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CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Fourteenth meeting of the Conference of the Parties
The Hague (Netherlands), 3-15 June 2007

ADDITIONAL INFORMATION ON BIOLOGICAL AND TRADE CRITERIA FOR PRECIOUS CORALS IN THE GENUS *CORALLIUM*

1. The attached document has been submitted by the United States of America.

2. The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries.

Precious corals (red/pink coral) in the Genus *Corallium*

In addition to the information presented in the document CoP 14 Prop. 21, the United States, as sponsor of this proposal on the genus *Corallium,* provides the following new information in response to comments received on the proposal from Parties, intergovernmental organizations, and non-governmental organizations*.* This information addresses scientific and implementation matters. Annex I provides further technical details.

Decline

The FAO *ad Hoc* Expert Advisory Panel (FAO panel) concluded that the available data did not demonstrate a historical extent of decline to 20-30% of the baseline, or a recent rate of decline that would require consideration for listing on Appendix II. We recognize the limited available biological data on declines in abundance (reported as numbers of individuals), and some of the concerns associated with the use of catch data. However, we feel the combination of available biological data, FAO catch data, and published historical reports describing *Corallium* fisheries are sufficient to raise concerns about the impacts of fishing and trade on *Corallium* populations, and these data provide sufficient biological underpinning for this proposed listing. Specific details on the use of best available scientific information are provided below.

Use of Catch Data as a Measure of Decline

The FAO panel raised questions about the use of catch data as a measure of decline in absence of information on effort, because changes in fishing intensity can lead to changes in catch values. The FAO catch data presented in the United States proposal illustrate a dramatic increase in harvest of Pacific species between 1978 and 1989. Beginning in 1990, harvest plummeted to levels that have remained at less than 5% of the peak values. Although these data provide no indication of effort, several publications document an increase in the number of vessels fishing for *Corallium* that corresponds with the discovery of several *Corallium* beds off Emperor Seamounts, followed by a decline in effort once these resources were depleted. Kosuge (2007) reports that the Japanese and Taiwan fisheries in the central Pacific were abandoned due to the costs of harvesting in deep water and low quality coral in these areas, and that reduced catch does not reflect a strong decline in abundance. The United States recognizes the economic implications of *Corallium* fisheries associated with a collapse in the price of raw materials. However, we disagree with the statements made in the FAO and IWMC assessments that Emperor Seamounts and Milwaukee Banks were not exhausted, as lower levels of catch, and increased harvest of poor quality *Corallium*, are strong indications of declines in abundance of *Corallium* and are suggestive of economic extinctions of the commercially important species. Numerous fisheries expeditions and research missions have been carried out throughout the IndoPacific over the last 20 years, including exploratory surveys in the Central Pacific in areas around Emperor Seamounts that formerly supported *Corallium* fisheries. These missions have either failed to identify *Corallium* beds, or led to discoveries of *Corallium* at very low abundances, and only a single new *Corallium* bed has been reported (Cross Seamount) that may be large enough to support commercial fisheries, although the MSY of this bed is only 35 kg/year (Harper, 1988; Grigg, 1993; Grigg, 2002).

Mediterranean *Corallium* fisheries have remained active since at least the 1700s, but peer-reviewed published reports by researchers working in France, Italy and Spain all report *C. rubrum* as being overexploited. FAO catch data also document a decline in harvest of 40% from 1987-1996 while other reports document a decline in yield over this period of 66% (Santangelo and Abbiati, 2001). We acknowledge some of these declines may be due to a shift from the use of dredges to selective harvest using SCUBA, a reduction overall in effort, and a change in management schemes. However, several areas that supported commercial fisheries in the past have been depleted, shallow populations in the western Mediterranean and Provence region of France suffered mass mortalities (Cerrano et al., 2000; Garrabou and Harmelin, 2002), and other populations have suffered sharp reductions in recruitment (Bramanti et al., 2005). As a result, active fisheries are currently restricted to a few locations. Like the Pacific, Mediterranean *Corallium* fisheries historically occurred in "pulses," where local patches are cleaned out selectively, leaving only inaccessible or non-commercial colonies, before another patch is located and harvested.

Declines in Biomass

The FAO panel raised the issue that catch declines do not reflect biomass declines. The United States believes the available data do demonstrate an overall decline in biomass to less than 20-30% baseline that would be required to meet the criterion for an Appendix II listing. The IWMC review (IWMC World Conservation Trust, 2007) notes that harvest of *C. rubrum* has increased slightly in recent years, and uses this to suggest the populations have not declined. While individual fishermen may collect the same quantity of coral or greater amounts of coral (by weight), this requires the harvest of a larger numbers of colonies to support the same biomass because populations have experienced a region-wide decline in size. There are reports of red coral fishermen from Spain exploiting increasingly smaller colony sizes, including records where the size decreased from large (1-2 cm diameter, 20-50 cm tall) colonies taken in the 1950s and 1960s, to sizes that are only slightly higher than the minimum legal size (7.8 mm diameter) (Tsounis, 2005; Tsounis et al., 2006).

