, *Corallium rubrum* (Cooper *et al.* 2011; Grigg 2002; Grigg 1993; Grigg 2010; Huang and Ou 2010; Torntore 2009).

Apart from the fact that complete, independent and 'reliable' data on harvesting, manufacturing and trade of precious coral are not easy to find, a comprehensive analysis of all the commercial species is out of the scope of the present document.

Therefore, the following paragraphs are focused almost exclusively on *C. rubrum* and are intended to summarize the main socio-economic data with the aim of providing useful information to the understanding of the current situation and the decision-making process related to the management of the Mediterranean red coral.

AT THE SEA (HARVESTING RED CORAL)

COUNTRIES INVOLVED

The countries where the harvesting of the Mediterranean red coral is/was realized are less than a dozen: Albania, Algeria, Croatia, France, Greece, Italy, Malta, Montenegro, Morocco, Spain and Tunisia. Some of them have a long tradition in fishing, dating back to centuries, while others have been involved only recently (some decades ago) (for details see the section dealing with the history of red coral fishery). However, in some of these countries the harvesting of *C. rubrum* is not yet practised (e.g. Malta) or it has been (temporarily) forbidden (e.g. Algeria).

In 2010 (more recent data are not available at the time of writing), FAO dataset records production data for 9 countries (all the above mentioned except Algeria and Malta) totalling for about 54 tons of red coral (50.5 tons from the Mediterranean Sea, the rest from the Atlantic beds).

Nowadays, Torre del Greco manufactures supply with Mediterranean raw corals from France, Italy, Morocco, Spain and Tunisia and in the past (when available) also from Albania, Algeria and Greece. The imported raw coral is not usually re-exported but worked on site. (C. Condito from ASSOCORAL, 2013 pers. comm.).

It is worth pointing out that, unfortunately, these are unofficial data on landings, not provided by Governments, but supplied to FAO by the Liverino company (Torre del Greco, Italy), a major import-export and coral jewellery wholesaler (Garibaldi in GFCM 2011). Data on red coral production are provided by this same source on a regular base since the mid-1980s; while representing consistent information for trend analysis (data provided may also include IUU harvests that are otherwise not reported in official national data), there is a raising concern about a possible conflict of interest. These data may refer in some cases to trade information rather than to actual annual harvest) (Garibaldi in GFCM 2010, 2011; Cannas *et al.* in GFCM 2010). Recognizing the importance of continuous and unbiased data to carefully and independently evaluate the status of the species, FAO and GFCM would to progressively incorporate in their databases as much as possible data from official national sources (Garibaldi in GFCM 2011). In particular, GFCM CPCs agreed to collect data on harvesting of red coral starting with the 2013 harvesting season (Recommendation GFCM/36/2012/1, Paragraph 8).

PEOPLE INVOLVED

It is very hard to determine the exact number of people harvesting red coral. In general, they can be assigned to two categories: people materially collecting colonies (divers) and people indirectly involved in it (the crew and owners of the boats equipped for the diving, people involved in supplying services for the

SCUBA diving); while for the first ones some rough estimates can be tentatively presented, the number of the last category is almost impossible to define.

In the last years many countries have regulated the harvesting of red coral by defining a fixed number of authorized divers (or boats); the number of divers and the individual quota, whenever available, are summarized in the following Table 1; considering that the number of authorizations can sometimes vary from year to year, if not otherwise specified numbers and figures refers to 2010.

The numbers of divers shown in Table 1 are those indicated in the respective national legislations as the maximum number allowed in each year/for each area; those figures do not indicate the actual number of divers effectively working at sea, since often not all the licenses are granted in a given year/area or not all the divers with a valid license actually work.

Table 1 FAO data on production, number of divers, quota limits and potential quota (see main text and notes for details).

Country	FAO data	Max n° divers	Quota limit (if available)	Potential total quota
Albania	1.2 tons	na	na	
Algeria	--	100[1]		8.9 tons [1]
Croatia	6.5 tons	15	200kg/license	3 tons
France (PACA+ Corsica)	9.3 tons	30 (20+10)	50kg/license[2]	na
Greece[3]	2.8 tons	10	na	na
Italy	10.3 tons	30[4]	2.5kg/license/day[4]	13.5 tons[4]
Montenegro	1.4 tons	na	na	na
Morocco (Atlantic)	3.6 tons	max 30[5]	600 kg/boat[5]	6 tons[5]
Morocco (Mediterranean)	3.51 tons	max 30[5]	500 kg/boat[5]	6 tons[5]
Spain	5.4[6] tons	47+[10+6][6]	400 kg/license[6]	25.2 tons[6]
Tunisia	10.1 tons	na	na	na

NOTES 1 – since 2001 the harvesting is forbidden; the number and quotas refers to the whole territorial waters of Algeria (Décret exécutif n° 95-323 du 21 Octobre 1995) and to the past when red coral could be legally collected in the country; 2 –the quota applies from 2012 and only in PACA (Arrêté n °2012157-0001); 3 – in 2011 no licenses were granted (see country profile for details); 4 - numbers of divers and quota refers to Sardinia, data from the rest of Italy is not available; potential quota was obtained multiplying the potential numbers of days in that season (180) x n° licenses x daily quota; 5 - the licenses and quotas for harvesting are granted to boats (10 boats in each area and a max of 3 divers/boat). From 2010 the harvesting in the Mediterranean is supposed to be closed; 6 –FAO data refers to Spain (Mediterranean), number of divers refers to the authorization whole Spain in aguas exteriores (47) and aguas interiores of

Catalunya (10) and Balears (6); potential quota was obtained multiplying the total n° of divers (63)*individual quota.

On the overall, it could be hypothesized that about 350 divers can be involved in the legal fishing of red coral summing up the 300 divers (see Table 1, comprising Algeria and considering that the harvesting will be reopened with the same number of licenses as it was in the past) and at least 50 more divers presumably working in Tunisia (30) +Albania (10) +Montenegro (10).

However, the actual number of people diving for red coral is supposed to be higher than that previously indicated, especially because in some areas the poaching seems to be very pervasive (CITES 2007; CITES 2009; Tsounis *et al.* 2013; Tsounis *et al.* 2010).

At the Costa Brava (Spain) all divers are natives and most of them in their 50s (the youngest is 45 year old). They usually form 2-3 person teams that dive together or in turns during the same trip (Tsounis *et al.* 2010).

In Sardinia (Italy), 50% of the authorized divers are non-natives, the mean age is 52.6 years (ranging from 34 to 73 years) (data source Autonomous Region of Sardinia N.13984/DET/540, 12.07.2012); divers usually dive alone using mixed gas, from boats that are crewed by one coxswain and one diver (Andaloro and Cicogna 1993).

In Corsica (France) all divers are French; the mean age is 52.4 years (ranging from 43 to 63 years) (Recueil des Actes Administratifs de Corse n°6, 2010). Similar figures are presented for the PACA region (France Continental) (see document by CRPMEM PACA Appendix F in GFCM 2011).

The graph in Figure 1 summarizes data on age for divers authorized to harvest red coral in Sardinia (2012), France Continentale (2011) and Corse (2010).

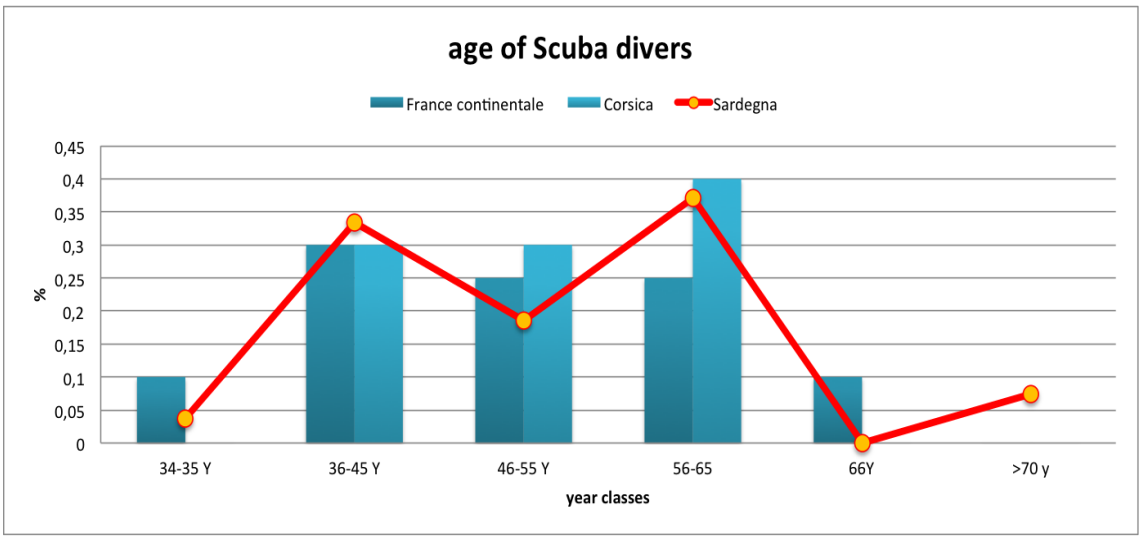

Figure 1 SCUBA divers harvesting red coral in France Continentale (PACA), Corsica and Sardegna (Italy) in % in the different classes of age

In general 'young' divers (<34 years old) are absent, with the prevalence of those in the range 56-65 years.

As *Corallium rubrum* harvesting mainly concentrates on the warmer summer months (May –October), it means that most of the divers are effectively working part time, and have often invested into other businesses as well (Tsounis *et al.* 2010).

As concerns the number of people indirectly involved in the harvesting, it is impossible to be determined from the available data; for instance, in some countries divers can work in couple or triple and hence share the crew or own the boat they use.

The collecting of such kind of information and more in general the realization of a full socio-economic analysis of the sector should be regarded as a priority by the countries involved in red coral exploitation.

REVENUES FROM RAW RED CORAL

From the time of classical Rome, Italy has been the centre of Mediterranean red coral harvesting, manufacturing, and trading.

However, based on historic data collected and compiled by private industries, Sardinian coral (*C. rubrum*) has been imported and used in expensive jewellery in Taiwan (Huang and Ou 2010 and references therein). This is also confirmed by the fact that in the years 1986-1988 substantial quantities of Mediterranean red coral were said to be exported to Taiwan and Japan for processing (GFCM 1989). *Corallium rubrum* imported into Japan, was regarded as one of the most valuable presents to state officials, and is still highly revered (Tsounis *et al.* 2010 and references therein).

Even in the very recent years relevant amounts of raw Mediterranean red coral have been exported from Italy to the US (CITES 2009) and more recently to India and China (unconfirmed data, pers. comm. from Sardinian divers). In fact, taking advantage of the current economic crisis, Chinese and Indian buyers (without much experience in the field) are said to be purchasing, since a few years, in the Mediterranean raw coral from fishermen (C. Condito from ASSOCORAL, 2013 pers. comm.). This fact leads to market distortion and loss of added value to the artisans of the Mediterranean countries, in particular in Morocco, Tunisia and Italy (C. Condito from ASSOCORAL, 2013 pers. comm.)

For instance, according to the data provided by the U.S. Fish and Wildlife Service from 2001 to 2008 the U.S. imported unworked skeletons of *Corallium rubrum* from Italy (Figure 2) (CITES 2009); this is probably due to the marketing of

stockpiles rather than the discovery and harvesting of new coral beds (Grigg in IUCN/TRAFFIC 2007).

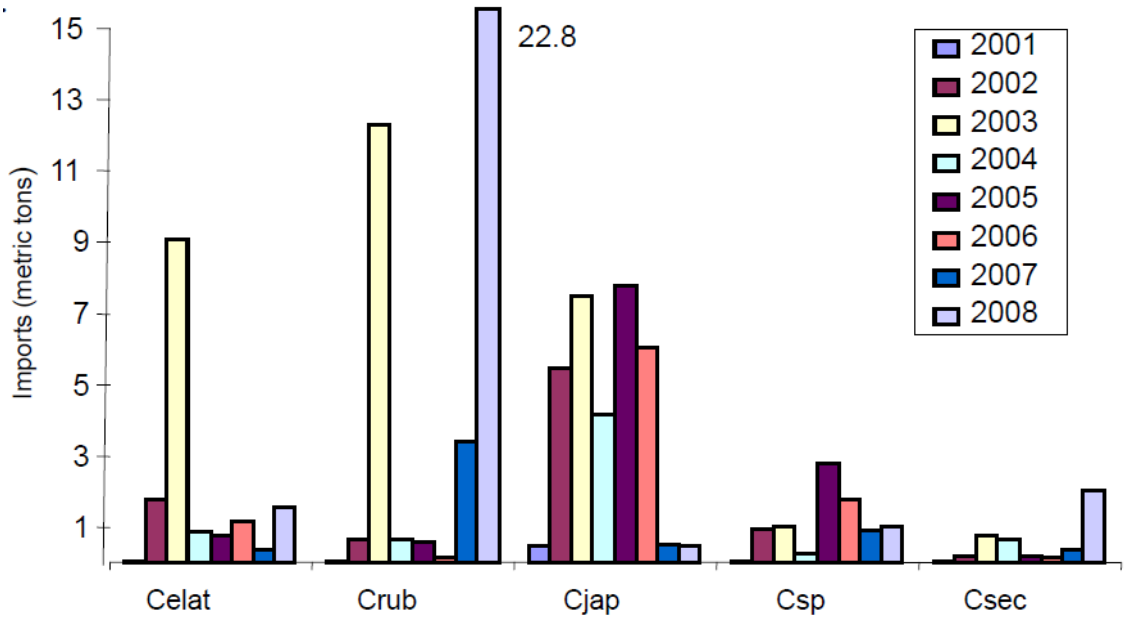

Figure 2 - Imports of five species of *Corallium* into the United States from 2001 to 2008. *C. elatius* = *Celat, C .rubrum* = *Crub, C. japonicum* = *Cjap, Corallium sp. nov.* = *Csp, C. secundum* = *Csec*. A. Total imports refer to unprocessed *Corallium* skeletons reported by kg. Source: U.S. Fish and Wildlife Service import data (from CITES 2009)

The market price of raw red coral varies consistent with its quality and origin. According to the information provided by Borras, a Spanish coral manufacturer, during the first GFCM technical consultation in 1984 (GFCM 1984), red coral colonies are classified in five different categories: tips, third category colonies (mainly < 7 mm of trunk diameter), second category colonies (7-9 mm of trunk diameter), first category colonies (>10 mm of trunk diameter, usually 12-14 mm) and special category colonies (>14mm in diameter and >100 g in weight). The quintessential profitable red coral colony should have the following characteristics: 15 * 12 cm in size, approximate weight of 100 g, 10-15 mm diameter of the trunk and at least 4 mm thickness at the tips.

The quality (and value) can vary depending on whether the specimen was harvested as a living or dead colony (or a dead broken branch). Coral that was harvested live is the most valuable because of its deep colour and high translucency, decreasing as a dead coral ages on the ocean bottom (Cooper *et al.* 2011). The quality of products made is also affected by damage from boring sponges of the family Clionidae, that create a series of holes in the skeleton (Cooper *et al.* 2011).

In 1984, the market price of raw red coral in Spain varied between 10000 pesetas / kg and 100000 pesetas / kg (approx 61 US $ to 610$/kg, considering the conversion rate for that years) (Borras in GFCM 1984).

The prices of by products like twigs and/or thin trunks, pieces and impaired remains for the costume jewellery market ranged between 30 and 70 pts / g (182-426 US $/kg)(Borras in GFCM 1984).

In the same years, the market price for red coral in Italy ranged from 40000/50000 to 400000/500000 Italian lire per kg (25-300 US $, considering the conversion rate for that years) depending on the quality, size and other elements that should be assessed case by case even for colonies caught in the same area (Iacobelli in GFCM 1984). At that time, in order to make profit, a boat (dredges were still in use) or a diver needed to collect about 200 kg of coral a year (Iacobelli in GFCM 1984).

According to the Chairman of the Association of Coral Producers of Torre del Greco, until the 1970's all kinds and qualities of coral were easily marketed (GFMC 1989). Later, in the mid-80's there was a strong request only for dark red coral of high quality while clearer corals can hardly be sold. Certain types of corals, although available on the market at reasonable prices were not any more interesting for the processing industry, this was reflected also in decreasing of the overall quantity of coral processed at Torre del Greco in those years (GFCM 1989).

Some year later, in Morocco red coral was sold to about 68 US $/kg (8 tons for a total of 6 millions Dh, source Département des Pêches Maritimes, 2000).

Today, *C. rubrum* is still sold for relatively high prices: in Torre del Greco are prevalently worked medium and big sized colonies whose prize can range from a minimum of 200 to a maximum of 2000 €/kg (in cases of colonies of extremely high quality). (C. Condito from ASSOCORAL, 2013 pers. comm.)

Unconfirmed information indicates that single, large *C. rubrum* colonies with a basal diameter of more than 4 cm are reportedly sold for as much as 45,000 Euro per colony (Tsounis *et al.* 2010).

