



NDF WORKSHOP CASE STUDIES  
WG 9 – Aquatic Invertebrates  
CASE STUDY 1

Corals

Country – HAWAII

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## CASE STUDY FOR BLACK CORAL FROM HAWAII

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### I. BACKGROUND INFORMATION ON THE TAXA

Currently, raw and worked black coral emanating from the United States is being harvested from Hawaii, where three species (*Antipathes grandis*, *A. dichotoma*, and *A. ulex*) are commercially harvested and only two of which, *A. dichotoma* and *A. grandis*, are currently reported to be exported from the United States. While some general black coral information will be provided, specific information focuses on the two U.S. species currently in trade (*A. grandis* and *dichotoma*).

#### 1. BIOLOGICAL DATA

##### 1.1. Scientific and common names

Black coral, in the order Anthipatharia, is comprised of seven families: *Antipathidae*, *Aphanipathidea*, *Cladopathidae*, *Leiopathidae*, *Myriopathidae*, *Stylopathidae* and *Schizopathidea* (ITIS 2007). There are over 200 described species (Opresko 1972; 2001). Overall, 11 genera have been reported in trade, seven of which are reported only to the level of genus; for the other four genera, 13 species are listed in the CITES trade database (Table 1) (WCMC 2008). There are also at least six genera, *Allopathes*, *Antipathella*, *Hillopathes*, *Parantipathes*, *Taxipathes* and *Tropidopathes* that have not been reported in international trade. There is considerable confusion regarding the taxonomy

of species of black corals. For instance, *A. dichotoma* is considered synonymous with (*A. cf. curvata*), but this species is in the process of being renamed (Opresko, in review). The species *A. ulex* was recently moved to the genus *Myriopathes* with the creation of the new family of *Myriopathidae* in Opresko 2001.

## 1.2. Distribution

Antipatharians are cosmopolitan in distribution, with the greatest number of species found in the subtropics and tropics. Although a few species occur in shallow waters, most live at depths of 20 m and deeper, to depths of 8000 meters (m). In general, most species and the greatest abundance of individuals occur in tropical seas from 30-80 m depth (Grigg 1993; Sánchez *et al.* 1998). In the United States, black coral occurs off California at depths of 90-360 m (Love *et al.* 2007); the Western Pacific islands, including American Samoa, Guam, Hawaii, and the Northern Marianas, at depths of 5-30 m; the Gulf of Mexico at depths of 56-100 m (Rezak *et al.* 1990); and the Caribbean islands, including Puerto Rico and the U.S. Virgin Islands, at depths of 30-50 m (Sánchez *et al.* 1998).

Two black coral species found in United States waters are currently exported under CITES permits: *Antipathes dichotoma* and *A. grandis*. These species are thought to be endemic to Hawaii, although wild populations have a patchy or fragmented distribution, and colony density is generally low (Grigg 1993; Opresko 2001). In Hawaii, where the only international U.S. export is currently occurring (See 3.2), 14 species of black coral have been identified, of which 9 species are found only below 100 m depth. The two dominant species (*A. dichotoma* and *A. grandis*) are highly aggregated on vertical drop-off's or undercut terraces, and are most abundant in the channel between Maui and Lanai (total area of available habitat is estimated at 1.7 km<sup>2</sup>) at 30-110 m depth. A smaller bed exists off Kauai (estimated available area = 0.4 km<sup>2</sup>) and another off the southwest coast of the island of Hawaii. The dominant species found in these locations are *Antipathes dichotoma* (95% of the population) followed by *Antipathes grandis*. The lower depth limit of *A. dichotoma* and *A. grandis* coincides with the top of the thermocline in the high Hawaiian Islands (Grigg 1976; 1993).