There are also reports that SCUBA fishermen in the Mediterranean are using increasingly more destructive methods, where all colonies regardless of size are detached from the substrate. These fishermen are completely denuding populations in individual patches, including locations that were previously inaccessible to dredges (e.g., crevices and ledges) (Santangelo et al., 1993; 2003; Tsounis, 2005. This has grave implications for the persistence and recovery of *C. rubrum* populations, as recruitment may decline due to increased competition for space with other early colonizing benthic organisms.

The FAO panel correctly notes that colonies of *Corallium* are made up of a number of individuals (polyps), and states that it is appropriate to use colonies as a unit of abundance. They do not, however, take into account colony size as a measure of decline. The most important biological parameters that should be used as a measure of decline for a colonial organism like *Corallium* are size and density, and not absolute abundance (numbers of colonies). *Corallium* are sessile (attached), modular organisms whose survival and reproductive potential is directly related to colony size and density. Throughout the Mediterranean, *C. rubrum* colonies have declined in height and diameter by much more than the 20-30% threshold as suggested by the FAO panel. In general, over 90% of *Corallium* colonies throughout the Mediterranean (in areas accessible by SCUBA) are less than 3-7 cm in height, and few colonies over 20 cm remain even in areas closed to fishing (Santangelo et al., 2003; Tsounis et al., 2006).Colonies over 50 cm in height were common in the 1950s and 1960s (Tescione, 1973). These smaller colonies do not have a fully developed branching structure, and each contains less than 10% of the numbers of individuals (polyps) of larger colonies reported in the past (Tsounis et al., 2006). A recent study determined that mean colony size in fished areas is only about half that observed in no-take marine protected areas (MPAs), and yet even after 20-30 years of protection, colonies within these protected areas are less than half the size of colonies collected by fishermen in the 1950s and 1960s (Garrabou and Harmelin, 2002). The observed decrease in size implies a dramatic reduction in the percentage of fertile colonies and the potential reproductive output, with mature smaller colonies observed today producing tens of larvae instead of thousands of larvae that were produced historically by larger colonies (Santangelo et al., 2003; Tsounis, 2005; Torrents et al., 2005).

Changes in Colony Density

The FAO panel and the IWMC review both noted that *C. rubrum* populations that population size is not small, based on the occurrence of high densities of *C. rubrum* in shallow water. We acknowledge the presence of high densities of *C. rubrum* in certain locations, but note that densities differ between locations. Unusually high densities (e.g., 1000-2000 colonies per square meter) are only known to occur in shallow locations off Calfuria, Italy (Cerrano et al., 1999), with lower densities observed in other areas of the NW Mediterranean (e.g., small patches with tens to hundreds of colonies; Cerrano et al., 2000; Garrabou et al., 2001; Tsounis et al., 2006). The high densities reported in the literature represent discrete, small patches (often less than 1 square meter) within a larger area of suitable habitat, and the overall density throughout the coralligenous zone is a fraction of the reported density (Tsounis, 2005). In addition, these shallow populations are dominated by young, immature colonies that have a short lifespan (less than 5% are legal harvest size, and no more than one third are reproductive; Santangelo et al., 2003; Tsounis, 2005). When considering the extent of decline in populations of fishery species, measures of abundance should be based on the numbers of mature 'individuals' (effective population size), and not all individuals, as juveniles are not yet a component of the fishery. If density data for shallow *C. rubrum* populations were re-analyzed to only include mature colonies the numbers would be 70-90% lower than that reported. Furthermore, all other species of *Corallium*, as well as deeper populations of *C. rubrum,* occur naturally at a relatively low density (typically less than 1 colony per square meter) and total population size within these beds is small (e.g., a few thousand colonies; Grigg, 2002). Because of the sessile nature of these species, additional fishing pressure can dramatically affect long term persistence of populations by reducing densities to levels that reduce the likelihood that gametes from one colony will meet and be fertilized by gametes from a distant colony (e.g., Allee effect).

Decline in Distributional Range

The FAO Experts Panel recognizes the possibility of localized depletions of individual species of *Corallium*, but concluded that there is no reason to suspect an overall decline in area of distribution, because the genus is distributed relatively widely. As indicated in the IWMC assessment, we acknowledge that the genus is found throughout the world's oceans, with reports of occurrence from at least 41 range states. We also recognize that certain species have a relatively wide distributional range, however the overall area of occupancy of these species is small, as individual species occur as fragmented populations that are restricted to suitable, high relief hard ground areas in association with small banks and seamounts (Baco and Shank, 2005). Suitable hardground habitats are generally small in size and occur within a limited depth range, with large expanses of unsuitable habitat between beds. For example, the reported range of *C. rubrum* is primarily limited to the western basin of the Mediterranean Sea, with isolated populations in some areas of the eastern Mediterranean and African Atlantic Coast (Garrabou and Harmelin, 2002). Yet, only a few isolated populations of *C. rubrum* remain that are large enough to support commercial exploitation, including areas off Italy, Spain, and France, and isolated populations off Morocco, Algeria, Greece, Croatia and Albania. Pacific species were historically known to occur in commercial abundances in small coral beds found in three locations off Hawaii, around Midway Islands and Emperor Seamounts, and off several island chains from the northern Philippines to islands off Japan (Grigg, 1993). Currently all known *Corallium* beds in international waters around Midway Islands and Emperor Seamounts, the primary location of *Corallium* fisheries during the 1960s-1980s, have been depleted and are not supporting any commercial fisheries (Grigg, pers. comm). While pressure from fisheries is unlikely to have affected the overall distribution, it has resulted in commercial extinction of individual beds, which represents a loss of biodiversity due to limited connectivity and dispersal between these subpopulations (Baco and Shank, 2005).