Even thin colony tips are bought for 230 – 300 $/kg, while they were practically worthless some decades ago (GFCM 1989; Tsounis *et al.* 2007). One reason is that since the introduction of composite coral manufacture a few decades ago (GFCM 1989). Therefore there no longer is a minimum size the industry can use. However, today, in Torre del Greco the tips are of low interest in processing and trade because of their low economic value (C. Condito from ASSOCORAL, 2013 pers. comm.).

Even smallest pieces of coral can be ground to powder and formed into beads by mixing it with epoxy or other substances, although it is unlikely that high quality manufacturers offer this type of jewellery.

Nevertheless, the Italian craftsmanship industry has never been using nor will ever make use of coral dust mixed with resin (C. Condito from ASSOCORAL, 2013 pers. comm.). Actually, the existence of such kind of product has been repeatedly denied by ASSOCORAL, as the coral powdered is white (being made of calcium carbonate) and hence it does not retain the original red colour (C. Condito from ASSOCORAL, 2013 pers. comm.).

Tropical *Corallium* species are also of high value. To have a term of comparison, in 2009 the prize/kg of the momo coral (*Corallium elatius*) in the Taiwanese auctions ranged from 840 to 2031 US $/kg, while for Aka coral (*C. japonicum*) the prize was 1093 US $/kg (Huang and Ou 2010). Considering an average trading price of 1437,5 US $ per kilogram, the total value for the production in 10 months only in 2009 works out to be about 4 million US $, which averages to a monthly income of 7800 US $ per vessel. The net profit after depreciation and overheads such as labour costs, fuel, provisions and maintenance is very little, and in some cases not even achieved (Huang and Ou 2010). Recently, a large *Corallium elatius* colony 1.1 m high and weighing 67 kg was reported to have been sold for about US $ 100,000–300,000. It is not clear, however, if colonies of this size occur in sufficient quantities to make fishing trips commercially worthwhile (Tsounis *et al.* 2010).

Large jewellery pieces of *C. elatius* that were sold to tribal groups in Nigeria during the 1960s are now being bought back by the industry to be resold to the luxury market, indicating a shortage of large tropical *Corallium* colonies (Tsounis *et al.* 2010).

AT THE WORKSHOP (PROCESSING RED CORAL)

A BRIEF HISTORY

The Mediterranean red coral has been made into beads and used by diverse cultures around the world for millennia (Torntore 2009). The processing of *Corallium rubrum* dates to at least the Classical period and continued through the Middle Ages, with major exports from Rome to India (CITES 2007). Throughout history, there were various centres of coral jewellery manufacture. In the tenth and eleventh centuries, Marsa'el Karez on the northern African coast was the largest coral port and trade centre. In the same period Genova, Trapani and Provence competed in the production of beads (paternostri) and coral artefacts (Liverino 1998). In general, Sicilian products were sent to the Eastern markets, while Ligurian and Provencal in Northern Europe (Liverino 1998).

In the fourteenth century, Paris and Barcelona were famous for its coral art (Liverino 1998); later, the main activity shifted to Lisbon and in the seventeenth century to Marseille, parallels between these shifts have been attributed to Jewish migrations (Tsounis *et al.* 2010 and references therein).

By the 17th century the major centres of the red coral processing (and trade) were Naples, Marseilles and Livorno, with exports to India and West Africa (CITES 2007). From the 19th century till present, the processing of red corals is mainly centred in Torre del Greco (near Naples).

Actually, although Torre del Greco was involved in coral harvesting since 1500 (when it had dozens of 'coralline' boats sailing along the coasts of all the Mediterranean Sea), it has not yet entered into any type of coral processing until the early 1800s, following the foundation (1805) of the first workshop for the manufacturing of red coral by Paul Bartholomew Martin, granted of a ten-year exclusive concession for the working of "red gold". This was the decisive step towards the creation of a complete economic cycle – harvesting, working, sales (Ascione 2010). Only a few decades later, in 1837, at the end of the concession, there were already numerous shops and eight large factories with more than fifty workers. The entire population seemed to be involved in activities tied to coral, not only in harvesting and decoration, but also in related concerns, from supply to shipbuilding (Ascione 2010).

In 1862, there were 347 boats fishing for corals, which in 1864 rose to 1200 vessels fishing, with 24 factories in Torre del Greco (Italy) and 17,000 persons employed in total (Tescione 1968, GFCM 1984). The great influence of coral processing on the cultural and economic life of the town is further witnessed by the creation, in 1878, of a 'School for the processing of Coral', annexed to the original laboratory for semi-precious stones created about a century and a half earlier by Charles III of Bourbon (Monti in GFCM 1989).

In those years the discovery of the Sciacca banks destabilized the sector of coral (Ascione 2010). The excessive abundance of coral gave rise to a crisis, caused by market saturation and depreciation of a large part of the production; even the prize for coral of best quality fell from 70/85 lire per kg to <3 lire per kg (D'Antonio 1998). In just ten years, the excess of supply made forced many workshops to close while other decided to put aside the supplies already acquired (the Sciacca coral revealed to be unsuitable for detailed and elaborate workings that the market wanted) and to try other sources importing corals from Japan (Torntore 2009; Ascione 2010). The Italian coral industry adapted to market demand and crafted large coral pieces of the popular pale pink coral, but it struggled to survive (Tsounis *et al.* 2010). The need to invest large amounts of capital for the purchase of the raw material caused a severe selection process among the existing companies. At the beginning of the XX century, given the higher prices for raw material, the production abandoned lower levels and moved up to luxury jewellery. The predominant use of Oriental coral in the most expensive and exclusive production did not mean that Mediterranean coral was no longer used, which on the contrary was kept alive to safeguard the harvesting of raw material, fundamental for the economy of Torre del Greco (Ascione 2010).

At that time, Mediterranean red coral was used primarily for low-cost items and necklaces in traditional styles, both for domestic and foreign markets (Ascione 2010).

The coral trade, therefore, depended not only on the state of the resource but also on market forces and the political situation (Tsounis *et al.* 2010).

In the 1950s, after a pause during World War II, there was a slowly growing increase in sales. With the reopening of the North African markets, in Nigeria, in the United States, and in the Far East, demand grew for both raw and worked coral, which in the meantime had been rediscovered by important jewellers such as Cartier, Boucheron, and Van Cleef (Ascione 2010).

In the mid-1980's the market for red coral in its artisan and industrial aspect was still confined to Italy and to a few firms just created in Costa Brava and the Balearic Islands (Spain) (Borras in GFCM 1984).

Today, Torre del Greco is still known for the high quality of their products, and as a luxury production centre. It is still among the most important locations in the world for the production of coral beads, competing with Taiwan and Japan, and it is the unique world centre for the processing of shell cameos (Torntore 2009).

In Torre del Greco the issues related to the coral industry are very complex, both because of the industry's economic and productive impact on everyday life and because of its importance on the social and cultural traditions, illustrated in the old saying 'corals and cameos are such a part of Torre del Greco that life without them is like trees growing without roots' (Monti in GFCM 1989).

THE PROCESSING OF CORALS NOW

Until the XI century only the production of coral grains or 'paternostri' is mentioned in the documents; regardless to their size and value, they were used to make prayers beads for Muslims and Christians, and later necklaces (Liverino 1998). Therefore, for a long time processing of red coral was limited to simple operations: cutting, rounding and polishing. Only towards the end of the seventeenth century pieces also took forms other than spherical (Liverino 1998).

Essentially, methods of processing red coral today are the same as in the past. It is a highly labour-intensive process of working, done mainly by hand, with mechanization appearing only in some steps (Stampacchia and de Chiara 2000; Torntore 2009 and references therein).

In general, a main division exists between artisan-artists who make the semi-finished product and the companies that perform the remaining steps of the assembly and placement of the product on the market.

At least 12 different stages are necessary before the production process is finished: these involves the washing, cutting, shaping, cleansing, polishing and stringing of red coral colonies (Stampacchia and De Chiara, 2000). As an example of how time-consuming the process is, it takes between 10.5 and 14.5 days to produce one kilo of the small beads called 'pallini' (Torntore 2009).

According to ASSOCORAL, the artisanal production in Torre del Greco is characterized by an extremely wide range of products making it difficult to establish a standard prize for worked corals; they can have a commercial value at the wholesale market extremely variable, related to the size, nature and quality of the product. For instance, the production of 'filame a palline tonde' (small round beads from 3 to 6 mm of top quality, which are usually obtained from colonies with basal diameter of 7 mm or greater) could reach an average wholesale prize of approx. 1500-2000 €/Kg. The prize is obtained by calculating not only the value of the raw material but also, and above all, the costs for the processing, that in this case is extremely high, and of the skilled labour. Obviously, if the diameter of the ball is smaller the cost will be lower, if larger will be greater. Other products, realized with cuttings and scrap, have a lower average value (C. Condito from ASSOCORAL, 2013 pers. comm.).

SARDINIAN CORAL AND THE OTHERS

After the crisis that followed the discovery of Sciacca banks, in the late 1800s, Italy started to import Western Pacific *Corallium* from Japan (Torntore 2009), that is new species discovered in the markets at Madras and Calcutta (India) (Ascione 2010).

Since then, Torre del Greco is not only processing the Mediterranean red coral but it is a major importer of other "precious corals". Historically the term precious coral referred to *C. rubrum* only, later the term expanded to incorporate all the Pacific Corallidae corals.

Corallium corals are traded as whole, dried colonies and unworked branches and branch fragments as well as beads and manufactured jewellery (Cooper *et al.* 2011). In general, they command high prices and near-global market demand. As a result, their trade is extensive, profitable and provides ample incentive for their harvest (Cooper *et al.* 2011).

In 2000 in Torre del Greco, apart from *C. rubrum,* other *Corallium* species were worked: principally *C. elatius*, and minor quantities of *C. japonicum*, *C. konojoi* and *C. secundum* (Torntore 2009).

According to Torntore (2009) nowadays 30% of the processed corals in Torre del Greco are *C. rubrum*, as 70 % are tropical *Corallium* species, all imported from East Asia. On the other hand, ASSOCORAL affirms that 60% of the coral used in Torre del Greco is of Mediterranean origin and only 40% of Asian origin. Moreover, in the last two years, partly due to the economic crisis as well as the inclusion in CITES App III of Pacific corals, the amount of coral imported from those countries is considerably decreased (C. Condito from ASSOCORAL, 2013 pers. comm.).

Even before the current crisis, a significant dichotomization of demand between products of low price / quality and medium-high price / quality has occurred. The first type of products is usually made from made with Pacific corals (Stampacchia 2010). Despite the more recent developments, therefore, the bulk of high quality production (and revenues) remains strongly linked to a specific raw material - the Mediterranean red coral -and to the skills and relationships that around it and from it have spread and entrenched for other materials and areas (Stampacchia 2010).

In any case, it is true that many workshops and independent producers import both beads and the roughly-shaped Pacific coral blanks and then finish them in Torre del Greco. These rough blanks are produced in Asian locations (mainly Taiwan) very inexpensively and in large quantities, making the final Italian product less expensive for the producer and more cost effective in the marketplace (Torntore 2009).

Today, the term precious coral has been further expanded to incorporate in trade for jewellery and fashion markets many more coral genera (Torntore 2009; Cooper *et al.* 2011).

At the end of the 19th century, despite the crisis that followed the discovery of the Sciacca banks, some 82 craft enterprises were still active in Torre del Greco with more than 4000 workers; three-quarters of them were women (D'Antonio 1998). Less than half of these employees work in the factories, while the remainder are clandestine and anonymous people who work within their own houses and has a indirect relationship with the company often mediated by the figure of the 'raccoglitore' (collector), who takes care of the distribution of the raw material and withdraws the worked material (D'Antonio 1998).

Today, the processing sector of corals, cameos and gold in Torre del Greco is based on a domestic and international network particularly dense and articulated. At the local level, many companies work for many other close companies, with a division of the total work that gives space to the creativity of the artisans and the ability to follow the international markets and follow trends in a proactive manner (Stampacchia 2010).

In 1982, in Torre del Greco there were some 150 factories employing 4,000 workers (GFCM 1989).

In 1999, according to the research carried out by the Department of Business Administration of the University Federico II of Naples (Stampacchia and de Chiara 2000) the number of workers declined. In fact, there was a total of 306 firms involved in coral manufacturing, with some 1,900 employees, including 1,300 internal workers and 600 workers at home; 88,2% of enterprises in the sector did not exceeded 10 employees and most of them were family-owned and family-run. In average companies were composed of 5.5 workers. In many cases, businesses had even just one internal worker, which often operates in his own home by having dedicated a part of this to the productive activity.

A substantial number of small companies specialize in outsourced processes for the larger companies. The three oldest companies ('Antonino De Simone', 'Ascione' and 'Liverino' established in 1830, 1855 and 1894, respectively) are significantly larger than the rest (Tsounis *et al.* 2010). For instance, the firm Antonino De Simone, listed among the "150 historical companies of Italy", employs some 30 people, some of them working consecutively for them for 40 years.

The total turnover of the coral industry of Torre del Greco in 1999 was around 170 million Euros (US $ 174 million at that time) (Pani in IUCN/TRAFFIC 2007).

In 2009 in Torre del Greco there were about 270 companies with over 2000 employees (Stampacchia 2010).

Updated figures, accessible in the Assocoral web site (http://www.assocoral.it/dettdati.asp; accessed on March 2013), are summarized in the following tables (Table 2 to 5) and seems indicate a substantial stability in the sector.

Table 2 – Number of workers in the cameos and coral sector in Torre del Greco

Total workers	**2600**
Total Induced employees	4500
Companies with 1 worker	32%
Companies with 2 or 3 workers	31%
Companies with more than 3 workers	34%
others	3%

To have a term of comparison, today, the principal competitor (the Taiwanese coral industry) includes some 2,000-3,000 companies/workshops/factories and over 30,000 people who work with coral and depend on the coral sector in some way for their livelihood (Torntore 2009).

Table 3 - Year of foundation of the coral companies in Torre del Greco

Before 1950	**35%**
From 1951-to 1970	21%
From 1971 to 1980	19%
From 1981 to 1990	15%
From 1991 to 1999	10%

In general, the familial traditions are passed down through the generations. In fact, more than 24% of companies are founded before the 1950s, while only 9% after 1990.

Table 4 - Classes of sale figures of coral companies in Torre del Greco

Up to 250000 Euros	**35%**
From 250000 to 500000	45%
From 500000 to 2500000	12%
More than 2500000	3%

Table 5 - Subdivision of sales by type of customers for coral companies in Torre del Greco

Sale to the general public	**9%**
Sale to retailers	27,3%
Sale to wholesalers	43,8%
Sale to other companies in the sector	19,6%

Apart from the processing, fifty companies are involved also in the distribution of the product, with special reference to exports (Japan, USA, Europe) which now accounts for over 75% of production (source Assocoral web page).

In the period 2001-2008, Italy exported about 90% of all their precious corals to the U.S.; however, Italy's contribution to US imports decreased from 50% in 2002 to less than 4% in 2006 (Figure 3)(CITES 2009).

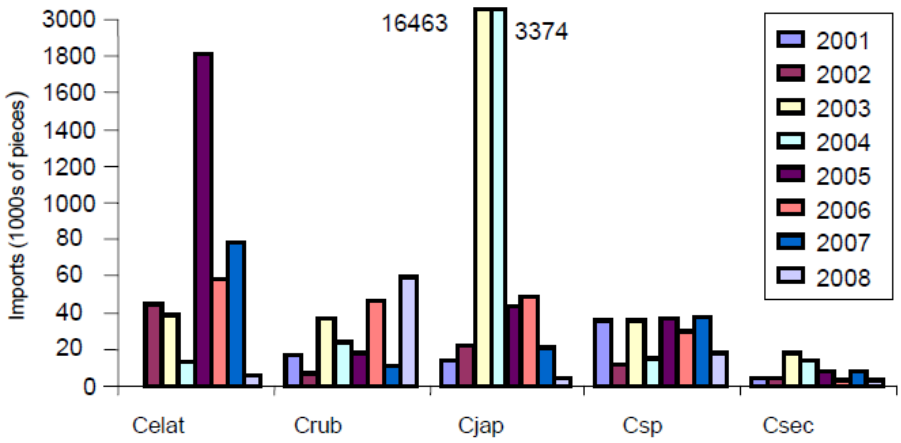

Figure 3 Total imports into the United States from 2001 to 2008 for manufactured *Corallium, reported by piece. C. elatius = Celat, C.rubrum = Crub, C. japonicum = Cjap, Corallium sp. nov. = Csp, C. secundum = Csec*. Source: U.S. Fish and Wildlife Service import data (from CITES 2009)

In 1988, the average annual value of coral exports from Torre del Greco amounted to nearly US $ 30 billion (Torntore in CITES 2007). However, Pani (in IUCN/TRAFFIC 2007) rejects these figures and affirmed that the total turnover of the coral industry of Torre del Greco in 1999 was much lower, around 170 million Euro (US$ 174 million at that time).

Nowadays on the whole, the specialized coral jewellery industry located in Torre del Greco is estimated to generate more than US $ 230 million per year (according to data ASSOCORAL from Tsounis *et al.* 2009); only part of this money comes directly from the *C. rubrum* trade.

Industry insiders say that the black market is significant, maybe totalling 50% of the trade (Tsounis *et al.* 2010).