## 1.3. Biological characteristics:

### 1.3.1. General biological and life history characteristics of the species

Black corals are colonial cnidarians and may be branching (bushy, feathery, dendritic, fan-shaped, whip-like or bottle-brush shaped) or

wire-like without branches (known as wire or whip corals) (Grigg 1993). Black corals have a similar gross appearance to branching gorgonians; however, live specimens can be differentiated by examining the polyps: Black coral polyps have 6 unbranched, non-retractile tentacles versus 8 pinnate tentacles found in gorgonians. Live colonies are usually white, yellow, orange, red or green. A single black coral colony may have thousands of individual polyps; in most species, each polyp has six unbranched, non-retractile tentacles with stinging cells (nematocysts). Unlike other cnidarians, polyps have no structural protection from the abrasive forces associated with strong currents and surge (Kim *et al.* 1992) and tentacles remain expanded during the day. Some species produce enlarged, heavily armed sweeper tentacles in response to organisms that colonize their branches (e.g., epibionts) (Goldberg *et al.* 1990). The horny axial skeleton is secreted in concentric layers around a hollow core, and is composed of chitin fibrils and non-fibrillar protein (Kim *et al.* 1992) that is similar to the gorgonin material found in gorgonian skeletons. In addition, the skeleton of black coral colonies have small spines; these are absent in gorgonians. Within the order Antipatharia, *Cirripathes* has an unbranched skeleton, while others have a branching morphology; genera are separated based on the numbers of mesenteries, number and type of septa, polyp morphology, and size, shape and density of axial spines. Identification of worked black coral to the level of genus is difficult (Opersko 1973).

Antipatharians are carnivorous filter feeders (specifically, planktivores) that ingest amphipods, copepods, chaetognaths, and possibly other zooplankton. Zooplankton is captured using tentacles and nematocysts, but mucus nets and strands, ciliary currents and mesenterial filaments are also important in the capture and ingestion of zooplankton and particulate organic matter (Lewis 1978). Unlike many stony corals and gorgonians, antipatharians do not contain zooxanthellae (symbiotic algae) in their tissues (Grigg 1993).

Black coral is characterized by slow growth, delayed first reproduction, long life, annual release of gametes, high colony fecundity, and low survivorship and recruitment of larvae (Parker *et al.* 1997). Species of black coral are mostly dioecious (having separate sexes); in hermaphroditic species, individual polyps are male or female (Grigg 1993). It is assumed that colonies shed eggs and sperm into the water (broadcast spawning) for external fertilization, although this has only been verified in one species, *A. fiordensis* (Parker *et al.* 1997). Overall, sexual recruitment in Antipatharians is thought to be episodic with the success of a few strong year classes critical to local population abundances (Grigg 1976). Asexual reproduction, involving fragmentation of indi-

vidual polyps and subsequent formation of small, motile ciliated bodies has been observed in the laboratory under stressful conditions (Miller and Grange 1997).

Colonies of *A. dichotoma* reach reproductive maturity at a height of 64-80 centimeters (cm), corresponding to an age of 10-12 years (Grigg 1977; Grigg 1993). Dispersal of larvae in Hawaiian populations is thought to be very restricted, but populations below 80 m may provide a source of larvae that recruit into shallow areas where harvest occurs (Rick Grigg, personal communication). However, the concept of deep refugia for Hawaiian black corals has never been shown and current work is underway to test this question (Montgomery, personal communication). Larvae are negatively phototactic, but avoid settling below the thermocline where lower temperature may prevent reproduction (Grigg 1993).

Antipatharians exhibit a slow rate of growth. Grigg (1993) characterized black coral as among "the slowest growing organisms of any known fishery past or present" (Grigg 1993). The dominant Hawaiian species, *A. dichotoma*, increases in height by about 6.4 cm/year (2.5 in/year) with no difference noted among different size classes; *A. grandis* grows at about 6.12 cm/year (2.4 in/year) (Grigg 1977). Colonies of *Antipathes* may grow to 2 m (6.5 ft), while wire corals such as *Cirripathes* may grow to 5 m (16 ft) in length. The largest and oldest colonies of *A. dichotoma* and *A. grandis* in Hawaii may be older than 75 years of age (Grigg 1976; 1988; 1993).