Productivity Measures

The FAO panel concludes that most species of *Corallium* fits into the low productivity range, based on age at maturity, longevity and natural mortality, while the FAO panel and IWMC review conclude that *C. rubrum* is a medium productivity species due to a presumed early age of maturity. The United States agrees with the assessment of low productivity for Pacific species, but concludes that *C. rubrum* also is a low productivity species, as it appears that published reports of age of *C. rubrum* were underestimated by a factor of 2-4, growth rates are 2.6-4.5 lower than previously thought, and age of maturity is substantially older than previously reported (Marschal et al., 2004).

Adequacy of National Management

The FAO panel and the IWMC review both conclude that strong local management is necessary to prevent unsustainable harvest, and highlight existing measures implemented in the Mediterranean in response to FAO-GFCM technical consultations. While these assessments acknowledge the need for further improvements in the management schemes, they felt that trade regulations would hinder these efforts. The United States commends countries that have taken steps to improve management of *Corallium* resources, but available scientific data suggest these have not been sufficient, given the recent rate of decline observed in these species and region-wide reports of overexploitation. Management measures have included a general ban on the use of non-selective trawls and dredges in most (but not all) Mediterranean locations and in the United States, along with application of minimum size, quotas, licensing schemes and area closures. All of these are key components of effective fishery management, but they may need to be reexamined and adjusted as necessary. For example, no take areas (MPAs) that contain populations of *Corallium* are currently limited to a few locations off France, Spain and the United States. These areas are all relatively small, and it is unclear whether they are situated in upstream locations where they would provide offspring that could colonize and replenish fished areas, especially when considering recent data that suggests populations are self seeding (Baco and Shank, 2005). Furthermore, full recovery of *Corallium* populations has not been documented in any of these MPAs even after 20-30 years of closure, presumably due to low rates of recruitment, slow growth, and the longevity of colonies (Grigg, 2001; Garrabou and Harmelin, 2002). These MPAs contain medium-sized colonies that are larger than that observed in areas open to fishing, but large colonies are still absent. Rotational harvest, as proposed for the Mediterranean may be ineffective unless areas are closed for 50-100 years (Francour et al., 2001).

Recent age studies indicate *Corallium* colonies are older than previously thought, and harvest would need to be limited to colonies that are much larger than current legal minimum size. For example, maximum yield of Mediterranean *C. rubrum* is reported to occur when colonies achieve an age of 33-98 years, while the current practice of harvesting 11 year old colonies results in only 6% of the potential yield (Tsounis, 2005). This suggests that more conservative quotas are needed, and existing minimum legal sizes of colonies may be too small to offer the necessary time for reproduction prior to harvest.

One of our major concerns is the absence of management in international waters, and most (if not all) of the harvest of Pacific species today still involves the use of non-selective trawls and dredges that remove all colonies in their path and cause substantial damage to associated habitats. Recent concern has been expressed regarding the sustainability of SCUBA harvest in the Mediterranean, as fishermen may be exploiting all colonies in an area and some of the underlying substrate in attempt to maximize their yield.

Through an Appendix II listing, commercial trade would still be allowed, provided that exporting countries demonstrate allowable harvest and trade is non-detrimental. This listing would provide the necessary impetus to acquire data on the status and trends of *Corallium* populations and the impacts of fisheries, it could lead to improvements in national management, and it would provide a more reliable source of data on harvest and trade levels. While we recognize additional administrative burdens associated with permitting and enforcement, a listing can help ensure the resource is sustainably managed and sources of *Corallium* are available for the long term.

<u>Emerging Threats</u>
There is a growing number of emerging threats, such as increasing competition with other benthic organism, bioerosion by sponges, mortality events associated with climate change and temperature anomalies, and increased pressure from recreational divers that are compounding threats associated with commercial harvest. International trade remains the greatest global threat to the family Corallidae. Due to the absence of management in many locations, the need for additional (revised) conservation measures in managed areas, and a general limitation of biological and trade data, it is likely that *Corallium* will continue to decline in absence of international protection. A CITES Appendix II listing can help address conservation needs for *Corallium* by improving trade data and by requiring implementation of sustainable management approaches necessary for determination of non-detriment.