AT THE (JEWELLERY) STORE

MAIN MARKETS

Torntore (2009) has categorized three markets for coral objects: 'Fashion', 'Ethnic', and 'Tourist' markets. The Fashion market prefers highly refined beads, without imperfections, that require a great deal of hand work to shape, polish, and match. Beads directed to Ethnic markets are larger in many cases and less refined in shape and texture than that for the Fashion market. The Tourist market caters to producing and selling less expensive souvenir types of items using beads all produced from coral pieces that would otherwise be thrown out as unworkable (Torntore 2009).

The red coral is closely linked to the overall touristic image Italy to the point that typical products are offered and sought after by foreign tourists both in Neapolitan area (Sorrento, Pompeii, etc..) as well as in other typical Italian tourist areas (Venice, Florence, etc.) (Stampacchia 2010). Coral jewellery sold in many of the smaller, lower-end tourist shops, is promoted by vendors as "Italian" (i.e., Mediterranean or *C. rubrum*) even though in most cases it comes from Japan or Pacific waters (Torntore 2009).

In recent years, the decrease in the harvesting of the most precious *Corallium* corals has led to a proliferation in the market to the enhancing or bleaching and dyeing of lower quality *Corallium* corals and unrelated corals to create the desired product that resembles the gold standard (Torntore 2009).Bamboo and sponge corals have appeared on international markets, often being died pink or red and sold as Coralliidae (CITES 2009).

Similar to the fraud with coral pieces that are made of plastic or low-quality species, red coral dust (still sold as a cure against various maladies or as an aphrodisiac), is often made from sponge coral that is sold as *Corallium* powder (Torntore cited in Tsounis *et al.* 2010).

MARKET PRIZES

In the mid-1980s the red coral partially worked, ready to be crimped, combined or designed for precious jewellery, reached a price ranging between 300 pts/g and 1500 pesetas/g (1825 US $ to 9125 $ /kg) considering the wholesale price (Borras in GFCM 1984). Then, after the increases due to the design, manufacturing, addition of other precious items the original price doubled and/or triplicated when the coral was sold to retailers and final customers (Borras in GFCM 1984).

Even the costume jewellery (made with the coral powder or the tiny twigs, after triturating and mixing) represented an additional source of income and allowed

for the training of the staff (e.g. allowing practical training and enhancement of knowledge of the advanced professionalized techniques) (Borras in GFCM 1984).

Today, *C. rubrum* worked beads are sold for 30-50 $ per gram (Tsounis *et al.* 2009; CITES 2009), while finished necklaces can cost as much as 20,000-25,000 $ (CITES 2009).

According to ASSOCORAL the market average prize of the finished product, mentioned in the CITES proposal, is likely relate to retail prizes in the U.S. market. In fact, prizes are significantly increased (even tripled) at retail jewellers as include their operating costs as well as gains and accessory costs. Therefore, it may be that a large necklace of Mediterranean coral can cost $ 20,000 but it is likely that it has also a nice closure of gold and diamonds (C. Condito from ASSOCORAL, 2013 pers. comm.).

THE GLOBAL MARKET FOR PRECIOUS CORALS

OTHER COUNTRIES

Apart from the number of species, since the 1970s the locations for processing *Corallium* have also expanded, including 'traditional' places such as Italy (since the Classical period and Middle Ages), Taiwan (since the 1920s), Japan, and India, as well as 'new' countries such as US and China (CITES 2009).

In the period 1990-1997, the majority of Mediterranean raw coral is sold to India and Japan. In particular, India was/is a big competitor in purchases of raw Mediterranean red coral, which is manufactured there for internal use and for export to Tibet and Nepal. They used to bought also large quantities of fragments of corals ("frantumi" and "cascami"), necessary in the preparation of medicines (Liverino1998).

Moving to the Pacific, between 1960 and 1980 Taiwan's coral fishery products used to account for over 80 % of total worldwide production. The saying, ''buy corals, visit Taiwan'' was used to describe the glorious state of the industry at the time (Huang and Ou 2010 and references therein).

Nowadays, Taiwan still occupies a very important position in the coral industry; approximately 90% of Taiwanese coral is exported—10% of this is raw and 90% is processed or finished in some form. In contrast to both the Italian and Japanese coral industries, Taiwanese sector is much larger, labour in Taiwan is much cheaper and therefore many products do not have to be expensive, high quality products (Torntore 2009).

Japan and China are also important manufacturing centres, with an annual value in 1982 of US $50 million (CITES 2007), although a large proportion of the exports are semifinished products (Tsounis *et al.* 2010).

China has recently reported to have begun exporting large quantities of raw *Corallium* corals and processing them into beads at even lower labour costs for the global market, in direct competition with Taiwan. However, the available data is not able to show the quantity and status of trade (Wu and Takahashi 2009).

The United States is the largest importer of precious corals, including unworked coral from China and Italy. While the United States does not export coral or coral products, a large part is sold to tourists (especially in Hawaii). China and Taiwan were responsible for 84% of 1,807,357 precious coral products imported into the United States in 2006 (CITES 2007).

TENTATIVES OF TRADE CONTROLLING

CITES and red coral

As concerns trade regulations, three times proposals for listing the Mediterranean red coral in CITES were presented: in 1987 by Spain, in 2007 by USA and in 2010 by Sweden (in behalf of EU) and USA. Actually, the first time the proposal was focused on the species *Corallium rubrum*, the second proposal aimed at listing the whole genus *Corallium* and the last one at listing the whole family Corallidae. All of them were rejected.

Since the documents are so numerous, and opinions quite contrasting (pros and against the listing) it is out of the target of this working document to deal with them. The following Tables 6-9 can help people particularly interested in deepening this aspect in having a reference guide.

In general, the possibility of introducing elements of bureaucratization of trade leading to significant reductions of red coral in processing has been perceived by the Torre's manufactures not as removing white gold jewels from the product range of a goldsmith but as the taking off the same source and reason of their training and power, which in time led them to expand to other materials and new areas of opportunity (Stampacchia 2010).

Table 6 - CITES Conferences of Parties (related to the red coral issue) – proposals and documents

CITES Cop6		
1987	Ottawa (Canada), July 12-24	CITES Cop6 - Proposals for amendment of Appendices I and II Cop6 Prop. 61 by Spain Inclusion in Appendix II of *Corallium rubrum* Rejected
CITES Cop13		
2004	Cop13 Doc. 57	CITES- Proposed revision of Resolution Conf. 9.24 (cop12 Com. I. 3). Criteria for listing on Appendix I and Appendix II. Test of the applicability of the criteria - *Corallium rubrum*
CITES Cop14		
2007	The Hague, Netherland, June 3-15	CITES Cop14 - Proposals for amendment of Appendices I and II Cop14 Prop. 21 by USA Inclusion of all species in the genus *Corallium* in Appendix II of CITES The listing proposal was defeated in a secret ballot, failing to achieve a two-thirds majority with 61 votes in favour and 55 against. Rejected
2007	The Hague, Netherland, June 3-15	Additional information on biological and trade criteria for precious corals in the genus *Corallium* Cop14 Inf. 36 by USA
2007	IUCN/TRAFFIC	IUCN/TRAFFIC analyses of the proposals to amend the CITES appendices Cop14 Inf. 13
CITES Cop15		
2010	Doha (Qatar), 13-25 March	CITES Cop15 - Proposals for amendment of Appendices I and II Cop15 Prop. 21 by Sweden, on behalf of the Member States of the European Community, and The United States of America Inclusion of all species in the family Coralliidae in Appendix-II of CITES The proposal was put to a vote, with a secret ballot requested by Tunisia, and was rejected with 64 votes in favour, 59 against and 10 abstentions Rejected
2010	IUCN TRAFFIC	IUCN/TRAFFIC analyses of the proposals to amend the CITES appendices CoP15 Inf. 18
2010	IUCN TRAFFIC	Summary of IUCN/TRAFFIC Analyses of the Proposals to Amend the CITES Appendices at the 15th Meeting of the Conference of the Parties CoP15 Inf. 18A
2010	Doha (Qatar), 13-25 March	ICRI recommendation on international trade in corals, coral reef species and related products Cop15 Inf. 42 BY SAMOA
2010	Doha (Qatar), 13-25 March	Additional information on the family Coralliidae Cop15 Inf. 48 by USA
2010	Doha (Qatar), 13-25 March	International workshops on Coralliidae science, management and trade Cop15 Inf. 54 by USA
2010	Doha (Qatar), 13-25 March	Conservation of and trade in Coralliidae species Cop15 Doc. 54 by USA

Table 7 - FAO documents on CITES proposals (as regards red coral)

2007	FAO Fisheries Report No. 833	Report of the second FAO ad hoc expert advisory panel for the assessment of proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species.
2010	FAO Fisheries Report No. 925	Third FAO expert advisory panel for the assessment of proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species

Table 8 - Comments/documents by other subjects on proposals to list red coral on CITES

Cop14 Prop. 21		
2007	Seaweb	Corallium in the red. Synopsis of literature for an Appendix II listing.
2007	Pani and Berney - IWMC	A review of the proposal to include the genus Corallium in Appendix II of CITES
Cop15Prop. 21		
2010	WWF	WWF POSITION STATEMENT Proposal 21: Red and pink corals (Coralliidae)
2010	Seaweb	Synopsis of literature for an Appendix II listing for red and pink coral - Corallidae in the red
2010	Pani - IWMC	PROPOSAL No. 21 Inclusion of the family Coralliidae in Appendix II. Ten reasons to reject the proposal

Actually, a timely restricted (January 1987 – June 1997) strict protection of Corallium rubrum was in place in Germany through the listing of the species in Annex 1 of Germany's Federal Ordinance on Species Conservation. This resulted in a total prohibition of any commercial trade into Germany both from EU and non-EU Member States. In that period German customs was confronted with commercial imports of premanufactured and manufactured products made of other *Corallium* species with significant (irresolvable) identification problems on the species level for enforcement officials in particular for pre-manufactured products, jewellery, or products made of coral powder (Dietrich 2010).

CITES and other corals

As regards other species of corals, in 2008, four species of Coralliidae had been listed by China on Appendix III of CITES: *C. elatius, C. japonicum, C. konojoi,* and *C. secundum*.

As a result, the Parties to the Convention were required to enforce the necessary CITES permitting requirements for those species. This in turn required enforcement and other authorities to identify products in trade made from Coralliidae to the species level in order to distinguish items made from the CITES-listed species from those not listed by CITES.

Recognising the different coral species in trade

Considering that there are about 35 different species in the Corallidae family (see taxonomy section for details) it is worth pointing out that only 7 species have populations large enough to support commercial harvest: six species are harvested in the Western Pacific and one is collected mainly in the Mediterranean (Table 9, from Cooper *et al.* 2011).

Table 9 Species, common names and colour of commercially important Coralliidae (from Cooper *et al*. 2011)

Scientific name	Common (commercial) name	colour
Corallium elatius	Pink coral, momoiro sango, momo	Light red, salmon, orange, and pink colours; interior core white
Corallium konojoi	White coral, siro sango	White; white with red or pink spotting
Corallium regale (laauense)	Pink coral Hawaii to the Milwaukee	Pink; may be streaked with white
Corallium rubrum	[Mediterranean] red coral, chichuukai sango, kowatari sango	Solid red; pale pink or white is rare
	Sciacca	Salmon or orange pink (bright or pale), occasionally yellowish marks
Corallium secundum	Midway coral, pink coral, angel skin, bokè,mittdo sango	White, spotted pink, light pink
Corallium sp. nov.	Midway deep-sea coral, sinkai sango	Bright pink with strong red markings (never a solid colour)
Paracorallium japonicum	Red coral, aka sango, tiaka	Dark to very dark red, blood red; interior core of white

Different methods for identifying the species of corals exist; in particular for ***Corallium*** corals, they depend on whether the coral specimens are still in a raw state or have been worked or processed. Where **raw or dead corals** are concerned, these can usually be identified to species level (CITES 2009). In some cases (e.g. when dealing with white or very pale specimens), the visual identification of worked coral and manufactured goods is very difficult (Cooper *et al.* 2011).

Apart from the red and pink corals (Corallidae), species of commercial importance are the "bamboo" corals (Isididae), the "sponge" corals (Melithaeidae), the

Antipatharian "black thorny corals", the "golden" corals (Primnoidae, Gerardiidae), the "blue" corals (Heliporidae), the "stony" corals (Scleractinia), that encompasses the "fossil", the "finger" and the "staghorn" corals (Cooper *et al.* 2011). Figure 4 (redrawn from Cooper *et al.* 2011, with minor modification as concerns the classification of some taxa) summarizes the main orders and families involved in commercial trade.

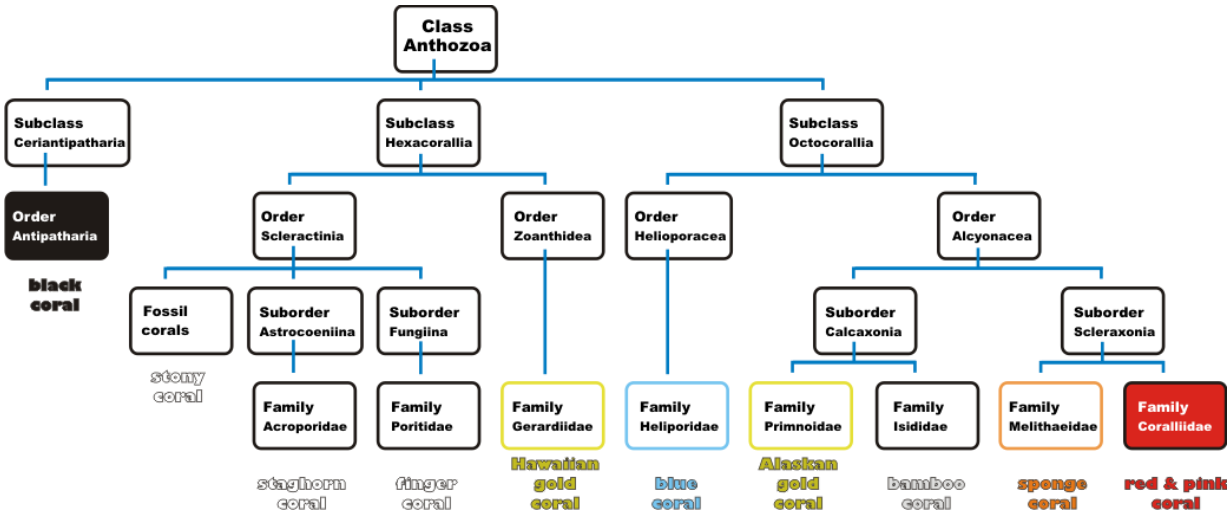

Figure 4 - Phylogenetic relationships among the precious and semi-precious corals of commercial importance (redrawn from Cooper *et al*. 2011; the classification follows that reported in WoRMS 2013).

Features sufficient for reliable identification do not exist for skeletons or as manufactured jewellery and curios, which is the bulk of the trade (CITES 2009). Nonaka and Muzik (2009) note that some identifications reported in the scientific literature and identifications by commercial sources are doubtful.

Taxonomic identification of octocorals requires microscopic analysis of shape, size and colour of sclerites embedded in the coenochyme and in the organic matrix of the axial skeleton, and these are lost when processed for jewellery. Identifying worked pieces of Coralliidae to species level could eventually be possible with use of laboratory techniques such as DNA analysis (Cooper *et al.* 2011).

However, it is worth pointing out that even this task is not an easy one. At present, the standard DNA barcoding system (based on cytochrome c oxidase subunit I) has been found to be 'unsuitable'; due to the low interspecific genetic divergence, it has been impossible to discern most Anthozoan species using this gene (Huang *et al.* 2008; Shearer and Coffroth 2008).

Particularly, where worked specimens contain multiple species, it may only be possible to identify worked specimens to the family level (CITES 2009). For coral powder that might be in trade, species may not be readily recognizable unless labelled (CITES 2009).

The introduction in national legislations of traceability systems and certification of origin for precious gems, hopefully and definitively would contribute to eliminate the problem of identification and fraud (C. Condito from ASSOCORAL, 2013 pers. comm.).

Some recent papers (Torntore 2009; Cooper *et al.* 2011; and references therein) could give further information and insights for those who are interested in identification of precious and semi-precious corals in commercial trade.

APPENDICES

APPENDIX A

CITES

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival CITES is an international agreement to which States (countries) adhere voluntarily however, it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level. The species protected by CITES are listed in one of the three Appendices: Appendix I (species threatened with extinction. Trade permitted only in exceptional circumstances), Appendix II (species not necessarily threatened with extinction, but where trade must be controlled in order to avoid utilization incompatible with their survival), Appendix III (species are listed at request of individual countries in order to gain assistance from other CITES Parties in controlling the trade).

CITES and FAO

A Memorandum of Understanding (MoU) between FAO and CITES was adopted by 10th Session of the COFI Sub-Committee on Fish Trade in June 2006 and signed by FAO and CITES during the 54th Meeting of the Standing Committee of CITES, on the third of October 2006. The MoU formalizes the intentions of the two Organizations in strengthening cooperation on issues related to commercially aquatic species listed on CITES Appendices and has been considered an important achievement by many FAO Member countries and Parties to CITES. Under the MoU, FAO and CITES will review and consult together on the scientific, legal and technical evaluation of commercially exploited aquatic species listed or proposed for listing in the CITES Appendices. For species that are already listed or set to become so, FAO will work with CITES and exporting countries to improve the monitoring and management of fisheries resources and help them ensure that exports only come from responsibly managed operations.