### 1.3.2. *Habitat types*

Water currents, turbidity, suspended particulate material, and bottom topography play a key role in regulating species distribution, composition and abundance. All species require a firm substrate free of sediment, most thrive in areas swept by moderate to strong currents. Colonies are found most frequently near drop-offs, terraces, or under ledges in areas with swift currents; in shallow water, colonies generally inhabit shaded areas or turbid water where surge is minimal. *Antipathes* spp. is one of the shallowest genera, preferring shaded or low light areas and occurring underneath ledges and in shallow water caves, where surge is minimal, or in the open on steep walls at deeper depths. *Antipathes* spp. appears to settle predominantly in depressions, cracks or other rugged features along steep ledges, with few colonies found on smooth basaltic substratum (Grigg 1965). Shallower antipatharians in Hawaii also appear to prefer substrates that are encrusted with calcium carbonate from coralline algae, bryozoans, and corals. Light and temperature appear to influence larvae more than adults. Grigg (1965) reported that adult colonies can withstand

light intensities of up to 60% of surface incident light and they survive in shallow water only where surge is minimal and light levels are reduced. In addition, larvae will settle preferentially in areas where light penetration is less than 25% of the surface light (Grigg 1965).

### 1.3.3. *Role of the species in its ecosystem*

Black coral colonies inhabit a very specific habitat type, and they create critical habitat for invertebrates and fish, including commensal species that are dependent upon black coral for survival. Their erect, branching structure creates substrate for attachment of sponges, tube-worms, barnacles, molluscs, anemones and echinoderms, shelter from predators for small fishes, and a sleeping perch for large fishes and rock lobsters (Grange 1985; Warner 1981). Boland and Parrish (2005) examined the role of black coral and associated fish communities. They reported black coral provided habitat for several species of fishes and the absence of black coral may impact fish assemblages. Several species of molluscs, echinoderms, crustaceans and fishes feed on the coral tissue or the mucus produced by the polyps (Table 3). Species that associate with *Antipathes* include 17 different pontonine shrimp from the Indo-Pacific (Australia, Madagascar, Kenya, Maldives, Indonesia, Zanzibar, New Caledonia, Borneo, and Hawaii) and the Caribbean (Spotte *et al.* 1994). Many invertebrate species have been found only among antipatharians, including some that only colonize dead skeletons while others inhabit the branches of living colonies (Love *et al.* 2007).

## 1.4. **Population:**

### 1.4.1. *Global Population size*

Black corals are distributed worldwide at ocean depths varying from 30-360 m (98.5 – to 725ft) (Grigg 1993; Sánchez *et al.* 1998). For the purposes of the non-detriment finding, information is presented on the Hawaiian populations.

In Hawaii, black corals are most abundant from 30-100 m depths. In 1975, the average density of the most abundant species, *A. dichotoma* (*A. cf. curvata*), was estimated at 0.05 colonies/square meter (m<sup>2</sup>). This species occupied an area of 1.68 million m<sup>2</sup> within the Au'au Channel, and had a total standing crop of 166,000 kilograms (kg) or 84,000 colonies (Grigg 1977). The second most abundant species, **A. grandis** occurred at a density of about 5% that of **A. dichotoma** and contained an estimated standing crop of 40,000 (kg)). Surveys conducted in 1998 indicated that the age frequency distribution and the abundance of colonies were not significantly different between surveys, except for