<u>Taxonomic Issues</u>
The IUCN/TRAFFIC analysis correctly identifies recent taxonomic revisions of the family, and the existence of several new species. We recognize the recent subdivision of the family Corallidae into two genera (*Corallium* and *Paracorallium*) and acknowledge 31 recognized species, in addition to an undescribed species listed as *Corallium* sp. nov (Midway deep coral). We also note that the taxonomy of the undescribed Midway coral has not been clarified, and although there are some indications that Midway coral may represent several species, these corals are still valid members of the family Corallidae (Grigg, 2001). The United States recommended inclusion of all species of the genus *Corallium*; although we identified the existence of *Paracorallium*, we did not separate the species into their respective genera to avoid potential confusion, as all published information on the biology and harvest of these precious corals refers to *Corallium*. Our intent was to include all species in the family Corallidae in the listing proposal.

<u>Implementation Issues</u>
Through our ongoing process of consultation on this proposal and a review of the assessments made by the Parties and intergovernmental bodies, we are aware that concerns have been raised over potential difficulties in the implementation of an Appendix II listing of *Corallium* species. We are committed to doing all we can to facilitate the success of this important listing if it is approved by the Conference of Parties. To allow time to discuss and address implementation concerns we are proposing to amend our proposal to allow for a delayed implementation to allow adequate time to

resolve implementation issues. Before the end of a year, the United States will support and convene a workshop to consider implementation challenges and arrive at practical approaches to meeting them.

Identification of species in trade: Major concerns were raised regarding the identification of worked specimens to the species level, along with difficulties associated with the mixing of different species of *Corallium* and other precious corals on single items of jewelry. We recognize difficulties in identifying coral in trade, and have worked with the Coral Working Group in the Animals Committee to address this issue for coral taxa that are currently listed on Appendix II, and feel difficulties could be resolved for *Corallium* as well. Through consultation with an expert working on *Corallium* identification (Dr. Susan Torntore), we know that identification of raw material is relatively easy through microscopic examination of the surface, but worked products are more difficult as the surface layer has been moved. However, individual species do have differences in color and density and experts in the *Corallium* industry can distinguish products of different species. While it may not be possible to identify all species of *Corallium* once the surface material is removed, only a few species are in trade (5-7) and these can be differentiated. The U.S. is establishing a collaborative project with Dr. Torntore to resolve identification issues and will support development of an identification manual.

Personal effects: We recognize that a portion of the trade in jewelry will be as tourist souvenirs which may be exempt from controls under the Convention. However, an Appendix II listing would benefit the species, as the bulk of the trade involves commercial shipments of raw coral and processed items. Furthermore, a substantial amount of jewelry and skeletons are traded internationally at a wholesale level, and a recent trade via the internet has emerged which will need to be addressed. A substantial portion of the tourist trade will represent "re-exports" that will have been initially imported under CITES provisions; the only exception to this may be those locations that have fisheries, including Japan, Taiwan, Italy, Spain and the U.S. The sale of *Corallium* to tourists in Hawaii either involves material imported by wholesalers (which would be regulated if these species are listed) or *Corallium* harvested from U.S. waters under a management plan based on harvest quotas, minimum size of harvest, and selective harvest.

Parties, independently or collectively, will need to take decisions on the treatment of *Corallium* jewelry when in trade as personal effects. One option is to apply a quantitative limit for personal effects through incorporation in Resolution Conf. 13.7

Stockpiles: We are aware of stockpiles of *Corallium* in Hawaii, Italy, Japan and possibly other locations that would be considered Pre-Convention material if the proposal is adopted. We recommend Countries with appreciable stockpiles of *Corallium* consider asking traders to voluntarily declare pre-convention stocks.

Annex I: Additional Biological Information on *Corallium*

Distributional Range of Individual *Corallium* species

- The FAO panel notes that depletion of some commercial beds may have occurred, but this may not reflect the overall abundance because *Corallium* is widely distributed. We recognize that the genus overall is widely distributed throughout tropical, subtropical and temperate oceans, and have identified 41 identified range states for the genus *Corallium.* However, individual species are restricted to certain ocean basins, and within those basins each species occurs within a limited depth distribution and in very specific habitat types.
- Known populations of *Corallium* are geographically isolated from other populations. They are spatially confined due to their specific habitat requirements (including rocky bottom banks and seamounts exposed to high currents and low levels of sedimentation). These rocky, high relief habitats cover a limited area on the sea floor, and are generally separated by large expanses of unsuitable soft bottom habitat. *Corallium* colonies exhibit a patchy distribution within these rocky areas. Pacific species occur primarily on outcrops, ridges and pinnacles with more than 2 m vertical relief (Grigg, 2001) and Mediterranean *C. rubrum* occur on and around ledges, caves and crevices. Preferred *Corallium* habitats include many of the most isolated benthic marine habitats in the world (Baco and Shank, 2005).
- The Mediterranean Sea population of *C. rubrum* has the widest depth range (7-250 meters), although the only known remaining commercially viable populations are restricted to the coasts of Sardinia, Corsica, southern Italy, Sicily and northern Tunisia. Morocco and Algeria, primarily from 30-50 m depth (Tsounis, 2005).
- Pacific species are also known to occur in a relatively small number of locations: 1) *Corallium secundum* and *C. regale* are found off the Hawaiian archipelago from Hawaii (20ºN) to the Milwaukee Banks (36ºN) at 350-475 m depth; 2) *Corallium.* sp. nov. is found from Midway Island to Emperor Seamounts, 28º-36ºN at 1,000-1,500 m depth; 3) *Corallium japonicum* occurs off Japan, Okinawa & Bonin Islands, 26º-36ºN from 100-300 m depth; 4) *Corallium konojoi* occurs from the Northern Philippines to Japan 19º-36ºN latitude, at 50-150 m depth, and 5) *C. elatius* from the Northern Philippines to Japan,19º-36ºN latitude, at 100-330 m (Grigg, 2002).
- Pacific *Corallium* beds that have been examined with submersibles are all very small in size. For example, the two largest known *Corallium* beds in the U.S. are only 4.3 km^2 (Makapuu Bed) and 0.96 km^2 (Keahole Point Bed) (Grigg, 2002).
- Several studies have identified significant genetic isolation between subpopulations, and limited larval dispersal between populations, with individual beds relying primarily on local recruitment (Weinberg, 1979; Abbiati et al., 1993; Baco and Shank, 2005). Thus, overexploitation of individual *Corallium* beds can affect the genetic diversity of the population as a whole, and recovery may be delayed due to reproductive failure.