The following table summarizes the main documents related to CITES criteria and to the Memorandum of Understanding FAO/CITES.

FAO documents on CITES criteria		
2000	FAO Fisheries Circular No. 954	An appraisal of the suitability of the CITES criteria for listing commercially-exploited aquatic species
2001	FAO Fisheries Report No. 667	Second technical consultation on the suitability of the CITES criteria for listing commercially-exploited aquatic species
2004	CITES	Conf. 9.24 (Rev. Cop13)* Criteria for amendment of Appendices I and II
2004	FAO Fisheries Report No. 741	Expert consultation on implementation issues associated with listing commercially-exploited aquatic species on CITES appendices
2004	FAO Fisheries Report No. 748	FAO ad hoc expert advisory panel for the assessment of proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species
Memorandum of Understanding (MoU) FAO/CITES		
2006	FAO /CITES	Memorandum of Understanding (MoU)
2006	FAO	CITES issues with respect to international fish trade and the CITES/FAO MOU

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ADAPTIVE MANAGEMENT PLAN FOR RED CORAL (Corallium rubrum) IN THE GFCM COMPETENCE AREA

THIRD PART- THE MANAGEMENT of red coral

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SUMMARY

The present document has been prepared to gather together all the available information useful for the first preliminary draft of a regional management plan (RMP) for red coral (*Corallium rubrum*) in the GFCM competence area.

It is prepared according to the Recommendation GFCM/35/2011/2 on the exploitation of red coral in the GFCM Competence Area that states:

"Scientific and technical knowledge acquired through the actions stipulated under paragraphs 3 (c), 5, 7 and 9 above shall be taken into account by SAC with a view to develop an adaptive regional management plan" (Paragraph 10)

and the Recommendation GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area that states:

"In addition to substantiate the Terms of Reference provided in the 2012 Work Plan of its Sub-Committee for Marine Environment and Ecosystems, and pending the development of a regional management plan for red coral, as requested by the Recommendation GFCM/35/2011/2..." (Paragraph 6)

"The GFCM Secretariat is requested to take actions in support of the SAC with a view to put into operation, not later than 31 May 2013, the adaptive regional management plan." (Paragraph 7).

It is composed by three parts:

'FIRST PART – BACKGROUND INFORMATION' contains data related to the distribution, biology, fishery, and legal instruments dealing with red coral

'SECOND PART – SOCIO-ECONOMIC ASPECTS' summarizes the main socio-economic data related to the red coral fishery

'THIRD PART – MANAGEMENT of red coral' contains the proposed the management for red coral

All three parts complement each other, only the combination of the three can give a complete picture of the past and present aspects concerning *C. rubrum*.

The present document 'THIRD PART- THE MANAGEMENT of red coral' is divided in three main sections:

A NEW APPROACH MANAGEMENT OF RED CORAL
THE REGIONAL MANAGEMENT PLAN FOR RED CORAL
THE NATIONAL MANAGEMENT PLAN FOR RED CORAL

The first section contains the description of the proposed new management approach for red coral. It briefly describes the principles that inspired the drafting of the plan and the general framework a 'standard' plan should

follows. Furthermore, it provides information on the data needed for an effective management of natural resources.

The second section contains the text of the proposed Regional Management Plan for red coral.

However, considering that two different typologies of plans, the Regional and several National Management plans, are supposed to coexist and possibly to complement each other, sections 2 and 3 specify their application as well as their reciprocal relationships.

Finally, it is worth pointing out that section 3 includes the framework of a National Management Plan; this is not provided for by any GFCM Recommendation but it was included by the authors of the present documents in order to provide a sort of ‘good’ template of a management plan to be applied at the national level.

A ‘NEW’ MANAGEMENT APPROACH FOR RED CORAL

THE GENERAL FRAMEWORK OF A ‘STANDARD’ MANAGEMENT PLAN

In general terms the Technical Guidelines on Fisheries Management (FAO, 1997) describe a management plan as "a formal or informal arrangement between a fisheries management authority and interested parties which identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery and specifies the management rules and regulations which apply to it and provides other details about the fishery which are relevant to the task of the management authority”.

However, a well designed plan should identify also the background to the fishery, including all major stakeholders, the agreed objectives (covering the economic, social and ecological components for the fishery) and the specific rules and regulations that apply (FAO, 2003).

In particular, the framework of a ‘standard’ Management Plan, in line with the above indications, is supposed to comprise at least 12 parts:

- I. Area of operation of the fishery and under which jurisdiction it falls
- II. History of fishing and management
- III. Goals and broad objectives
- IV. Operational objectives
- V. Indicators, Reference Points, and associated Limit, Target, and Threshold Reference Points
- VI. Decision rules (with the definition of stakeholder’s role and degree of participation, if applicable)
- VII. Recovery plan
- VIII. Management measures
- IX. MCS system (Monitoring, Control, Surveillance)
- X. Implementation and enforcement mechanisms
- XI. Assessment of performance and reviewing system
- XII. Recovery strategy (eventual)

Apart from some general parts (I and II), the description of the contents expected for points from III to XII is provided in the following paragraphs. Further indications can be found in several Guidelines and Technical papers for instance:

- FAO Fishery Resources Division and Fishery Policy and Planning Division. Fisheries management. FAO Technical Guidelines for Responsible Fisheries. No. 4. Rome, FAO. 1997
- FAO A fishery manager’s guidebook. Management measures and their application. Cochrane, K.L. (ed.) FAO Fisheries Technical Paper. No. 424. Rome, FAO. 2002
- FAO Fisheries Department. The ecosystem approach to fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2. Rome, FAO. 2003.

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GOALS AND BROAD OBJECTIVES

Firstly, goals and management objectives must be specified.

Fishery management has three main aims (goals): sustain the stock, sustain the fishery and sustain the employment. Because they can potentially conflict, a delicate balance and priorities among them should be set.

In absolute terms, the over-riding goal of fisheries management is the long-term sustainable use of the fisheries resources (Code of Conduct, Paragraph 7.2.1).

Management objectives are targets that are actively sought and provide a direction for management action. These should focus on achieving long-term sustainable use of the fisheries resources (Code of Conduct, Paragraph 7.2.1), along with any further aims related to the social and economic status of each fishery. They are usually put in place and modified infrequently, typically being reviewed only every five years or longer

OPERATIONAL OBJECTIVES

The broad objectives should be further developed into explicit “operational objectives”.

An operational objective should be SMART: S – specific and easily understood; M – meaningful and written in terms of what will be accomplished, not how to go about it; A – agreed, with stakeholders’ responsibilities defined; R – realistic and relevant; and T – time-bound, that is, defined within a limited time period (FAO, 2011).

The operational objectives that need to be considered fall into four main categories: biological, ecological, economic, social and institutional (Table 1). Many reasonable objectives will be mutually incompatible. The trade-offs between them must have been agreed upon and the conflicts and contradictions resolved (FAO, 2002).

Table 1 Examples of fishery goals and operational objectives (from FAO, 2002)

Domain	Goals	Operational objectives
Biological	To maintain the target species at or above the levels necessary to ensure their continued productivity	To maintain the stock at all times above 50% of its mean unexploited level
Ecological	To minimize the impacts of fishing on the physical environment and on non-target (bycatch), associated and dependent species	To maintain all non-target, associated and dependent species above 50% of their mean biomass levels in the absence of fishing activities
Economic	To maximize the net incomes of the participating fishers	To stabilize net income per fisher at a level above the national minimum desired income
Social	To maximize employment opportunities for those dependent on the fishery for their livelihoods	To include as many of the existing participants in the fishery as is possible given the biological, ecological and economic objectives listed above

Different data may provide information to select the operational objectives (Table 2)

Table 2 Some basic data requirements for providing information to fisheries managers and decision makers (from FAO, 2002)

Objective(s)	Data Requirements
Biological	Total landings by major species per fleet per year Total effort by fleet per year Length and/or age composition of landings for major species Areas fished by each fleet
Ecological	Impact of fishing gear and activities on the physical habitat Changes in critical habitats brought about by non-fishing activities
Economic	Average income per person year Costs per person per year Destination of landings from each fisherman, and a measure of the dependence on the fishery of other sectors of the community (e.g. processors, wholesalers etc)
Social Institutional	Total number of fishers employed Total number of people employed in fishing Dependence of fishers for their livelihoods

INDICATORS AND REFERENCE POINTS

To monitor the progress of the fishery and to measure the performance of management in achieving the objectives, “indicators” and “reference points” are needed.

Indicators show the state of the fishery

Reference points (RP) are particular values of indicators and show the states you would like to achieve or avoid. Reference points are values of indicators defined on some technical basis, which are believed to represent important changes in the fishery system (Caddy, 2004).

Indicators and RPs should be used in combination with each other to express the operational objectives in ways that can be estimated in quantitative fisheries assessments (Table 3).

A reference point is an estimated value derived through an agreed scientific procedure, which corresponds to the state of the resource and of the fishery, and which can be used as a guide for fisheries management.

Two types of reference points should be used: conservation, or limit reference points and management, or target reference points:

- **Limit reference points** (LRPs) indicate situations that are undesirable and to be avoided at all costs; they set boundaries which are intended to constrain harvesting within safe biological limits;
- **Target reference points** (TRPs) correspond to situations considered as desirable and to be achieved on average; they are intended to meet management objectives.

Recognizing the uncertainty in the stock assessment process, the management plan may also include ‘**precautionary’ reference points**: these provide thresholds at which initial actions can be taken to reduce the risk that the limits may be broken.

When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set.

Both reference points and indicators are commonly based on agreed scientific procedures and/or models.

Many reference points are connected with the maximum sustainable yield concept, based on a model, which assumes that the annual net growth in abundance and biomass of a stock increases as the biomass of the stock increases, until a certain biomass is reached at which this net growth, or surplus production, reaches a maximum (**MSY**). This biomass is referred to as B_{MSY}, and the fishing mortality rate which will achieve MSY is similarly referred to as F_{MSY}. (Table 3 and

Table 4).

Reference points may also be set at arbitrary values (‘common sense RP’) which are not explicitly based on models but which are nevertheless agreed with the stakeholders.

Reference points are required for each of the biological, ecological, social and economic operational objectives of the fishery.

Table 3. Examples of different types of indicators and reference points used to guide fishery management actions

	Purpose	Categories and examples
Indicators	Measure the current position of the fishery for a range of different dimensions or criteria	• State, e.g. stock biomass, *B*now ; total catch • Pressure, e.g. fishing effort; fishing mortality, *F*now • Response, e.g. quota allowed; size limit set; % of total area set aside as MPAs
Performance indicators	Measure the current state of the fishery, relative to the associated reference points	• *B*now / B_{MSY} • *F*now / F_{MSY}
Conceptual reference point	Used to define decision control rule frameworks that guide management actions	• Limit reference points (LRPs) identify situations to be avoided, e.g. *B*lim , *F*lim • Target reference points (TRPs) identify values to aim at, e.g. MSY • Precautionary reference points (PRPs), trigger management actions before a LRP is reached, and should be set according to the uncertainty in the analysis and the risk tolerance of the fishery stakeholders, e.g. *B*pa , *F*pa
Technical reference points	Provide explicit mathematical definitions and/or procedures for quantifying the conceptual reference points	• MSY-based, e.g. B_{MSY} , F_{MSY} , as proposed by UNCLOS etc • Proxies for MSY, e.g. $F_{0.1}$, *F*max • Protection of reproductive capacity, e.g. *F*%SPR, • Economic and social, e.g. F_{MEY}

Table 4. Main categories of single-species stock assessment methods and their characteristics (FAO, 2002).

Method	Main Information Required	Comments
A. Production models	-Annual catch -Annual index of abundance e.g. CPUE or biomass estimate	- Do not consider age structure of catch or population - Estimate parameters and variables such as MSY, effort at MSY, mean unexploited stock size, biomass time series etc. - Caution should be used, especially when fitting with equilibrium methods - Good estimates require good data contrast in effort and biomass
B. Size and age-based models Yield and biomass per-recruit	-Natural mortality rate - Age/size at recruitment to fishery - Selectivity of gear for different age/size classes -Mean size at sexual maturity	- The Beverton and Holt per-recruit models assume knife-edge selectivity and constant fishing mortality and natural mortality for all ages. The general models avoiding these assumptions are preferred. - Assume the stock is in equilibrium i.e. that the biomass and age –structure are constant from year to year. - Assume that recruitment is constant from year to year, which is likely to be false at high fishing mortalities when low spawning biomass may reduce recruitment.

It is encouraged the use of a broad range of indicators and RP to reflect the life histories and fishery characteristics, ideally within a transparent fisheries harvest law understood and agreed to by managers and stakeholders (Caddy 2004)

DATA NEEDED VS DATA AVAILABLE

Collection of appropriate data is essential for the stock assessment, the identification of reference points, the setting of limits and actions. Initially, if data is poor, conditions uncertain, the management should be highly precautionary. In the data poor situation the management controls should be simple and robust, commensurate to the available data and easily collectable. When further data are collected, management should allow for increased exploitation levels (still sustainable). Moving from low to high exploitation levels can be seen as an incentive for fishers to provide good data (Pilling *et al.*, 2008)

In general according to Hoggarth *et al*. 2006, three main categories of data are useful for a stock assessment:

- **Catch and effort data** are usually obtained by catches at port, or by the submission of log books. Catch and effort data may be used directly in biomass dynamic models because, under certain conditions, CPUE gives an index of abundance. When time series and effort information are available, they may provide indication of trends in resource abundance (carefully interpreted!).
- **Data on size** are important for gauging possible changes to exploited populations over time, and for monitoring the outcomes of management interventions in relation to size. Size data can signal important changes (truncation of age classes and increasing, or heavy predominance of, small colonies in catches) that could be fishery induced and may warrant management attention. In long-lived species such as the red coral, loss of larger individuals may substantially affect reproductive output and may need management action.
- **Other biological** parameters of individuals and populations obtained through specific biological studies. Data on population demographics, especially density, abundance, size structure, and morphology (branching pattern), as well as certain life history traits (e.g. growth rates, reproductive strategy, and longevity), must be taken into consideration when developing fisheries management strategies as these provide indicators of the status of populations.

VALIDATION OF DATA

The verification or validation of data is essential to ensure that it is accurate, complete and gives a true indication of the state or value of the factors under consideration. The problems associated with the collection of fisheries data mean that the risks of collecting erroneous or inappropriate data are very high without careful and statistically valid design and monitoring of sampling approaches (FAO, 1997).

Different types of data will need to be verified in different ways (FAO, 1997). Some examples of methods to validate data include: checking logbooks against landings data (e.g. sales notes); sampling catches for species composition; comparing landings statistics with certificates of origin, trade and commodity production statistics (e.g. processed fish) and similar sources of information; inspecting data collection methods by statistical staff; interviews with fishers; observer schemes; reporting from sea on retained catch on entering and leaving the fishing zones; developing and implementing the use of vessel monitoring systems such as transponders to monitor the position, catch and activities of vessels; and instituting airborne and shipboard surveillance, associated with the boarding of vessels (FAO, 1997).

Adequate training and supervision of staff involved in monitoring are essential if the data collected are to be valid. It is important that they are prepared for this with adequate training and that every effort is made to maintain morale and an awareness of the role of their task (FAO, 1997).

According to FAO (2009) the type of data available permit to identify three main different starting situations, leading to different approaches, priorities and strategies to be implemented when planning the management of a given resource.

CASE A – no data/poor data

(No knowledge other than qualitative data from markets)

The priority actions are to:

- Apply conservative and precautionary approach (FAO Code and CBD).
- Avoid fishing pressure increase until a knowledge base is established.
- Develop knowledge base, at least for regular documentation of landings and effort information.
- Conduct interviews to assess fishery status, and collect information on traditional ecological knowledge for fishery history.
- Encourage traditional customary use of biological resources compatible with sustainable use and conservation.
- Identify possible critical habitat/species from published literature and consultation.
- Assess potential of MPAs/temporal measures as management tools.

Case B – medium data

(Short- or long-term catch data. Length data by year. No effort data. No local biological studies)

- Apply conservative and precautionary approach (FAO Code and CBD).
- Avoid increase in fishing pressure until knowledge base strengthened.
- Assess length and catch data for any changes in length over time; declining average length or catches might signal overfishing.
- Consider reductions in effort if substantial declines in length or catch.
- Collect fishing effort data.
- Strengthen knowledge base. Plan for biological and ecological studies on key species.
- Apply traditional knowledge to reconstruct fishing history and assess perceptions on fishery status.
- Identify possible critical habitat/species from published literature and consultation.
- Assess potential of MPAs/temporal measures as management tools.