colonies that exceeded 20 years of age. The proportion of 20+ year olds declined from 10.8% of the population in 1975 to 8.6% in 1998. In addition, 97% of the population in 1998 consisted of colonies that were less than 23 years of age, indicating that the bed consisted almost entirely of colonies that had recruited since the area was last examined in 1975. These results suggest that between 1975 and 1998, the population remained fairly stable, steady recruitment occurred, and harvest pressure had not exceeded the mean sustainable yield (Grigg 1998). However, from 1999 to 2005, the reported average annual catch more than doubled that for the previous 7-year period, likely due to increased consumer demand and improved fishing techniques (Parrish 2006). Although Grigg (2001) showed a sustainable harvest from 1975 to 1998, both Grigg (2004) and Montgomery (2006) show a decline in younger age classes. Montgomery (2006) showed an increase of total mortality for post harvest age classes in between 1998 and 2004 (19.7% to 30.9%, respectively). In 2004, the pre-harvested age classes showed a zero percent total mortality suggesting that recruitment has been reduced considerably. In addition, black coral reefs previously believed protected from harvest by their extreme depths are experiencing large-scale mortality from invasion by a species of invasive coral (*Carijoa riisei*) (Kahng 2006).

#### 1.4.2. Current global population trends

increasing     decreasing     stable     unknown

Global: This is not known. There are very few surveys done in recent years. Most work has focused on Hawaii. It is known that most black coral colonies from tropical coral reefs has been largely depleted at depths accessible by recreational divers, although isolated colonies can still be found below 20 m depth or so throughout the Caribbean and IndoPacific. The only known populations that are of commercial size are now in Hawaii.

Hawaii: Stable to decreasing. Recruitment and growth in managed populations were in near steady state from 1975-1998. Recent research suggests that, since 1998, there has been a decline in larger older classes and a recent decline in age classes under 5 (Grigg 2004; Montgomery 2006). The causes for decline have been attributed to increased consumer demand, improved fishing techniques, and overgrowth by an invasive species (Montgomery 2006). Furthermore, NOAA (73 FR 47098, 2008) reports a decrease in the biomass of black coral within Au'au Channel of at least 25% between 1976-2001 (Grigg 2004), with notable declines in both recruitment and the abundance of legal-sized colonies.

## 1.5. Conservation status

### 1.5.1. *Global conservation status* (according to IUCN Red List): *Not listed*

- |                                                |                                          |
|------------------------------------------------|------------------------------------------|
| <input type="checkbox"/> Critically endangered | <input type="checkbox"/> Near Threatened |
| <input type="checkbox"/> Endangered            | <input type="checkbox"/> Least concern   |
| <input type="checkbox"/> Vulnerable            | <input type="checkbox"/> Data deficient  |

### 1.5.2. *National conservation status for the case study country*

### 1.5.3. *Main threats within the case study country*

- No Threats
- Habitat Loss/Degradation (human induced)
- Invasive alien species (directly affecting the species)
- Harvesting [hunting/gathering]
- Accidental mortality (e.g. Bycatch)
- Persecution (e.g. Pest control)
- Pollution (affecting habitat and/or species)
- Other \_\_\_\_\_
- Unknown

Populations of black coral are impacted primarily by harvest pressure, although bycatch associated with trawling (only in limited areas, but outside the United States) and other fishing activities as well as habitat destruction are localized threats, but primarily outside of Hawaii. This is mostly because most black coral is 2 to 7 miles offshore in deeper water (60 m or more, especially in the Au'au Channel). A significant and increasing threat in Hawaiian waters is an invasive coral, *Carijoa* spp. which prefers black coral habitat and is overgrowing and smothering black coral colonies. It is thought to have killed 70 % of the black coral trees between 68 – 114 m depth within the coral bed in the Au'au Channel. However, the impact occurred mostly below the primary operating depth (41 m) of the fishermen, at 85 – 90 m, and is less widespread than previously thought (Kahng and Grigg 2005; Grigg 2004; WPRFMC 2007). Species are particularly vulnerable to overexploitation because of their patchy distribution and potentially limited larval dispersal, slow growth rate, and delayed reproduction. In addition, decades of accumulated standing stock can be collected during short intensive periods of fishing (Grigg 1993), but it is not clear what the longer term impacts are on the population biomass.