Evidence of decline to levels required for Appendix II listing proposals

- Based on the guidelines in Annex 5, a species of low productivity like *Corallium* should have declined to 15-20% of the historic baseline for consideration in Appendix I and possibly 20-30% for Appendix II, as suggested by the FAO Panel.
- There is a lack of historic (baseline) information on the population size and an absence of data on current population abundance (based on numbers of individuals) throughout the range of each species. Indices of abundance are largely unavailable due to 1) their occurrence in deep water where it is difficult and expensive to conduct research, 2) the patchy and discrete nature of populations, and 3) limited information on the locations of suitable deep water habitat. In general, the species diversity and range of each species has been determined from trawl surveys, museum collections, incidental take associated with bottom fisheries, and limited, detailed *in situ* documentation of occurrence through the use of ROVs and submersibles. Hence, most available information for Pacific *Corallium* is presence/absence data. Extensive data on population dynamics is available for populations of *C. rubrum* in the Mediterranean from about 10-50 m depth, mainly because these coral beds are accessible by SCUBA. However, most of this work has been conducted over the last 20 years and quantitative data from individual sites over time is available only from few locations.

- In absence of these data, we used the best available information, which includes changes in catch and fishing pressure (see below), information on locations of occurrence based on exploratory surveys, and available data on changes in biomass (size and density).
- Numerous exploratory dives and trawl surveys for *Corallium* undertaken throughout the Indian, Pacific and Atlantic Oceans over the last three decades have revealed the presence of *Corallium*, including identification of new species. A few recent exploratory fisheries expeditions have yielded *Corallium*, but the material has generally been of low quality, low abundance, and low commercial value. The only instances involving discovery of large, valuable *Corallium* beds occurred between the 1960s-1980s in the far west Pacific, primarily around Emperor Seamounts and the Hawaiian Islands. Only a single small bed of *Corallium* has been discovered in this region over the last 20 years, but MSY within this bed is only estimated at 35 kg per year (Grigg, 2002).

Use of catch data as a surrogate for population declines

- Indices of decline presented in the proposal were primarily based on reductions in catch, using FAO statistics. While these data alone do not provide information on effort, several publications have documented rapid increases in effort shortly after a discovery of a new *Corallium* bed, which correspond to increases in reported catch data. This includes discoveries of *C. rubrum* beds in the Mediterranean in the 1800s and early 1900s and the discovery of several large *Corallium* beds in the central Pacific beginning in the 1960s. In both locations, the number of vessels exploiting coral increased to 100 or more within a few years of discovery. Within individual *Corallium* beds, catch began to decline after several years of intensive fishing until the fishery was no longer economically viable, and particular beds were abandoned. With each new discovery, this boom and bust cycle has repeated. Since the late 1980s, no new beds have been discovered and reported catch has remained at low levels, especially from the Pacific.
- Kosuge, 2007 indicates that Japan and Taiwan abandoned fisheries in the central Pacific due to costs of harvesting coral in deep water and increasing harvest of low quality coral, but not due to a strong decline in abundance or biomass. Yet, this pattern is consistent with discovery and depletion of sessile benthic resources to uneconomic levels. If abundant coral resources still remained in these locations, the fishery would continue to yield high quality coral (living, large old growth colonies) at relatively high abundances, not low quality coral as indicated by Kosuge, 2007.
- While total catch is at least partially related to effort, catch reported by weight provides no indication of quality and age of corals. It is possible to achieve the same yield by taking a larger number of small colonies, which is what has begun to occur in the Mediterranean. We also note that catch data (total weight) from the Mediterranean is reported to have increased slightly over the last 5 years (as indicated in the IWMC review), but there are reports of increased take of smaller colonies, emphasizing the growing pressure on the resource to support international trade (Tsounis, 2005).
- There are reports that stockpiles of Pacific *Corallium* exist in Japan, Taiwan, Italy and Hawaii, and these materials are being used in recent production of jewelry, thereby requiring reduced levels of harvest in recent years to support commercial demand. However, this has not been sufficient to fully support this industry, as wild harvest has continued in the Pacific and Mediterranean.