Case C – rich data

(Species-specific length data, short- or long-term landings and fishing effort data by year by major fishing sectors, biological studies conducted on few major species. Little ecological information)

- • Able to move towards more sustainable use of resources.
- • Refer to Precautionary Principle, FAO Code, CBD and EAF.
- • Apply Biological Reference Points (BRPs) where possible.
- • Manage for sustainable yield concomitant with maintenance of biodiversity.
- • Assess status For long-term data sets

DECISION RULES

Reference points should be agreed with stakeholders in advance and used to trigger specific conservation and management actions, also agreed in advance. Stakeholder involvement in fact provides an opportunity to explore and integrate ideas together, generate new options and solutions that may not have been considered individually. Such agreements may be formalized as “harvesting strategies” and “decision control rules”. These jointly define how the conceptual and technical reference points will trigger particular actions at different states of the fish stocks or other economic or environmental indicators.

Both the harvesting strategies and the control rules should be clearly specified in mathematical or logical terms, and should show what management action will be taken, depending on the positions of the indicators relevant to the reference points.

When precautionary or limit reference points are approached, measures should be taken to ensure that they will not be exceeded. If such reference points are exceeded, recovery plans should be implemented immediately to restore the stocks.

Appropriately widespread consultation should be undertaken with the interested parties (Stakeholders) during the process of formulating or amending the fisheries management plan (FAO, 1997). In this context, Stakeholder involvement can increase stability in a complex environment and expand capacity rather than diminish it under changing circumstances. All of these issues are becoming increasingly important in the context of a marine planning to avoid incompatible uses, resolve conflicts and move toward ecosystem-based management.

Two types of stakeholders are generally defined (The World Bank 1996)

1) primary stakeholders who are directly affected (positively or negatively) by proposed interventions/policies; either because they depend on it for their livelihoods or they are directly involved in its exploitation in some way.

2) secondary stakeholders who are indirectly affected by proposed interventions/policies. Secondary stakeholders include those who have technical expertise and/or links to primary stakeholders, e.g. non-governmental organizations (NGOs), various intermediary or representative organizations and technical and professional bodies. They often represent public interests

Stakeholder involvement as the participation of stakeholders in policy-making, planning and management processes, can generally take place, among others, in three broadly defined ways (Sen and Nielsen, 1996):

- **Instructive stakeholder involvement**. Where government is the decision-maker, but mechanisms exist for limited exchange of information with other stakeholders. This tends to be government informing stakeholders about decisions they plan to make.
- **Consultative stakeholder involvement**. Where government remains the decision-maker, but there are formal and informal mechanisms for consultation with stakeholders. Stakeholders have some degree of influence over outcomes.
- **Cooperative stakeholder involvement**. Where all primary stakeholders and government work together as partners in the decision-making process. Secondary stakeholders play a consultative role.

Although there are clear benefits, experiences with co-management have shown that it is neither simple nor quick to establish (Hoggarth *et al*. 2006).

Working with local stakeholders is not necessarily easy and requires special training and skills. Co-management requires compromise, respect and trust among stakeholders and a commitment to transparency, empowerment and communication, all of which may take time to develop, especially against a background of top-down regulation and control. Methods that enable this are therefore crucial.

Co-management thus requires that government agencies and researchers adopt a new way of thinking, develop new skills, and find new ways of interacting with other stakeholders

RECOVERY PLAN

A recovery plan may be considered a specialized control rule which applies when the stock is outside safe biological limits.

States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine the action to be taken if they are exceeded.

MANAGEMENT MEASURES

Once operational objectives, reference points, a harvesting strategy and decision control rules have been technically defined and agreed, a management strategy can be developed (FAO, 2002).

The management strategy is the sum of all the management measures that are selected to achieve the biological, ecological, economic and social objectives of the fishery.

Management measures can be classified as follows:

• Technical measures, usually permanent regulations on gear type or gear design, and closed areas and closed seasons;

• input (effort) and output (catch) controls, e.g. a limit on the total number of vessels in a fishery, or an annual total allowable catch (TAC); and any access rights designed around the input and output controls

TECHNICAL MANAGEMENT MEASURES

Technical measures aim to control the exploitation pattern of the fishery. The main technical measures are size limits, closed seasons, closed areas and gear restrictions or bans. Technical measures are usually designed to protect reproductive potential, prevent growth overfishing, or prevent the use of destructive fishing gears.

Technical measures may either be set with a combination of common sense and limited technical data, or using the output of models. Optimal size limits and the timings of closed seasons can be estimated using analytical models.

INPUT MANAGEMENT MEASURES (FISHING EFFORT CONTROL)

Fishing effort restrictions aim to limit fishing mortality (F) by controlling one or more of the following factors:

1) The total number of vessels in the fishery, e.g. by allocating limited access rights and restricting the number of licenses issued;

2) the effort allowed by each individual vessel, e.g. the number of gear units allowed, the number of trips that may be made each year, or the number of days at sea;

3) The power of individual vessels, e.g. the size or engine power of the vessels, or the types of gear that may be used.

Recommendations on adjustments to fishing effort (e.g. to bring Fnow closer to F_{MSY} or Fpa) can be produced by analytical models (e.g., Beverton and Holt “invariants” methods), or using biomass dynamic models.

OUTPUT MANAGEMENT MEASURES (CATCH CONTROL)

Output controls such as the total allowable catch (TAC) indirectly control the fishing mortality. Approximate catch limits may also be estimated using the Beverton and Holt “invariants” methods or using empirical methods based on resource area and nominal effort measures

MCS SYSTEM (MONITORING, CONTROL, SURVEILLANCE)

Monitoring, control and surveillance (MCS) is all about compliance to fishery management measures. Monitoring gathers information on the fishery that is used to assist in developing and assessing appropriate management measures, while surveillance uses this information to ensure that these controls are complied with.

If a more precise meaning for MCS is required reference should be made to a definition developed by an FAO Expert Consultation in 1981):

(i) Monitoring – the continuous requirement for the measurement of fishing effort characteristics and resource yields;

(ii) Control – the regulatory conditions under which the exploitation of the resource may be conducted; and

(iii) Surveillance – the degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities.

The MCS system may be subdivided in 4 different components:

BEFORE FISHING

Control of fishing vessels or fishers before fishing trips, at the time of the issue of a license, through annual frame surveys or through spot checks is a useful and low-cost MCS operation that can facilitate the following:

the checking of gear and effort control mechanisms to ensure that regulations or license conditions are complied with;

if illegal gear is detected or shown then it can often be secured so that it is not possible to use it while fishing;

To gather information for fishery statistics;

DURING FISHING

Fisheries MCS operations carried out at sea can have an impact as a deterrent or for enforcement of all control measures but generally they are most significant for output and technical controls. It is the only method that allows

infringements in relation to logbooks, gear types and catch to be detected on the site of the crime (while fishing).

AT LANDING

The place of landing provides a bottleneck in fishing operations where vessels can be checked, documents such as logbooks collected and the corals being landed can be weighed. Monitoring of landings is one of the most important elements of MCS operations when output controls are in place.

AFTER LANDING

Inspections of markets, transport providers and sales organisations can provide valuable information about the catches. This type of operation generates valuable information for biological and economical crosschecks as well as validation of other MCS information. It is also a viable operation for control of illegal catches, especially undersized

IMPLEMENTATION AND ENFORCEMENT MECHANISMS

The management plan provides details on how the fishery is to be managed and by whom. It should include a management procedure which gives details on how management decisions are to be made according to developments within the fishery, particularly in response to changes in resource status from year to year. The choice of approach (instructive, consultative, cooperative) will depend on the legal and institutional environment, decision-making processes and the capacity of stakeholder organizations in each country. None of these processes are static and are likely to adapt to changes in experience and situation(s) over time.

Finally, it is critical that stakeholders are involved early and continually in all phases of the management, including the planning, plan evaluation, implementation and post-implementation phase, and not just consulted afterwards. In addition to participating, stakeholders need to be empowered to enable their full engagement. Activities directed to empower stakeholders, including environmental education, capacity development, and social communication, are primarily focused on building constituency for the management plans, and will ultimately aim to establish behaviour and attitude changes so that the process can be sustainable over time

ASSESSMENT OF PERFORMANCE

Measuring performance of the MCS system against the strategic targets should be an annual activity of the MCS organization and it should involve feed-back from involved interested parties. The most practical way to estimate compliance is to compare the number of detected infringements in relation to

the percentage of the population being sampled. The number of infringements can then be raised to the estimated number in the entire population that is being sampled on a monthly, seasonal or annual basis. The resultant estimate may not be completely accurate for many reasons but it does give a reasonable estimate of the level of compliance for a given management measure and can be compared both to the target and across time as a trend for changes in compliance.

REVIEWING SYSTEM AND TIMEFRAME

Factors of importance to fisheries change through time; therefore MPs must be periodically reviewed.

The mechanism for review should be specified in the plan itself.

The review should consider whether monitoring is achieving the quantity and quality of data collection required for the regular updating of management measures.

In general, the consultation process should parallel the initial process used to develop the plan but is likely to be shorter in time and should only require one draft review document seeking comments from interested parties and the public, and a final draft to be submitted for approval. Major reviews may require public meetings, where interested parties can air their views about the proposed amendments to the plan. Longer-term reviews may provide evidence that an objective set earlier (e.g. recovery to a certain target abundance level by a particular date) is no longer appropriate (FAO 2003).

Often, plan reviews are motivated by changes in the socioeconomic status of the fishery or the biological status of the fish stock. It is to be expected that, after the initial development of a plan, it will take several years to close the information gaps that may have been identified during its development. Therefore, a major review of an MP is unlikely to happen until several years have passed and people have had time to review and evaluate the need for, and effects of, possible new management regulations MPs therefore must be reviewed whenever it is precautionary to review the plan, not just when new data become available. It is therefore recommended that within the MP a regular schedule for reviews is defined. At a minimum, a plan should be reviewed every five years.

THE REGIONAL MANAGEMENT PLAN FOR RED CORAL (RMP)

CONTEXT

GFCM (General Fisheries Commission for the Mediterranean) has been involved in red coral management since the 1980s. In those years, in response to the declining yields and intense international poaching in the Mediterranean region, a first proposal to regulate trade of red coral by CITES was advanced by Spain (CoP6, 1987). After the rejection, the GFCM organized three Technical Consultations on Red Coral (Spain 1983, Italy 1988 and Algeria 1989) in order to provide helpful guidelines for a more effective management of the resource. However, the suggested measures were implemented sporadically and in different forms in the different Mediterranean countries.

More recently, new concerns about the sustainability of coral harvest due to past and ongoing exploitation led to two new proposals of including corals in CITES: in 2007 by USA and in 2010 by Sweden (in behalf of EU) and USA. In particular, the second proposal aimed at listing the whole genus *Corallium* in CITES and the third and last one at listing the whole family Corallidae. A broad discussion about the opportunity (pros and cons) to include *Corallium rubrum* involved the general public as well as the scientific community, the fishermen and the industry. It is out of the scope of this document to discuss or comment the validity of the proposals and/or of the rejections; Appendix (first part) contains the list of the main documents related to the CITES, FAO and red coral issue for those who are interested in deepening the 'red coral CITES issue'.

In the two following years, after the rejection of the last proposal GFCM organized two Transversal workshops on the Red Coral (September 16-17 2010 in Alghero, Italy & October 5-7 2011 in Ajaccio, Corsica, France) in order to start the process that will lead to the implementation of a regional management plan (at the GFCM level) and local management plans (at the national level) designed to the sustainable management and conservation of this important resource. The results and conclusions of these meetings have been in part translated into binding recommendations, adopted in 2011 and 2012 by the GFCM.

The full text of them is provided in Annex A and Annex B they will be discussed in detail in the next paragraphs.

PREMISE

The present document is the draft of the Regional Management Plan for red coral.

It has been introduced to the 13th session of the Subcommittee (SC) on Marine Environment and Ecosystem in February 2013.

On the basis of the discussions held at the SC, the first draft was refined including requirements and needs for its implementation.

The revised draft was then introduced to SAC in April 2013.

Finally, the final proposal of RMP has been presented to the GFCM Commission in May 2013.

Practically, the management plan, both at the regional and at the national level, should to translate high-level policy goals into day-to-day management activities, providing for a rigorous setting of operational objectives, decision rules, management measures and evaluation of management performance.

Once approved in its definitive form by the Commission it will be implemented starting from the ensuing fishing season .

CONTENTS (RMP)

The Regional Management Plan for red coral in the GFCM competence area (henceforth RMP) is composed by the following parts:

- Definition
- Relationship with the NMPs
- Background information
- Principles
- Goals and broad objectives
- Operational objectives
- Reference points and decision rules
- Recovery strategy (eventual)
- Management measures
- MCS system
- Implementation and enforcement mechanisms
- Reviewing system and Timeframe
- Stakeholder role and involvement
- Conservation and Ecosystem-related issues
- Future developments
- Definition (RMP)

The Regional Management Plan for red coral is prepared according to the Recommendation GFCM/35/2011/2 on the exploitation of red coral in the GFCM Competence Area that states:

- "Scientific and technical knowledge acquired through the actions stipulated under paragraphs 3 (c), 5, 7 and 9 above shall be taken into account by SAC with a view to develop an adaptive regional management plan" (Paragraph 10)

and the Recommendation GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area that states:

- "In addition to substantiate the Terms of Reference provided in the 2012 Work Plan of its Sub-Committee for Marine Environment and Ecosystems, and pending the development of a regional management plan for red coral, as requested by the Recommendation GFCM/35/2011/2..." (Paragraph 6)
- "The GFCM Secretariat is requested to take actions in support of the SAC with a view to put into operation, not later than 31 May 2013, the adaptive regional management plan." (Paragraph 7)

The RMP contains all the management measures applicable at the regional level, necessary for a sustainable management of the red coral resource in the GFCM competence area.

The Regional management plan for red coral follows the provisions of the 'Guidelines on a general management framework and presentation of scientific information for multiannual management plans for sustainable fisheries in the GFCM area' (henceforth 'the GFMC Guidelines'), adopted by GFCM in 2012, and reported in full in Annex C of the present document.

However considering that, as explicitly stated in Paragraph 1, the Guidelines mainly refers to the management of demersal and small pelagic stocks ('GFCM may develop and adopt multi-annual management plans for fisheries exploiting demersal and small pelagic stocks,...'), it is worth stressing that red coral, a sessile, slow growing species, poses additional, different and new challenges, implying that not all the indications and provisions included in the Guidelines should be easily applied or strictly followed in its management.

RELATIONSHIP WITH THE NMPS

Considering the Recommendation GFCM/36/2012/1 Paragraph 5 stating that 'the adaptive regional management plan [is] based, whenever available, on national plans' the following paragraphs define the respective contents and area of application of the RMP and NMPs.

The provisions contained in the RMP apply to all the red coral banks within the GFCM competence area while the NMP defines the management of red coral banks occurring within the territorial waters of each specific country.

In accordance with to Point 7 of the GFCM Guidelines the adoption of the present Regional management plan for red coral does not affect the possibility for CPCs to develop their own national management plan, provided that

objective and measures therein are not less strict or in contradiction with GFCM measures.

Therefore NMP must contain all the management measures provided for by the RMP as well as additional or stricter regulations with respect to the RMP, necessary for a sustainable management of the red coral resource at the national level.

Within the context of GFCM priorities and strategies, action could be undertaken to assess the progress or capacity of GFCM member countries to formulate National Management Plans, identify where national action, technical assistance or capacity strengthening might be needed.

BACKGROUND INFORMATION (RMP)

The background information is included in two separate files titled 'First Part - Background information' and 'Second part – socio-economic aspects' which are to be regarded as integral part of the RMP. They contain data on the main threats and environmental issues related to red coral and coralligenous biocoenosis along with data on the biology, fishery, past and present management and production of *C. rubrum* at the GFCM and country level. The socio-economic aspects of the red coral fishery have been described and analysed. A brief summary of the main international legal instruments for red coral and international legal framework for management is also provided.

It is worth mentioning that, despite the importance of socio-economic aspects of red coral fishery, stunningly important in driving the exploitation of the resource, reliable, independent and updated data on these issues were very difficult to retrieve. Therefore the socio-economic paragraphs included in the present documents should be regarded as not exhaustive, and could be greatly improved in the future thanks to data provided by the interested countries and stakeholders, and analysed by specialized social and economic scientists.

PRINCIPLES (RMP)

In a broad general sense, the RMP for red coral adheres to the six principles known as The Lisbon Principles (Costanza *et al.*, 1998) that aim at promote sustainable governance of the oceans:

- **Responsibility principle** Responsibility to use resources in an ecologically sustainable, economically efficient and socially just manner
- **Scale-matching principle** Decision-making at the scale of governance which has the most relevant ecological information, which considers actors, and which internalizes costs and benefits
- **Precautionary principle** The need to take uncertainty about potentially irreversible impacts into account by erring on the side of caution

- **Adaptive management principle** Monitoring social, economic and ecological systems because they are dynamic and have some level of uncertainty; learning-by-doing
- **Full-cost allocation principle** The need to identify and allocate all internal and external costs and benefits (social and ecological) of alternative uses of resources
- **Participation principle** The importance of full stakeholder participation in the formulation and implementation of decisions about environment and resources

In particular, the RMP recalls the FAO principle according to which 'fisheries management should aim at achieving the optimal and sustainable utilization of the natural resource for the benefit of humanity, while maintaining biodiversity' (FAO, 2011).