Natural mortality also impacts populations. Smothering by sediments, abrasion and overgrowth by encrusting organisms is a major source of mortality in some locations (Grigg 1993). Sedimentation is a problem for nearshore populations in shallow water; it may have

minor impacts in deeper areas off Hawaii, but most corals occur in channels with high currents and high visibility, so flushing is likely to remove most sediments. Colonies also die when they break off at their base as a result of bioerosion or physical disturbance. Diseased tissue has been observed infrequently (Rick Grigg, personal communication), but has never been documented. A few predators of antipatharians have been identified, including cyclopid copepods (family Vahiniidae) and a coralliophilid gastropod (*Rhizochilus antipathicus*).

Probably the greatest threat today is harvest pressure, which may have increased over the last decade to support an increase in demand in black coral and a 25-50% increase in sales since 1998. This has been addressed by the State of Hawaii by relaxing the size limit and introducing a grandfathering scheme that allowed veteran divers (that reported black coral harvest in the preceding 5 years) to collect corals that are at least 0.9 m in height. Previous size limits were not based on a minimum height but rather a minimum basal diameter of 3/4 inch.

Another reason that the fishery has become more efficient is the availability of detailed bathymetric maps and the adoption of GPS positioning (Stone and Shotwell 2007). This has led to a decline in black coral biomass of 25 % (Grigg 2004), possibly posing a threat to the population. In 1998, after 23 years of harvesting, no colonies older than 27-33 years old were left in the population (Grigg 2001), but mature colonies still remained in the population. Three years later, no colonies older than 24 years were left (Grigg 2004), illustrating a biomass loss due to an increased intensity of fishing.

## **2. SPECIES MANAGEMENT WITHIN THE COUNTRY FOR WHICH CASE STUDY IS BEING PRESENTED.**

### **2.1. Management measures**

#### *2.1.1. Management history*

In Hawaii, commercial black coral beds are located in state and federal waters. State waters include areas within 3 miles of islands as well as inter-island waters and harvest is regulated by the Department of Land and Natural Resources (DLNR)-Division of Aquatic Resources (DAR). The area extending from 3 miles to 200 miles outside the State of Hawaii falls under federal jurisdiction and is referred to as the United States Exclusive Economic Zone (EEZ) (Grigg 1993; NOAA 2006).

#### *2.1.2. Purpose of the management plan in place*

Hawaii (in both state and federal waters) established management plans for the harvest of black coral to limit the number of fishermen



and the amount of harvest, with the goal of ensuring the fishery is sustainable and the black coral colonies are protected from extinction.

### 2.1.3. General elements of the management plan

STATE (DLNR) MANAGEMENT: State management involves a system of licensing and reporting requirements (elaborated upon in Section 1.2.2.1), as well as maximum sustainable yields, and minimum size limits (as described below).

FEDERAL PRECIOUS CORAL FISHERY MANAGEMENT PLAN: Regulations have been adopted to include specific provisions for harvest within designated known beds of precious corals. The FMP also includes MSY, size restrictions and gear restrictions (as described below).

MAXIMUM SUSTAINABLE YIELD (MSY): There is an MSY established for federal areas, but not for state waters. In 1976, the maximum sustainable yield (MSY) for the Au'au channel was estimated to be just over 5,000 kg (11,000 lb) for the stock in the Au'au channel and 1250 kg (2,750 lb) for Kauai. As mentioned under 1.4.1, population studies conducted through 1975-1998, indicated a fairly stable population level, with steady recruitment and harvest pressure not exceeding the mean sustainable yield (Grigg 2001). However, from 1999 to 2005, the reported average annual catch more than doubled that for the previous 7-year period, likely due to increased consumer demand and improved fishing techniques. These surveys suggest that the maximum sustainable yield (MSY) should be adjusted downward by approximately 25% (Parrish 2006; Grigg 2004).