Use of size as a measure of decline

- The FAO panel felt there was inadequate biological data on decline to justify listing the species on Appendix II. While the U.S. recognizes the limited availability of data from most locations in the Pacific, and from deeper locations in the Mediterranean, we feel that data on changes in the size of colonies is a suitable measure of decline. Two factors considered when assessing status and trends in populations of fishery species are abundance and biomass. Abundance measures generally reflect mature 'individuals' (effective population size), and not pre-reproductive individuals that are not part of the fishery. For sessile species, abundance measures must incorporate **size**, which is a major determinant of first reproduction, reproductive output and colony survival, and larger colonies is equivalent to a larger number of individuals. Size should also be linked to **density**, as these species exhibit density-dependent reproduction. Therefore, for colonial organisms population size (and decline criteria) can be inferred from the size of the colonies in a given area, given that different sizes of colonies contribute in a very different way to the reproduction of the population (as they contain a greater number of individual polyps), and the density of reproductively mature individuals.

- While individual species of *Corallium* are unlikely to become extinct due to fishing pressure, due to refuge populations that are not targeted, harvesting has caused a substantial reduction in the density of mature individuals and a decline in the mean size of colonies, with reports of extirpations of subpopulations.
- A shift from large colonies to small colonies represents a decline in the number of individual polyps, and thus the reproductive potential / recruitment success. Each colony is made up of numerous individual polyps, and the number of polyps is correlated to colony height and number of branches. Given a shift in Mediterranean *C. rubrum* populations from historic measures of 20-50 cm height to a dominance (>90%) of colonies less than 7 cm in height, there has been much more than a 60-70% decline in the number of individuals.
- Comparisons of the diameter and height of colonies between fished areas, MPAs, and historic observations from the 1950s and 1960s illustrates a dramatic extent of decline over the last 40 years. Mean diameter (0.6 cm) and height (7 cm) in fished areas was 40-60% less than that observed in an MPA. Even ion a site where fishing has not occurred for about 20 years, colonies were less than half the size of those collected in the 1950s-1960s (e.g, 2 cm diameter) (Garrabou and Harmelin, 2002).
- All species of *Corallium* with exception of shallow populations of *C. rubrum* occurs naturally at a relatively low density (typically less than 1 colony per square meter). Because of the sessile nature of the species, additional pressure from fisheries can dramatically affect reproductive potential by preventing successful fertilization of gametes (due to a greater distance between colonies and less likelihood that gametes from one colony will meet and be fertilized by gametes from a distant colony) (e.g., Allee effect). Because of the isolation of subpopulations, non selective fisheries will continue to deplete coral populations from individual banks, thereby affecting biodiversity.
- *Corallium rubrum* can reproduce at 2-3 cm height (previously reported as 2-3 years old colonies, but new estimates by Marschal et al. (2004) suggest they may actually be 7-10 years old. Also, colonies do not reach 100% fertility until they reach a minimum size of about 6 cm (10-20 years old) (Tsounis et al., 2006b). Colonies of 2-3 cm are too small to ensure the reproductive potential needed for the survival of a population because they have a relatively small number of branches and only produce 10s of larvae annually (Tsounis, 2005). Reproductive output continues to increase exponentially with size, with larger, arborescent colonies producing most of the reproductive output (thousands of offspring per colony).
- If considering the size of colonies as a base to assess population size, there is a clear decline on the natural populations and subpopulations of *C. rubrum* throughout its range. This decline exceeds the suggested decline to 20-30% historic baseline for an Appendix II listing, in terms of the number of polyps present historically versus the total number of polyps present today. In three well studied locations with the largest fisheries (Marseille, France; Liverno Italy; Costa Brava Spain) over 95% of the colonies were below legal minimum size for harvest (less than 7 mm in diameter). While historic data documents the existence of colonies over 50 cm in height, 91% of the colonies at Costa Brava were less than 5 cm height and none were larger than 20 cm (Tsounis, 2005).
- Colony density and patchiness is highly variable throughout the distributional and depth range of *C. rubrum*. The highest densities have been reported off Italy (Cerrano et al., 1999), with lower densities observed in other areas (e.g., small patches with tens to hundreds of colonies; Cerrano et al., 2000; Garrabou et al., 2001; Tsounis et al., 2006). While densities may be locally high, these represent small isolated patches and total red coral abundance on all coralligenous hard substrate is much lower. Furthermore, shallow populations throughout the Mediterranean consist primarily of small, non-reproductive colonies that exhibit relatively short life spans (less than 5% are legal harvest size; Santangelo et al., 2003; Tsounis, 2005) and are susceptible to several recent mass mortality events (Tsounis, 2005). Deeper populations, where most fishing currently occurs (30-50 m depth) are characterized by lower colony densities, although patches may extend over large areas (covering an entire bank) (Tsounis, 2005). For example, *Corallium* occurs in small, dense patches that may have hundreds of colonies or more per square meter, but overall densities in coralligenous habitats in Spain is only 3.4 colonies/m^2 (Tsounis, 2005).