The RMP is informed by the scientific information available on *C. rubrum* and other related coral species, which is used to develop the rules under which the fishery should operate to ensure its sustainability (FAO, 2011).

In other words, in the view adopted here 'the resource system should be managed, not for products and commodities but for resilience, defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedback' (FAO, 2011).

GOALS AND BROAD OBJECTIVES (RMP)

The Regional Management Plan (RMP) main goal is to keep red coral stocks at a sustainable level.

The Regional Management Plan (RMP) broad objective is to developing a responsible management strategy for the red coral resource within the GFMC competent area.

In particular, accordance with to Point 2 of the GFCM Guidelines the Regional management plan for red coral is designed to counteract overfishing (reported occurring in many areas especially for the shallower populations) and prevent overfishing in areas still not fully exploited, while providing high long-term yields. Moreover, it aims at maintaining, to the extent possible, the stocks size at levels which can produce the optimum sustainable yield and with a low risk of stocks falling outside safe biological limits.

OPERATIONAL OBJECTIVES (RMP)

The broad objectives defined above are further developed into explicit **"operational objectives" (Oob)** that are the primary tasks of red coral fisheries management.

The choice of the operational objectives proposed here is determined by the data that are or will be available in the near future (within 1-2 years) at the GFCM level thanks to the collection data framework provided by the Recommendation GFCM/35/2011/2 and GFCM/36/2012/1.

It is expected that in the next years the quantity of data will increase as well as their quality. Any new valid information shall lead to reconsider the present Operational Objectives and eventually to set new ones. This is also in line with GFCM/35/2011/2 Paragraph 10 that affirms the need to develop an adaptive regional management plan based on the best available Scientific and technical knowledge.

However, considering the Precautionary Principle: 'The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures' (FAO CODE OF CONDUCT FOR RESPONSIBLE FISHERIES, 1997), the implementation to the present RMP should not be postponed anymore.

In accordance with to Point 8 of the GFCM Guidelines, for the attainment of the previously defined goals and objectives the Regional Management Plan for red coral includes several reference points as well as the correlated target, threshold (precautionary) and limit reference points.

All the above considered the 'provisional' operational objectives of the RMP are:

RMP Oob1: To Control that the actual legal size limit for harvesting red coral colonies is enforced at the GFCM level;

RMP Oob2: To maintain the same catch level of three previous years, in order to keep the fishery working while waiting for a consistent assessment of red coral populations based on sound scientific information;

The rationale for the choice of the **RMP Oob**1 is to have an indicator of the performance of the management measures already imposed at the GFCM level.

The rationale for the choice of the **RMP Oob**2 is to allow the fisheries to keep on at the actual level of exploitation, supposing it to be sustainable.

The Oob2 is temporary, with the prevision that the level of exploitation should be changed if the future data collected by the countries within the GFCM collection data framework will reveal that this fishing effort is above the sustainable level.

REFERENCE POINTS AND DECISION RULES (RMP)

In order to measure the performance of management in achieving the objectives, “reference points” (RP) are fixed for each Oob.

To each RP three values are associated:

Target reference point (TRP), corresponding to a situation considered as desirable and to be achieved on average;

Limit reference point (LRP), indicating a situation that are undesirable and to be avoided at all costs;

Threshold or Precautionary reference point (PaRP): providing a threshold at which initial actions can be taken to reduce the risk that the limit may be broken.

In accordance with to Point 9 of the GFCM Guidelines, target, thresholds and limit reference points of the Regional management plan for red coral have been chosen along with a range of management actions depending on the available scientific and socio-economic data for the resource. However, considering the peculiarity of the red coral resource and the structural lack of reliable and updated data on actual yield and populations’ status in many areas of the distribution range, it is worth pointing out that the reference points frequently used in fisheries management (whose application is advised by Points 11-13 of the Guidelines) can hardly be applied. In any case, the proposed reference points reflect the paucity of information and are to be regarded as provisional and may be revised on the basis of the SAC advice and GFCM deliberations (Point 13).

A decision control rule is associated to each Oob.

The decision control rule defines in advance what management action will be taken, depending on the position of the indicator relevant to the reference point.

The value of TRP for **RMP Oob**1 is chosen on the basis of the actual size limit imposed by the GFCM Recommendations and the relative allowance of 10% in live weight for undersized colonies.

The value of LRP for **RMP Oob**1 is chosen on the basis of the TRP increased by a further 10%. The presence of 20% of undersized coral colonies in the landings, a value double of the current value is considered as the limit situation to be avoided.

The value of PaRP for **RMP Oob**1 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering a value intermediate between the TRP and the LRP that is an

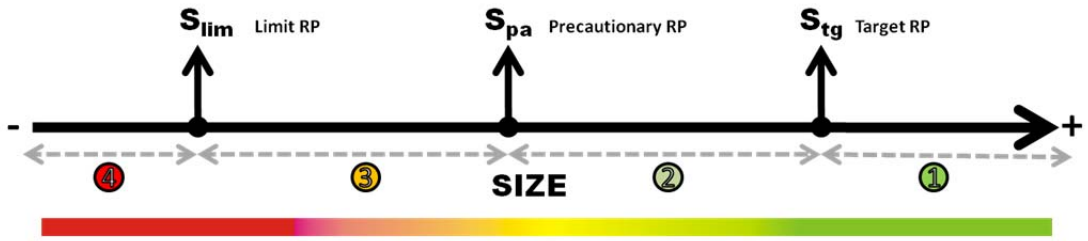
allowance of 15% of undersized colonies. This provides a threshold at which initial actions should be taken to reduce the risk that the limit is broken.

The decision control rule for the **RMP Oob**1 is shown in Figure 1, it shows also the relative reference point, target, limit and precautionary RP.

It provides that actions at the GFCM level should be undertaken when the % of undersized colonies in landing data is above the actual allowance value, calling countries for a stricter implementation of this management measure through stronger enforcement defined by the interested CPCs.

The values 10%, 15% and 20% were chosen arbitrarily, being considered 'common-sense' RP, they can be specified otherwise on the basis of scientific evidence or pre-agreed decisions among all the stakeholders.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL STOCKS AT A SUSTAINABLE LEVEL	Control that the size limits are enforced	SIZE=S (average size landing data)	Target= S_{tg} (90% of landings is at average size = legal size limit LS) Limit=S_{lim}= (80% of landings is at average size = legal size limit LS)	Threshold= S_{pa}=(85% of landings is at average size = legal size limit LS)



Decision control rule		
1	(Snow≥Stg)	No action
2	(Spa<Snow<Stg)	Recommend stricter controls
3	(Slim<Snow<Spa)	Recommend stricter controls Surveys to evaluate the actual size structure
4	(Snow<Slim)	Recommend stricter controls Surveys to evaluate the actual size structure Evaluate the possibility to close the fishing

Figure 1 - Decision control rule for the RMP Oob1 and relative target, limit and precautionary RP.

The value of TRP for **RMP Oob**2 is chosen hypothesizing that the average catches of the previous three years are at a sustainable level.

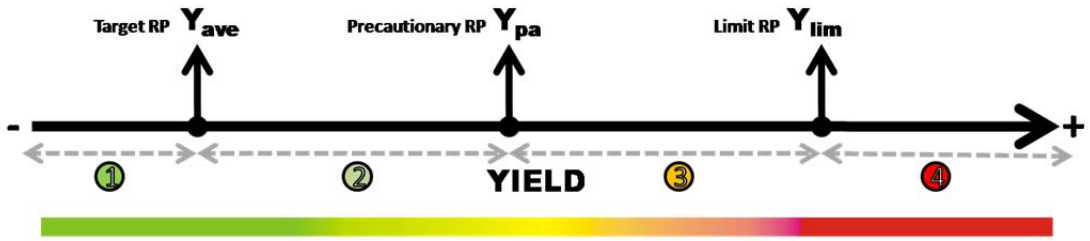
The value of LRP for **RMP Oob**2 is chosen on the basis of the TRP increased by a further 20%. The increasing of 20% of total catches at the GFCM level is considered as the limit undesirable situation to be avoided.

The value of PaRP for **RMP Oob**2 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering that an increasing of 10% of total landings provides a good threshold at which initial actions should be taken to reduce the risk that the limit is broken.

The decision control rule for the **RMP Oob**2 is shown in Figure 2; it shows also the relative reference point, target, limit and precautionary RP.

It provides that actions at the GFCM level should be undertaken when the catches calculated from landing data are 10% of the average catches of the previous 3 years, calling countries for a stricter implementation of catch control defined by the interested CPCs.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL HARVESTING AT A SUSTAINABLE LEVEL	Maintain the average catch level of three previous years	YIELD= Y (database FAO)	Target= Y_{ave} (Average yield past 3 years) Limit=Y_{lim}= Y_{ave}+X	Threshold= Y_{pa}=Y_{ave}+(1/2x)



Decision control rule		
1	($Y_{now} \leq Y_{ave}$)	No action
2	($Y_{ave} < Y_{now} < Y_{pa}$)	Recommend catch control at the national level
3	($Y_{pa} \leq Y_{now} < Y_{lim}$)	Recommend catch control at the national level Surveys to evaluate the actual biomass
4	($Y_{now} \leq Y_{lim}$)	Recommend stricter catch control at the national level Surveys to evaluate the actual biomass Evaluate the possibility to close the fishing

Figure 2- Decision control rule for the RMP Oob2 and relative target, limit and precautionary RP.

RECOVERY STRATEGY (EVENTUAL) (RMP)

The GFCM Commission and CPCs should determine in advance the recovery strategy that is the actions to be taken when the stock is outside safe biological limits. The pre-agreed recovery strategy allows to implement without delay the necessary and urgent measures and actions.

MANAGEMENT MEASURES (RMP)

Considering the previously described **RMP Oob**1 and **RMP Oob**2 and the relative RPs the management measures already in place provided for by the GFCM Recommendations GFCM/35/2011/2 and GFCM/36/2012/1 are adequate to achieve the objectives.

The current management measures are reported below:

TECHNICAL MEASURES ON GEAR

Recommendation GFCM/35/2011/2

Paragraph 1 Contracting Parties and Cooperating non-Contracting Parties (CPCs) in the GFCM Competence Area shall prohibit the use of any kind of towed gear, irrespective of the specific name, to exploit red coral. The only permitted gear for the harvesting shall be a hammer used by a scuba diver. This provision is without prejudice to stricter measures which may be adopted or maintained by CPCs.

Paragraph 2 CPCs shall prohibit the use of the Remotely Operated underwater Vehicles (ROVs) in the GFCM Competence Area for the exploitation of red coral.

Paragraph 3 By way of derogation from paragraph 2, formally granted by a Contracting Party on the basis of a specific fisheries authorisation, the use of ROV may be authorized in zones under national jurisdiction only and subject to the following conditions:

a) In Contracting Parties where ROV is already authorized only for reasons of observation and prospection and provided that ROV models cannot be equipped with manipulator arms or any other device allowing the cutting and harvesting of red coral. Contracting Parties concerned shall provide to the GFCM Secretariat the list of authorizations issued (specifying the date of their issuance) not later than the end of September 2011 and shall ensure that no new authorisation will be granted. The authorisation of ROV for prospection shall only be allowed until 2015, unless scientific advice states otherwise.

b) The provision in paragraph (a) above is without prejudice to Contracting Parties which have not yet authorised the ROV for prospection and may wish to do so. This authorisation shall be granted only on the basis of scientific

results obtained in the context of national management plans and showing no negative impact on the sustainable exploitation of red coral.

c) Within a framework allowing for scientific experimental campaigns both for observation and harvesting during a limited period not extending beyond 2015, carried out under the supervision of national research institutions and/or in collaboration with national, international bodies as well as any other relevant stakeholder. The scientific results of these studies will be presented to the SAC, through the GFCM Secretariat, for its consideration and advice, including the status of the stock, the impact and the advisability of using ROV for direct harvesting of red coral. This derogation shall be without prejudice to stricter measures which may be adopted or maintained by Contracting Parties.

Paragraph 8 SAC is requested to advice on the status of red coral banks and, not later than 2014, on the impact and adequacy for the continuation of using ROV for the prospection and harvesting of red coral banks.

TECHNICAL MEASURES ON SIZE

Recommendation GFCM/36/2012/1.

Paragraph 1 Contracting Parties and Cooperating non-contracting Parties of the GFCM (hereafter referred to as CPCs) shall ensure that red coral colonies whose basal diameter is smaller than 7 mm at the trunk, measured within one centimetre from the base of the colony, is not harvested, retained on board, transhipped, landed, transferred, stored, sold or displayed or offered for sale as raw product.

Paragraph 2 By way of derogation from Paragraph 1, Parties may authorize a maximum tolerance limit of 10 % in live weight of undersized (<7 mm) red coral colonies provided that a strict national management framework has been developed ensuring an authorization system and specific monitoring and control programmes are in place.

Paragraph 3 By 31st December 2014 at the latest, the SAC is requested to assess the impact that the implementation of the 10 % tolerance margin can have on the size composition of catches and on the sustainability of red coral harvesting.

Paragraph 4 Provisions under paragraphs 1 and 2 above are without prejudice to stricter measures which may be adopted or maintained by CPCs in their national management framework.

TECHNICAL MEASURES ON DEPTH LIMIT

Recommendation GFCM/35/2011/2

Paragraph 4 CPCs shall ensure the prohibition of the exploitation of red coral populations at depth less than 50 m until scientific studies, as validated by GFCM-SAC, indicate otherwise

Paragraph 5 By way of derogation from paragraph 4, Contracting Parties may authorize exploitation of red coral at less than 50 m provided that an appropriate national management framework has been developed ensuring an authorization system and that only a limited number of red coral banks are exploited by the establishment of adequate spatio-temporal closures. This derogation shall be without prejudice to stricter measures which may be adopted or maintained by Contracting Parties.

If new data provide evidence that the measures already set are no longer appropriate, due amendments to the RMP should be made without delay.

In particular, the size limit imposition is to be regarded a 'temporary' measure, fixed at an intermediate value between the request of scientists (10 mm) and that of fishers (traders) (not legal limit). All actions should be undertaken to obtain valid scientific data that confirm the current size limit is 'biologically sustainable'.

MCS SYSTEM (RMP)

For the compliance to the previously described fishery management measures the following Monitoring, control and surveillance (MCS) actions are already provided for by the GFCM Recommendations GFCM/35/2011/2 and GFCM/36/2012/1.

DESIGNATED PORTS

Recommendation GFCM/36/2012/1.

Paragraph 5 With a view to ensure adequate monitoring and data gathering needed to set up the adaptive regional management plan based, whenever available, on national plans, the CPCs shall ensure that red coral catches are landed only in a limited number of designated ports with adequate port facilities. The list of designated ports shall be communicated to the GFCM Secretariat not later than 31st January 2013.

LOGBOOK

Recommendation GFCM/35/2011/2

Paragraph 7 CPCs shall ensure that authorized fishermen record and report to national authorities the daily catches and fishing effort by area and depths (e.g. number of fishing days, numbers of diving, etc) while allowing, whenever the case, comparisons with results of ROV experimental campaigns. This information must be made available to GFCM Secretariat for transmission to SAC for its considerations and advice.

DATA COLLECTION

Recommendation GFCM/36/2012/1

Paragraph 8 In order to collect data on harvesting of red coral, CPCs shall compile data collection forms provided by the Secretariat. CPCs shall return the filled forms by 31st January of each year starting with the 2013 harvesting season.

POST LANDING ACTIONS (TRACEABILITY MECHANISMS)

Recommendation GFCM/36/2012/1

Paragraph 6 In addition to substantiate the Terms of Reference provided in the 2012 Work Plan of its Sub-Committee for Marine Environment and Ecosystems, and pending the development of a regional management plan for red coral, as requested by the Recommendation GFCM/35/2011/2, the SAC shall also evaluate the feasibility and implications, including services needed and economic consequences, to establish traceability mechanisms including, inter alia, a DNA bar-coding system for red coral.

In particular, a special procedure for the traceability of red coral colonies should be implemented by CPCs with the obligation of: 1. Inclunding in the logbook a specific section for trade data; 2. Certifying total weight and number of colonies in the relevant pages of the logbook at the designated ports within 72 hours from collection; 3. Completing, at the time of each sale, the relevant data section of the logbook with the data of the sold colonies, of the seller and the buyer. Furthermore, the seller must send a copy of that, within 72 hours of sale, to the competent authorities in the territory where the sale occurred. The feasibility of labelling all the colonies with a unique univocal code, to be mandatorily cited in the selling documents, should be also evaluated.

Further actions are recommended should be developed such as, *inter alia*:

VALIDATION OF LOGBOOK DATA

A mechanism for the verification or validation of data from logbooks should be implemented to ensure that they are accurate, complete and gives a true indication of the fishery.

To validate data the checking logbooks against landings data is suggested.

Spot or regular monitoring at landing

A detailed program of data monitoring at landing should realized on a regular basis and urgently implemented.

Apart from being weighted, the colonies being landed must be counted and measured on a timely planned and standardized way by trained personnel. This information is essential to the checking and validation of logbooks. This type of data is also important for the assessment of the stock status.