MINIMUM SIZE LIMIT: *Antipathes dichotoma* colonies mature at 10-12 years, which corresponds to a 1.25-1.5 cm base diameter and a height of approximately 64-80 cm (25-30 in). Grigg (1976) recommended a minimum size limit of 1.2 m (4 ft) in height and a basal diameter of 2.54 cm (1 in) to ensure that immature colonies are not harvested, and to maximize the mean sustainable yield (MSY). The state has maintained a minimum size requirement for black coral fishing since 1998, limiting harvest to specimens with a minimum base diameter of 1.91 cm (3/4 in) (Hawaii Administrative Rules, 13-91 1999). While a minimum size of 122 cm (48 inches) height or 2.54 cm (1 inch) diameter became effective in federal waters on April 17, 2002, an exemption allowed existing licensed fishers that had reported black coral harvests in the five years prior to 2002 to continue to harvest black coral with a basal diameter of 3/4" (1.9 cm) in federal waters. In 2007, this exemption was removed in order to reduce the impacts of fishing on Au'au

Channel black coral; size limits reverted back to the minimum 2.54 cm basal diameter for all fishers (72 FR 58259<sup>1</sup>).

**VOLUNTARY SIZE LIMITS:** According to Tony Montgomery (Marine Biologist, Department of Land and Natural Resources (DLNR)-Division of Aquatic Resources (DAR), Honolulu, Hawaii, personal communication 2007), within the last few years, there has also been a voluntary agreement to buy only colonies 122 cm (48 in) in height. Unfortunately, it is not possible to verify whether this practice is being followed. DLNR is in the process of updating their reporting forms to better capture this information (Montgomery, personal communication 2007).

**FEDERAL:** Black coral is managed under the Fishery Management Plan (FMP) for the Precious Coral Fisheries of the Western Pacific Region. The management plan classifies known beds of precious corals and establishes harvesting methods and limits within these beds. Beds are classified as: 1) Established Beds, 2) Conditional Beds, 3) Refugia Beds, and 4) Exploratory Permit Areas (Grigg 1993). This plan covers all precious corals, and the specific designation of different types of beds refers to other non-black coral precious coral species.

Established beds have a history of harvest, optimum yields have been established on the basis of biological stock assessment techniques, and selective harvesting gear (submersibles or remote control harvester vehicles) is required. Until 2008, Makapu'u (off Oahu) was the only designated Established Bed (Grigg 1993). NOAA recently revised the regulations to include Au'au channel as an established bed and changed the annual MSY of 5,000 kg (11,023 lb) to a biannual MSY; this quota applies to black coral in state and federal waters (73 FR 47098).

Conditional beds are ones for which yields have been estimated on the basis of bed size relative to established beds with the assumption that ecological conditions at established beds are representative of conditions at all other beds. Four beds continue to be designated as conditional beds: Kea-hole Point, Kaena Point, Brooks Banks, and 180 Fathom Bank (73 FR 47098; Grigg 1993). Nonselective harvesting was permitted in the two conditional beds in the Northwest Hawaiian Islands (Brooks and the 180 Fathom Banks) until 1999 (Grigg 1993).

Refugia beds are set aside to serve as baseline study areas and possible reproductive reserves. No harvesting of any kind is permitted in

<sup>1</sup> Regulations and amendments to Federal Fishery Management Plans are published in the Federal Register Notice. These are listed here by the volume (e.g., 72 or 73) and page number.

Refugia. Presently, the WESTPAC bed, between Nihoa and Necker Islands, is the only designated Refugia (73 FR 47098; Grigg 1993). This bed does not contain any black coral (Andy Bruckner, personal communication 2007).

Exploratory permit areas are unexplored portions of the EEZ, where habitat exists, but no beds have been confirmed. There are four exploratory permit areas; one surrounding the Hawaiian Islands, another that encompasses Guam and the Commonwealth of the Northern Marianas (referred to as CNMI), a third that encircles American Samoa, and a fourth, which was created by Amendment 1 to the FMP, which includes the EEZ's of all the remaining U.S. Pacific Island possessions (73 FR 47098; Grigg 1993).

The FMP, as amended in 2002, prohibits the use of nonselective gear (e.g. tangle nets, dredges) throughout the management area. Black coral is primarily found in State waters and the State and the WPFMC jointly manage the resource. Quotas and minimum size limits are monitored through mandatory reporting to NMFS and the Hawaii State Division of Aquatic Resources using coral landing logs and buyer reports.