Species productivity and relationship with harvest levels

- The FAO panel suggests most species of *Corallium* fit into the low productivity range because colonies are relatively slow growing and long lived, and turnover of a population occurs about once every 15-25 years. The FAO panel also states that C. rubrum may be in the low to medium productivity range because it reproduces at a much younger age. The United States does not agree with a low to medium productivity estimate, mainly because reports on the age of *Corallium* appear to be underestimated. Ages have been determined largely by counting growth rings, which may not be deposited for the first two years. Using both actual in situ measures of growth and staining of the organic matrix of the skeleton demonstrates that colonies are substantially older, and first reproduction occurs at a much older age (Marschal et al., 2004; Garrabou and Harmelin, 2002). For example colonies with a basal diameter of 7 mm (minimum legal size for harvest) may be 30-40 years old (Marshcal et al., 2004).

- Certain shallow populations of *C. rubrum* were thought to reproduce at a relatively young age and small size (e.g., 2-6 years and 2 cm height). However, these small individuals have not developed a branching morphology and consist of relatively few reproductive polyps that are able to produce only low numbers of gametes (10s of gametes per colony) once per year. Colonies reach 100% fertility once they are 6 cm in height, but still produce a relatively small number of gametes at this size (Torrents et al., 2005; Tsounis, 2005).
- Maximum sustainable yield of *C. rubrum* is estimated to be reached at an age of first capture of 98 years (based on the Beverton-Holt 1986 method). Existing legal harvest in Spain of colonies that achieve a 7 mm basal diameter are only about 11 years old and may have reproduced only one to three times before they are harvested. If these stocks were harvested according to MSY, annual yield could be 64 metric tons (mt) per year, yet current yield (based on 7 mm diameter) is estimated at 4.5 mt, with declared harvests of only 1 mt (Tsounis, 2005).
- The three largest known *Corallium* beds off Hawaii (USA) exhibit low densities and total numbers of colonies, and are relatively small in size. For instance, Makapuu Bed, the largest known *Corallium* bed in U.S. waters (4.3 km^2), has a density of 0.3 colonies/m^2 and a total population size of 120,000 *C. secundum* colonies; if a fishery was active here, the estimated MSY is only 1500 kg. The second largest bed (Cross Seamount) was estimated to contain 2500 legal size colonies of *C. regale*, with an estimated MSY of only 35 kg., while Keahole Point Bed contains up to 7,000 legal sized *C. regale* colonies, with an estimated MSY of 90 kg (Grigg, 2002).
- There is evidence of an overall decline in Mediterranean harvests of 40% from 1987-1996 and a decline in yield of up to 66%. While this reflects, at least partially, a shift from non-selective harvest using a dredge to the use of SCUBA gear, decrease in total weight of catch is also due to an increase in the number of small colonies taken and an absence of large colonies. For example, off Costa Brava the legal minimum harvest size is 7 mm and the average diameter in a professional harvest was 7.8 mm, which is indicative of nearly depleted stocks (Tsounis, 2005).

Current rates of exploitation and effects of harvest on population dynamics

- It is generally assumed that precious corals become economically extinct before they are close to biological extinction. This may be the case for *C. rubrum* in the Mediterranean Sea, which has withstood harvesting on and off for over 2,000 years, without suffering extinction. This example is atypical for the genus overall, since *C. rubrum* is the most fecund of the precious corals and it exhibits high localized recruitment due to its reproductive life history strategy (it is a brooder with short lived passive larvae).
- Population viability of *Corallium* depends on the stock structure, including extent of dispersal between populations, rates and patterns of reestablishment, and basic life history patterns. Although isolated colonies may survive heavy fishing pressure, because of their sessile nature they may become reproductively isolated if densities of colonies are reduced (e.g., the Allee effect). Recent genetic studies suggest that Pacific species of *Corallium* may be self recruiting with only limited long distance dispersal events. Low heterozygosity observed in sampled populations suggests the species may be suffering from inbreeding depression. Hence, survival of individual populations may be further compromised through unregulated/unmanaged non-selective fisheries.
- Data on larval biology and genetic population structure denote a low rate of exchange between local populations and persistence of populations is supported by local recruitment (Torrents et al., 2005). Mediterranean *C. rubrum* populations separated only by 80 km exhibit significant genetic structure, with moderate isolation between the two populations.

Efficacy of existing management measures

- Most countries in the Mediterranean have improved management of *C. rubrum* fisheries through effective bans on the use of non-selective dredges and other measures such as area closures, rotational harvests, fishery seasons, and minimum size.