Adequate training and supervision of staff involved in monitoring are essential if the data collected are to be valid (FAO 1997).

OBSERVER PROGRAM

Considering that monitoring of landings does not detect undersized colonies or trans-shipped coral or coral sold prior to landing, the setting up of a detailed program of observers at sea it is highly recommended.

The observer programs can represent a very effective way to implement and to ensure compliance with legal size limit.

Furthermore, the observers can provide valuable information for the scientific studies if asked to collected biological data.

To perform their task adequately, specialized training, manuals and suitable equipment and supervision should be provided to observers.

STANDARDIZED SCIENTIFIC DATA COLLECTION PROGRAM

Considering that valid scientific information is essential to develop meaningful management measures, a standardized data-collection program for red coral in the GFCM area should be urgently planned, adequately funded and urgently implemented. The design, protocols and timeframe for sampling as well as the methodologies for the analyses should be defined accordingly to the allocated budget and priorities and defined by an ad-hoc WorkGroup.

In general, in accordance with Point 19 of the GFCM Guidelines, the GFCM and its CPCs should, individually and collectively, engage in capacity building efforts and other research cooperative activities to improve knowledge on red coral fishery and exploited stocks and to support the effective implementation of this Regional management plan, as adequate, entering into cooperative arrangements with other appropriate international frameworks.

Moreover, in accordance with Point 20 of the GFCM Guidelines, Members and cooperating non-Members should: i. improve the implementation of data collection and provision to the SAC; ii. support research programmes and

projects supporting the work of the SAC; iii. contribute to the training of scientific researchers, including young scientists.

IMPLEMENTATION AND ENFORCEMENT MECHANISMS (RMP)

In order to be effective, the RMP must be fully implemented and be capable to be enforced.

In accordance with to Point 6 of the GFCM Guidelines, all the Contracting Parties and Cooperating non-contracting Parties of the GFCM agreed to cooperate with a view to gradually develop, implement and enforce the present RMP.

Considering that implementation and enforcement should take into account the unique nature of national legal systems and related economic, social, and cultural circumstances, CPCs are asked to take all measures to ensure that the provisions of the RMP are covered under national legislation. The implementation and rule-enforcement mechanisms of the RMP should be defined by setting up a series of laws, and regulations at the national level. In particular, increase enforcement against poaching, reported to be widespread and in alarming increase, is highly envisaged.

CPCs shall identify, as appropriate, focal points to deal with the implementation, enforcement, amendment/reviewing process of the present RMP.

REVIEWING SYSTEM AND TIMEFRAME (RMP)

In general, the adaption and revision of the present Regional Management Plan should be realized in accordance with Point 15, 17, 18 of the Guidelines.

In particular, the SAC should provide each year, whenever possible, or on a longer time scale depending on the investigated stocks and availability of the data, advice on the status of exploited stocks and pressure exerted by fishing activities and monitor the achievement and maintenance of the objectives of the management plan so that, whenever the case, required adaptation of the management plan could be attained (Point 15). The reviewing of RMP should occur every 3-5 year or earlier if new data and/or urgent matters require for the anticipation of the process.

Furthermore, whenever the GFCM, on the basis of advice from SAC, finds that the exploitation rate and associated spawning stock biomass levels or other suitable indicator are no longer appropriate to achieve the objective(s) of the plan, then it should revise the reference levels in accordance with Point 17.

Moreover, where SAC advice indicates that the specific targets of the Regional plan are not being met the GFCM should decide a revision of management measures to ensure the sustainable exploitations of the resource (Point 18).

THIRD PART- THE MANAGEMENT of red coral

The review should be based on all the information gathered through the annual reports coming from the CPCs, and from the compilation of all the available data on red coral from different sources (scientific community, society, industry, fishers).

CPCs should report annually to GFCM on the implementation, enforcement and results of the present RMP and their eventual NMPs on red coral. Furthermore, any problem and emerging issue, as well as proposals for amendment of the established management measures, should be submitted.

CPCs should include these requests and transmit them to GFCM concomitantly to the submission of the red coral data form within the data collection framework. In case of urgent questions, specific separate reports should be submitted at any time.

Following receipt of this communication concerning red coral and the present RMP, the GFCM Secretariat will take up action and inform the SAC in order to timely include the question in the working agenda of the pertinent Subcommittees and working groups.

Furthermore, the GFCM shall promptly communicate all relevant information to all interested CPC, partners and organizations and solicit them to involve, in the proper way defined by each one, all pertinent stakeholders for providing advice and recommended actions.

All the interested parties are encouraged to propose amendments to the plan. Reports asking for amendments or implementations of the present RMP, based on new relevant information on the status of the red coral population, environmental and ecosystem, fishery, and socio-economic aspects, can be also submitted to GFCM by international organizations, NGOs, fishery or other stakeholders. These documents should clearly illustrate the problem/issue/proposal and possibly recommend regulatory adjustments to the present RMP.

Amendments will be implemented if new data provide evidence that an objective (measure) set earlier is no longer appropriate. The final decision on which modification is to be accepted is made by the GFCM Commission (following the advice of SAC).

In order to provide the SAC with the necessary information, the members are called to engage in capacity building efforts and other research activities to improve knowledge on red coral exploitation and to support the effective implementation and eventual adaptation of this plan entering into cooperative arrangements with other appropriate international frameworks.

STAKEHOLDER ROLE AND INVOLVEMENT

CPCs should provide for continuing and qualified participation by members representing various red coral fishery sectors (including, among the others, fishermen, commercial, scientific and ecosystem and habitat representatives) in all relevant consultations.

Ad hoc meetings and specific *fora* could be eventually convened by GFCM, whenever necessary, to address specific and/or urgent issues.

Furthermore, considering:

the recent Memorandum of Understanding between GFCM and REGIONAL ADVISORY COUNCIL FOR THE MEDITERRANEAN SEA (RACMED) (composed by fishermen, processors, traders, environmental and consumer organisations and others) that recognizes the need to:

- Exchange of relevant information concerning fisheries and aquaculture in order to ensure that decision-making in the Mediterranean Sea is informed by the views and the opinions of stakeholders;
- Promoting and strengthen means that ensure the collection of information relating to fisheries and aquaculture that is of relevance for the development of a more comprehensive framework, bearing in mind the need to reinforce links between stakeholders and scientific advice leading to conservation and management measures in the Mediterranean Sea

the provisions of COUNCIL REGULATION (EC) No 1967/2006 - CHAPTER VII - Article 18 – Paragraphs 2 providing that

- 'Member States and/or a Regional Advisory Council for the Mediterranean Sea may submit suggestions to the [EU] Commission on matters relating to the setting up of management plans'

RACMED, as appropriate, shall be promptly involved and asked to provide inputs and advises on the amendments to the existing and the eventual new management measures of the present RMP.

CONSERVATION AND ECOSYSTEM-RELATED ISSUES (RMP)

In accordance with to Point 3 of the GFCM Guidelines the Regional management plan for red coral, in line with GFCM provisions, is coherent with the precautionary and ecosystem approaches and aims at minimizing the impact of fishing on the sensitive habitats such as the coralligenous biocoenosis.

The RMP already provides for technical measures on gear selectivity and depth limits, with the ban of some destructive or highly impacting fishery methods (dragging gears and ROVs) and the protection of the overharvested shallower red coral populations.

Considering that in some countries marine protected areas already exist (see the document 'First part – Background information' for further details) the opportunity to further extend the protection of other vulnerable populations/sites with the setting up of new protected areas (both temporarily and permanently) or reserve networks should be taken as a priority by CPCs.

In fact, refugia or preserves (that is coral beds closed for some period of time for exploitation) are valuable tool both for management and conservation purposes:

- to establish possible reproductive reserves for enhancement of recruitment into adjacent areas
- to establish control areas that could be used in the future to measure the environmental impact of coral harvesting
- to preserve coral beds as natural beds for purposes of research.

FUTURE DEVELOPMENTS

Considering that GFCM is committed to enhance collaboration with other relevant organizations as appropriate, including those whereby Memoranda of Understandings (MoUs) have been signed (see Appendix D), it is to be regarded as a priority action the involvement in red coral management and conservation related issues of:

- IUCN (THE WORLD CONSERVATION UNION)
- UNEP-MAP (THE UNITED NATIONS ENVIRONMENT PROGRAMME)
- MED-PAN (Network of Managers of Marine Protected Areas in the Mediterranean).

UNEP-MAP and GFCM shall cooperate in:

- Promoting of an ecosystem based approach for red coral fishery;
- Mitigating the impact of red coral fishery on the marine habitats and species;
- Identifying, protecting and managing marine areas of particular importance for red coral in the Mediterranean Sea;
- Monitoring the status of *Corallium rubrum*, species listed in Annex 3 to the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean;

MEdPAN and GFCM shall cooperate in:

- fostering the creation and sustaining functioning of an effective Mediterranean network of marine protected areas, including these pertinent for red coral conservation

IUCN and GFCM shall cooperate in:

- the development and participation in the implementation of the Ecosystem Approach to red coral fishery

- the identification of a representative network of Mediterranean marine restricted fishing areas, including for sensitive habitat for red coral conservation and management.

The nature of the collaborative activities may include, but will not necessarily be restricted to:

- Exchange of information on technical issues of common interest
- Organization, participation in and collaboration on joint initiatives, that may include research and conservation projects, reports, seminars, conferences;
- Collaboration in the publication and dissemination, in relevant international fora, of red coral related issues;

Where necessary, GFCM and the over mentioned organizations may establish a specific arrangement or project dealing with red coral.

THE NATIONAL MANAGEMENT PLANS FOR RED CORAL (NMP)

The following pages include the framework of a National Management Plan; this is not provided for by any current GFCM Recommendation but it has been included by the authors of the present documents considering that

the management of red coral can be effective at the regional level only whether all countries involved in red coral fishery have harmonized regulations;

the setting up of a National Management Plan for red coral, by all the countries involved in red coral fishery in the GFCM competence area, should be provided for by future binding GFCM Recommendations.

At present, the proposed NMP could be regarded as a sort of 'good' example or template of a management plan for red coral to be applied at the national level.

In particular, considering that reliable stock assessment models should be applied for the proper management of the red coral resource, the following Operational Objectives, References Points and Control Rules proposed for a 'rich data condition' should be implemented and applied also at the regional level as soon as data will be available.

CONTENTS (NMP)

Any NMP should follow the general framework, as described for the RFM, and should contain the following parts:

- Definition
- Relationship with the RMP
- Background information
- Principles
- Goals and broad objectives
- Operational objectives
- Indicators, Reference Points, and associated Limit, Target, and Precautionary Reference Points
- Decision rules
- Recovery strategy (eventual)
- Management measures
- MCS system (Monitoring, Control, Surveillance)
- Implementation and enforcement mechanisms
- Reviewing system and Timeframe
- Ecosystem-related matters (eventual)

DEFINITION (NMP)

The National Management Plan for red coral in the GFCM competence area (NMP) contains all the management measures applicable at the national level,

necessary for a sustainable management of the red coral resource in the country

The development of adaptive national management plan for red coral is requested by the Recommendation GFCM/35/2011/2 and GFCM/36/2012/1.

The NMP should prepared by each CPCs within the GFCM competence area, coherently with the provision of the RFM.

RELATIONSHIP WITH THE RMP

Considering the Recommendation GFCM/36/2012/1 Paragraph 5 stating that 'the adaptive regional management plan [is] based, whenever available, on national plans' the following paragraphs define the respective contents and area of application of the RMP and NMPs.

While the measures contained in the RMP apply to all the CPCs, NMPs applies to the red coral banks occurring within the territorial waters of the State.

The NMPs must contains all the management measures provided for by the RMP as well as additional or stricter regulations respect to the RMP, necessary for a sustainable management of the red coral resource at the national level.

BACKGROUND INFORMATION (NMP)

The background information section should contain data on biology, fishery, past and present management and production, threats and environmental issues related to red coral and coralligenous biocoenosis at the country level.

PRINCIPLES (NMP)

The NMPs should conform to the principles that inspire the RMP (see related section).

GOALS AND BROAD OBJECTIVES (NMP)

The NMP is inspired by the following principles: sustainability, precautionary approach, and ecosystem-based approach to fishery, adaptive and participated approaches.

The National Management Plan (NMP) main goal is to keep red coral stocks at a sustainable level in each specific country.

The National Management Plan (NMP) broad objective is to developing a responsible management strategy for the red coral resource within the national territorial waters.

OPERATIONAL OBJECTIVES (NMP)

The broad objectives defined above are further developed into explicit "operational objectives" (Oob) that are the primary tasks of red coral fisheries management in the country.

The choice of the operational objectives will be determined by the data that are or will be available in the near future (within 1-2 years) at the national level also thanks to the collection data programme required by the Recommendation GFCM/35/2011/2 and GFCM/36/2012/1.

The following paragraphs illustrate some examples of possible operational objectives to be used at the national level. They should be regarded as 'examples'. The choice and number of the Oob contained in each NMP will depend on the quantity and quality of data available in each country.

Table 5 provides a summary of data needs for estimating different indicators and RP.

Table 5 Summary of data needs and intermediate parameters for selected methods for estimating different fishery indicators (from Hoggarth *et al.* 2006)

Data					Reference points	
Catch	Effort	Length freq.	Age freq.	Intermediate parameters	Method	Indicators
Myr TS						Y_{tg}; Y_{lim}
		1 yr TS				S_{tg} ; S_{lim}
			SS	Growth M Size-weight relationship	Analytic model : Yield per recruits(Y/R) Beverthon and Holt (1957)	A_{tg}; A_{lim}
Myr TS	Myr TS				Production models (Schaeffer model (1957); Fox model (1970); Pella and Tomlinson(1969)	B_{oy}; B_{msy}

Myr Multiyear; TS time series of data; SS single sample

Considering the data available or that will be available in the near future at the national level for red coral in the GFCM competence area, three main different starting situations can be envisaged:

- **poor data**: size data from landings and short-term catch data (at least 3 running years)
- **medium data**: size data from landings and medium-term catch and effort data; ; local biological studies (e.g. age, mortality, size-weight relationship)
- **rich data**: size data from landings and long-term catch and effort data; local biological studies (e.g. age, mortality, size-weight relationship)

It is highly recommended that each country progressively pass from a poor data condition to a rich one when reliable stock assessment models can be applied.

Data collection programs, scientific surveys and studies should be encouraged, planned and adequately financed by each CPC in order to gather crucial information on red coral population at the national level and to set up the proper management strategy.

CPCs should report annually on the actions undertaken to fulfil this recommendation.

The possible operational objectives, indicators and reference points, related to these 4 situations are presented in the next paragraphs.

In a **Poor data** case two operational objectives can be set:

NMP Oob1: Control that the actual size limits are enforced at the national level

NMP Oob2: Maintain the same catch level of three previous years

The rationale of the choice of the **NMP Oob**1 is to have an indicator of the performance at the national level of the size limit imposed at the GFCM level.

The rationale of the choice of the **NMP Oob**2 is to allow the local fisheries to keep on at the actual level of exploitation, supposing it to be sustainable.

The **NMP Oob**2 is temporary, with the prevision that the level of exploitation should be changed if the future data collected by the country within the GFCM collection data framework will reveal that this fishing effort is above the sustainable level.

In a **medium data** case an addition operational objective can be set:

NMP Oob3: Verify that the mean age of the population of a national bank is at an optimal level (OSY) above the MSY.

The rationale of the choice of the **NMP Oob**3 is to regulate the local fisheries at a sustainable level.

In a **rich data** case an addition operational objective can be set:

NMP Oob4: Maintain the biomass at a sustainable level (OSY)

The rationale of the choice of the **NMP Oob**4 is to regulate the local fisheries at a sustainable level.

REFERENCE POINTS AND DECISION RULES (NMP)

To measure the performance of management in achieving the objectives, “reference points” (RP) are fixed for each Oob.

To each RP three values are associated:

Target reference point (TRPs), corresponding to a situation considered as desirable and to be achieved on average;

Limit reference points (LRPs), indicating a situation that are undesirable and to be avoided at all costs.

Precautionary reference point (PaRP): this provides a threshold at which initial actions can be taken to reduce the risk that the limit may be broken.

To each Oob the relative decision control rule is associated. The decision rule defines in advance what management action will be taken, depending on the position of the indicator relevant to the reference point.

The value of TRP for **NMP Oob**1 is chosen on the basis of the actual size limit imposed by the GFCM Recommendations and the relative allowance of 10% in live weight for undersized colonies.

The value of LRP for **NMP Oob**1 is chosen on the basis of the TRP increased by a further 10%. The presence of 20% of undersized coral colonies in the landings, a value double of the current value is considered as the limit situation to be avoided.