- Rotational harvest and area closures are effective tools for conservation of reef fishes with pelagic dispersal of larvae. However, for sessile, slow growing organisms like *Corallium*, area closures are likely to require up to 100 years or more for full population recovery (Francour et al., 2001). After 14 years of closure in the Medas Islands MPA off Spain, populations have not rebounded to their natural state, as colonies over 20 cm were still absent. In another study from the Mediterranean it took 20 years for subpopulations to reach the development (colony size and density) of *Corallium* populations in adjacent areas, but these populations still had not reached commercial size in this time frame (Garrabou and Harmelin, 2002). There are currently only four MPAs in the northwestern Mediterranean that protect red coral (three in France and one in Spain) (Francour et al., 2001).
- In a population off Hawaii (Makapuu bed) low levels of selective harvest between 1972-1978 caused a decrease in the proportion of large colonies that was still apparent 20 years later, even though no additional harvest occurred during this period (Grigg, 2002).
- Current legal harvest of colonies of *C. rubrum* (minimum basal diameter of 7 mm) may be inadequate to protect the reproductive stocks, as these small colonies have the potential to reproduce only two to three times before harvest, and their small size and relatively limited branching pattern limits their reproductive potential. Estimates of MSY for *C. rubrum* support harvest of much larger colonies (Tsounis, 2005).
- In the U.S. Pacific, MSY has been determined for known coral beds based on a minimum size of harvest (25.4 cm tall) and an assumed linear increase in growth rate of 0.9 cm/yr, as estimated from growth rings which were presumed to be annual (Grigg, 2002) . Recent estimates of growth and age of *Corallium* using radiocarbon dating indicates colonies grow 2-3 times slower than previously reported, and age has been underestimated. Roark et al (2006) estimated colonies that are 28 cm tall at 67-71 years old, or approximately 3 X that reported by Grigg (2002). The very slow growth rates and longevity of colonies indicates that a revised, more conservative MSY is necessary for sustainable harvest.
- The ages of Mediterranean *C. rubrum* colonies, as determined by counting growth rings, are also thought to underestimate age and overestimate growth rates by a factor of four. For example, earlier studies reported reproduction in colonies that were 2-4 years old (Santangelo et al., 2003), but more recent studies suggest these may actually be 7-10 years (Torrents et al., 2005). Sampled colonies with a basal diameter of 7 mm (minimum legal harvest size) may be at least 30-40 years old (Marschal et al., 2004). Fertility is known to increase with colony size (height and number of branches). The current legal size of harvest for *C. rubrum* (7 mm diameter) appears to be too small and does not take into account colony height or branching structure.
- While historic harvest of *C. rubrum* focused on large colonies, the recently developed coral paste (coral powder mixed with synthetic resins) is made with coral of all sizes. This has led to new patterns of exploitation (often illegal) which affect small colonies and the bases of coral colonies which are completely extracted from the substrate by divers that scrape the substrate, resulting in a loss of individuals and substrate available (through being occupied by other organisms).

Additional Threats

- Non-selective harvest using dredges and trawls have been banned in the U.S. and most of the Mediterranean, but it still is used legally in some areas, including Corsica and Algeria (Harmelin, 2007) and it occurs illegally in several locations. It is also used in international waters of the Pacific and around Japan, Okinawa and Bonin Islands.
- Although most *C. rubrum* fishermen are now using SCUBA, they are exploiting increasingly smaller colony sizes and using highly destructive methods affecting the whole size range (Santangelo et al., 2003).
- There has been a recent increase in new sources of disturbance to *C. rubrum* populations, including several mass mortality events linked to elevated temperature anomalies, and mechanical disturbance due to increased recreational diving activities and souvenir collection, (Garrabou et al., 1998, 2001, 2003). These threats may be driving red coral populations, especially in shallow water habitats to situations of risk of local extinction in the near future (Torrents et al., 2005).
- One of the main natural causes of mortality, that can affect up to 50% of the colonies is detachment and bioerosion associated with boring sponges (Corriero et al., 1997)
- Although some shallow *C. rubrum* populations exhibit high rates of recruitment and populations have a high density, these are small non-reproductive colonies that have short lifespans due to a high incidence of mortality from boring sponges and other types of competition.

Taxonomic status of the family Corallidae

- Bayer and Cairns (2003) subdivided the family Corallidae into two genera, *Corallium* and *Paracorallium*. The genus *Paracorallium* includes seven species that are morphologically distinct from *Corallium* due to the presence of structures around each of the corallites (beaded margins surround the axial pits and longitudinal grooves in the colony axis).
- One of the seven species of *Paracorallium* (*P. japonicum*) is in commercial trade; the other 5-6 species in commercial trade remain in the genus *Corallium.*
- Five additional species of *Corallium* are reported by Cairns (2007), bringing the total number of species reported in the family Corallidae to 32.
- One recent study suggests that one commercially important species, *C. regale* is a synonym of *C. lauuense* (Baco and Shank, 2005), while taxonomists indicate these are separate species. The species *C. lauuense* is also spelled *C. laanense* (Bayer and Cairns, 2003) This taxa have been reported to be harvested off Hawaii and in international waters around Emperor Seamounts, yet these are not reported in FAO catch data.
- While all species were lumped under the genus *Corallium* to simplify the listing proposal, all 31 closely related species in the family Corallidae are recommended for inclusion in Appendix II of CITES.

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