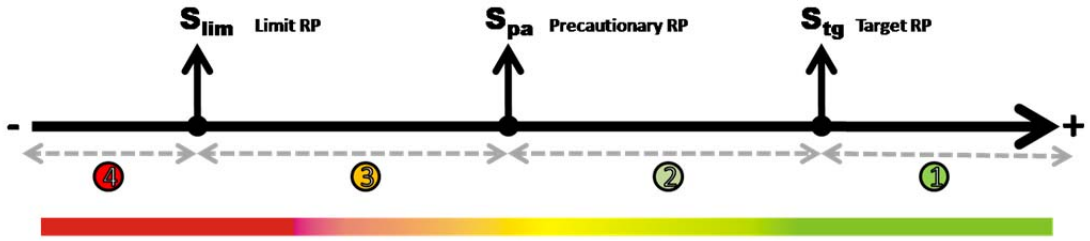
The value of PaRP for **NMP Oob**1 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering a value intermediate between the TRP and the LRP that is an allowance of 15% of undersized colonies. This provides a threshold at which initial actions should be taken to reduce the risk that the limit is broken.

The values 10%, 15% and 20% were chosen arbitrarily, being considered ‘common-sense’ RP, they can be specified otherwise on the basis of scientific evidence or pre-agreed decisions among all the stakeholders.

The decision control rule for the **NMP Oob**1 is shown in Figure 3 showing also the relative reference point, target, limit and precautionary RP.

It provides that actions at the national level should be undertaken when the % of undersized colonies in landing data is above the actual allowance value, calling the country for a stricter implementation of this management measure through temporary closure of the fishing area to allow the stock to rebuild. The length of the closure will depend on the status of the stock that can be defined only by scientific surveys.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL STOCKS AT A SUSTAINABLE LEVEL	Control that the size limits are enforced	SIZE=S (average size landing data)	Target= S_{tg} (90% of landings is at average size = legal size limit LS) Limit=S_{lim}= (80% of landings is at average size = legal size limit LS)	Threshold= S_{pa}=(85% of landings is at average size = legal size limit LS)



Decision control rule		
1	(Snow≥Stg)	No action
2	(Spa<Snow<Stg)	short temporal closure (X yrs)
3	(Slim<Snow<Spa)	medium temporal closure (Y yrs)
4	(Snow<Slim)	long temporal closure (Z yrs)

Figure 3- Decision control rule for the NMP Oob1 and relative target, limit and precautionary RP.

The value of TRP for **NMP Oob**2 is chosen hypothesizing that the average catches of the previous three years are at a sustainable level.

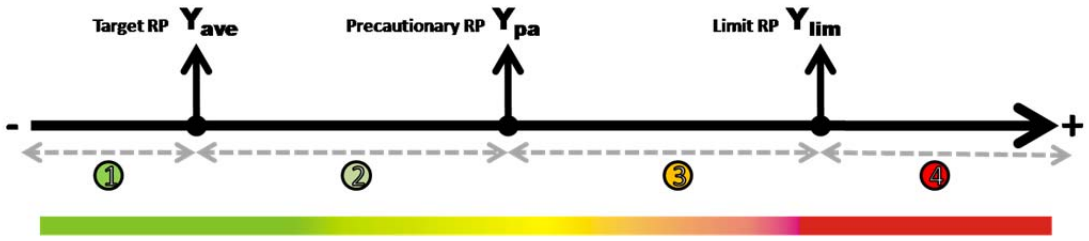
The value of LRP for **NMP Oob**2 is chosen on the basis of the TRP increased by a further 20%. The increasing of 20% of total catches at the national level is considered as the limit undesirable situation to be avoided.

The value of PaRP for **NMP Oob**2 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering that an increasing of 10% of total landings provides a good threshold at which initial actions should be taken to reduce the risk that the limit is broken.

The decision control rule for the **NMP Oob**2 is shown in Figure 4 showing also the relative reference point, target, limit and precautionary RP.

The values 10% and 20% were chosen arbitrarily, being considered 'common-sense' RP, they can be specified otherwise on the basis of scientific evidence or pre-agreed decisions among all the stakeholders.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL HARVESTING AT A SUSTAINABLE LEVEL	Maintain the same catch level of five previous years	YIELD= Y (national database)	Target= Y_{ave} (Average yield past 5 years) Limit=Y_{lim}= Y_{ave}+X	Threshold= Y_{pa}=Y_{ave}+(1/2x)



Decision control rule		
1	($Y_{now} \leq Y_{ave}$)	No action
2	($Y_{ave} < Y_{now} < Y_{pa}$)	Small reduction on the effort of W
3	($Y_{pa} \leq Y_{now} < Y_{lim}$)	medium reduction of the effort of Y
4	($Y_{now} \leq Y_{lim}$)	strong reduction of the effort of Z or moratorium

Figure 4 - Decision control rule for the NMP Oob2 and relative target, limit and precautionary RP.

It provides that actions at the national level should be undertaken when the catches calculated from landing data are 10% of the average catches of the previous 3 years, calling the country for stricter controls on effort at the national level.

The value of TRP for **NMP Oob**3 is the age at Optimal sustainable yield (OMY=MSY-X).

The value of LRP for **NMP Oob**3 is the age at Maximum sustainable yield. The decrease of X of the age of coral colonies in the landing is considered as the limit situation to be avoided.

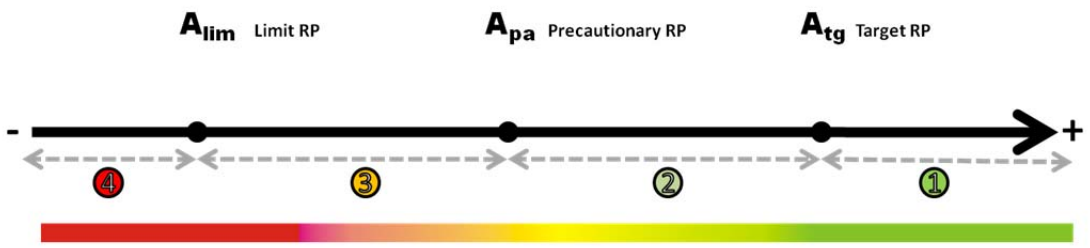
The value of PaRP for **NMP Oob**3 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering a value intermediate between the TRP and the LRP, which is a decrease of Y of the age of colonies. This provides a threshold at which initial actions should be taken to reduce the risk that the limit is broken.

The decision control rule for the **NMP Oob**3 is shown in Figure 5 showing also the relative reference point, target, limit and precautionary RP.

It provides that actions at the national level should be undertaken when there is a decrease of the age in the sampled population below a certain value (X) calling the country the for a stricter controls on effort in that specific area.

The values X, Y, W, and Z should be specified on the basis of scientific data pre-agreed among all the stakeholders.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL STOCKS AT A SUSTAINABLE LEVEL	Verify that the mean age of the population at an optimal level (OSY) above the MSY	AGE=A (yield per recruit model Beverthon & Holt 1957)	Target= $A_{tg}=A_{OSY}=A_{MSY}-x$ Limit=$A_{lim}=A_{MSY}$	Threshold= $A_{pa}=A_{tg}=A_{MSY}-1/2x$



Decision control rule		
1	(Anow≥Atg)	No action
2	(Apa<Anow<Atg)	Small reduction on the effort of W
3	(Alim<Anow<Apa)	medium reduction of the effort of Y
4	(Anow<Alim)	strong reduction of the effort of Z or moratorium

Figure 5- Decision control rule for the NMP Oob3 and relative target, limit and precautionary RP.

The value of TRP for **NMP Oob**4 is the biomass at Optimal sustainable yield (OMY=MSY-X).

The value of LRP for **NMP Oob**4 is the biomass at Maximum sustainable yield. The decrease of X of the biomass of coral colonies is considered as the limit situation to be avoided.

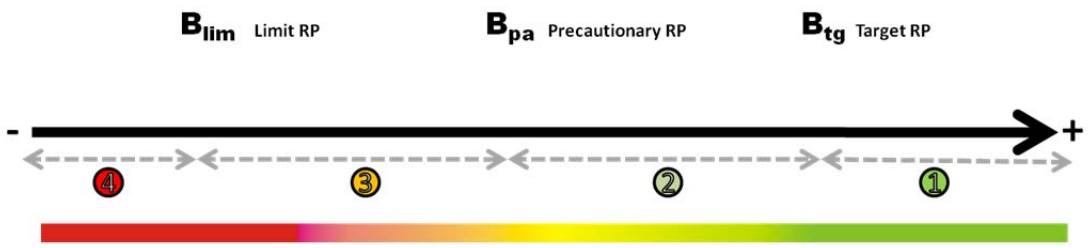
The value of PaRP for **NMP Oob**4 is chosen on the basis of the LRP to represent an early warning of the approaching of the limit. It is fixed considering a value intermediate between the TRP and the LRP, which is a decrease of Y of the biomass. This provides a threshold at which initial actions should be taken to reduce the risk that the limit is broken

The decision control rule for the **NMP Oob**4 is shown in Figure 6 showing also the relative reference point, target, limit and precautionary RP.

It provides that actions at the national level should be undertaken when there is a decrease of the biomass landed in the sampled population below a certain value (X) calling the country the for a stricter controls on effort in that specific area.

The values X, Y, W, and Z should be specified on the basis of scientific data pre-agreed among all the stakeholders.

GOAL	OBJECTIVE	INDICATOR	REFERENCE POINTS	Precautionary RP
TO KEEP RED CORAL STOCKS AT A SUSTAINABLE LEVEL	Maintain the biomass at a sustainable level (OSY)	BIOMASS=B (production model model eg. Schaefer, Fox, Pella and Thomson)	Target= $B_{tg}=B_{OSY}=B_{MSY}$-x Limit=B_{lim}= B_{MSY}	Threshold= $B_{pa}=B_{tg}=B_{MSY}$-1/2x



Decision control rule		
1	(Bnow≥Btg)	No action
2	(Bpa<Bnow<Btg)	Small reduction on the effort of W
3	(Blim<Bnow<Bpa)	medium reduction of the effort of Y
4	(Bnow<Blim)	strong reduction of the effort of Z or moratorium

Figure 6- Decision control rule for the NMP Oob3 and relative target, limit and precautionary RP.

RECOVERY STRATEGY (EVENTUAL) (NMP)

The NMP should contain the detailed description of the recovery strategy that is the actions to be taken when the stock is outside safe biological limits. The pre-agreed recovery strategy will allow to implement without delay the necessary and urgent measures and actions.

Consultations with stakeholder are highly encouraged.

MANAGEMENT MEASURE (NMP)

Considering the previously described Operational Objectives (Oob1, Oob2, Oob3 and Oob4) and the relative RPs, the management measures to be put in place should be decided locally.

The management measures decided at the regional level (defined in the RMP) should be mandatorily implemented and eventually complemented with additional or stricter ones in the NMP.

MCS SYSTEM (NMP)

THIRD PART- THE MANAGEMENT of red coral

For the compliance to the previously described fishery management measures the proper Monitoring, control and surveillance (MCS) actions should be decided locally commensurate with the different capabilities of the different country.

The elements of MCS system decided at the regional level (defined in the RMP) should be mandatorily implemented and eventually complemented with additional or stricter ones in the NMP.

The following Figure 7 reports, as a title of example, some actions that can be considered for implementation within the national MCS framework

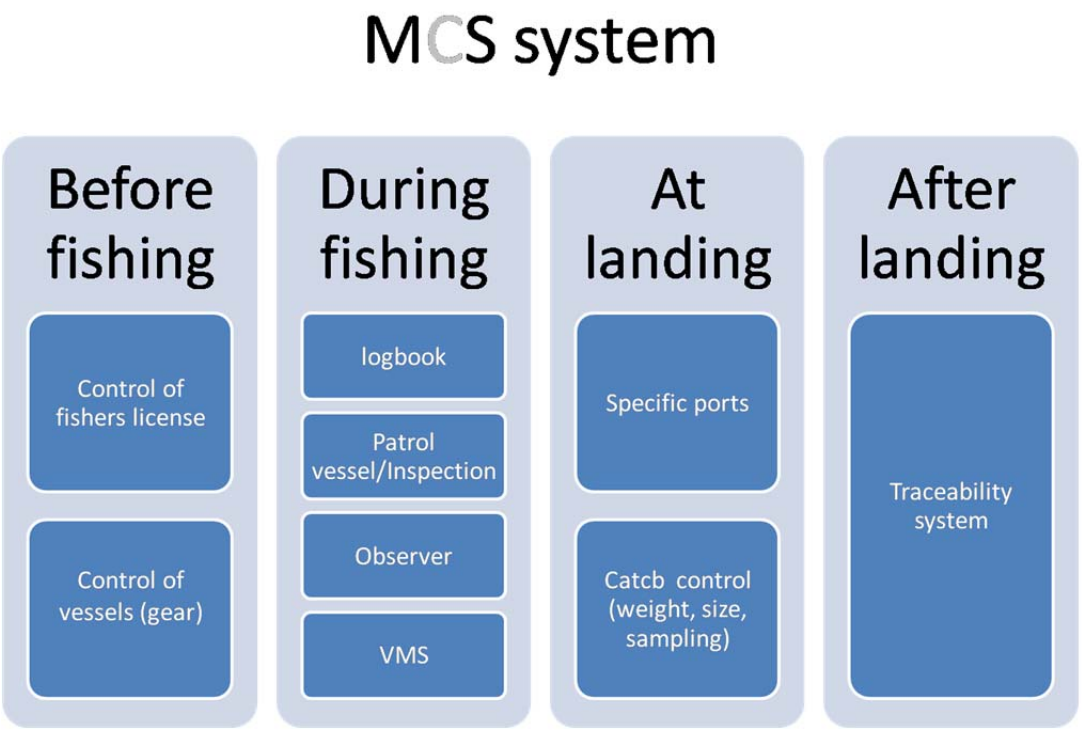


Figure 7 - Elements of the MCS system to be implemented for red coral in the NMP

PATROL VESSELS

The use of fishery patrol vessel is a traditional tool for MCS because it is able to monitor and enforce fisheries legislation on the fishing grounds. Patrol vessels, although costly to buy and to operate, are in many ways irreplaceable.

VMS

VMS monitoring has been recently inserted as an important element of the MCS system in the management plan for precious corals in Taiwan (Huang and Ou, 2010; Chen, 2012; Chang *et al*., 2013).

A Vessel Monitoring System (VMS) provides real-time position, course and speed (PCS) data through a communication link directly into a base station. This allows operators to follow all licensed activity as it happens. Fishing in illegal areas, trans-shipments can be indicated through this system.

It also significantly supports the more efficient direction and deployment of patrol vessels. Additional opportunities provided by a VMS include the manual entering of catch and effort data (from logbooks) that can be forwarded through the same system for assisting in management of quotas and stock assessment when timely information is required. VMS can be limiting due to its cost for smaller artisanal that can seldom be burdened with the cost of the required vessel units. This has generally limited the use of VMS to larger commercial vessels although a trend towards less expensive units is emerging.

IMPLEMENTATION AND ENFORCEMENT MECHANISMS (NMP)

This section of the NMP should provide details on how the fishery is to be managed and by whom with details on how management decisions are to be made according to developments within the fishery. TO BE IMPLEMENTED by the each country

REVIEWING SYSTEM AND TIMEFRAME (NMP)

The reviewing of NMP should occur annually or earlier if new data and/or urgent matters require for the anticipation of the process.

The review should be based on all the information coming from the compilation of all the available data on red coral from different source (scientific community, society, industry, fishers) within the country.

Eventual amendments are to be implemented if new data provide evidence that an objective (measure) set earlier is no longer appropriate.

Annually, CPCs should report to GFCM on the implementation, enforcement and results of their respective NMPs.

These reports are an essential source of information for the updating/reviewing the RMP.

A long-term review every 3-5 years should be necessary to reconfirm the validity of the operational objectives and measures in place, and made major amendments at the plan.

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APPENDICES

APPENDIX A - RECOMMENDATION GFCM/35/2011/2

Recommendation GFCM/35/2011/2 on the exploitation of red coral in the GFCM Competence Area

(http://151.1.154.86/GfcmWebSite/SAC/SCMEE/13/REC_GFCM_35_2011_2_RedCoral.pdf)

APPENDIX B - RECOMMENDATION GFCM/36/2012/1

Recommendation GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area

(http://151.1.154.86/GfcmWebSite/SAC/SCMEE/13/Rec_GFCM36_2012_1_RedCoral.pdf)

APPENDIX C – GFCM GUIDELINES FOR MULTIANNUAL MANAGEMENT PLANS

Guidelines on a general management framework and presentation of scientific information for multiannual management plans for sustainable fisheries in the GFCM area

(http://151.1.154.86/GfcmWebSite/GFCM/36/EU-proposal-Guidelines-Management.pdf)

APPENDIX D - OTHER RELEVANT DOCUMENTS

COUNCIL REGULATION (EC) No 1967/2006

COUNCIL REGULATION (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea

(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:409:0011:0085:EN:PDF)

MEMORANDA OF UNDERSTANDING BETWEEN FAO (GFCM) AND INTERNATIONAL ORGANIZATIONS

Memorandum of Understanding between GFCM and IUCN
(ftp://ftp.fao.org/fi/DOCUMENT/gfcm/gfcm_32/inf10e.pdf)

Memorandum of Understanding between

- GFCM and UNEP-MAP;
- GFCM and MedPAN;
- GFCM and RACMED

(http://151.1.154.86/GfcmWebSite/GFCM/36/GFCM_XXXVI_2012_Inf.5-e.pdf)