#### 2.1.4. *Restoration or alleviation measures*

Of the two major commercial beds, one situated off Maui (Au'au Channel) and the other off Kauai (Makawaena Point) (Grigg 1993), Makawaena Point is not currently being harvested.

Black coral is selectively harvested by divers using SCUBA gear, which limits harvest to depths above 246 feet (Kahng 2006). Selective harvest can be accomplished by hand, using axes, hammers, and saws but submersibles have also been employed to harvest other coral species (Grigg 1993). There are significant amounts of black coral that are below the limit of standard SCUBA equipment. These black coral beds, previously believed protected from harvest by their extreme depths, were thought to serve as a refuge for shallower populations. However, surveys from 2001-2004 on reefs below 70-m showed that over 50% of the colonies were overgrown by a species of invasive coral, *Carijoa riisei* (Kahng 2006). Large colonies are most severely impacted and are experiencing large-scale mortality from this invasion (Kahng 2006). State (DLNR) and federal (NOAA) authorities are in the process of amending their regulations and management strategies to address this concern (72 FR 44074).

**MAXIMUM SUSTAINABLE YIELD (MSY):** Recent biological data suggest that the MSY should be adjusted downward by approximately 25% (Grigg, 2004; Parrish 2006). State (DLNR) and federal (NOAA) authorities recently amended their regulations to for Au'au channel, where the

bulk of black coral harvest occurs. This bed is now designated as an established bed and the allowable harvest has been effectively reduced by 50%. This includes a reduction from an annual harvest quota of 5,000 kg (11,023 lb) in federal waters to a biannual harvest of 5000 kg in both state and federal waters combined (73 FR 47098).

**MINIMUM SIZE LIMIT:** In 2007, the exemption for fishers who were allowed to continue to harvest black coral with a basal diameter of 3/4" (1.9 cm) was removed in order to reduce the impacts of fishing on Au'au Channel black coral, Now all harvested coral in Federal waters must have a 1" basal diameter (72 FR 58259).

**VOLUNTARY SIZE LIMITS:** The state is in the process of updating their reporting forms to better capture any industry self-imposed voluntary size limits (Montgomery, personal communication 2007).

## **2.2. Monitoring system**

### **2.2.1. *Methods used to monitor harvest***

DLNR requires black coral fishers (coral harvesters) to obtain a state license to harvest from state or federal waters (Commercial Marine License); NOAA requires a federal license for fishing in federal water only (Pacific Precious Coral permit). The number of permitted commercial divers has remained stable over the last decade, varying between 3-5 licensed divers (72 FR 44074; Western Pacific Regional Fishery Management Council 2005).

Fishers are required to report landings by submitting a "Commercial Catch Report," which includes the date, license number, weight, etc. Dealers are not required to have a license, but are required to report first points of purchase from a fisher on the "Commercial Marine Dealer's Report on Purchases of Marine Life" form.

### **2.2.2. *Confidence in the use of monitoring***

Confidence is high. The state has implemented adaptive management practices, including controlling the number of permitted divers (See Section I.2.2.1), responding to biological research and monitoring data (See Sections I.2.1.4 and I.3.2.2), amending regulations as needed (72 FR 44074; 73 FR 47098), and has been consistently responsive when consulted regarding international exports.

## **2.3. Legal framework and law enforcement**

Black coral is managed under the Fishery Management Plan (FMP) for the Precious Coral Fisheries of the Western Pacific Region. Regulations

implementing the FMP are published in:  
Subpart F 50 CFR 665  
(Title 50: Wildlife and Fisheries, Part 665—Fisheries In The Western Pacific, Subpart F—Precious Corals Fisheries)  
<<http://law.justia.com/us/cfr/title50/50-8.0.1.1.10.html#50:8.0.1.1.10.6>>

Subpart H 50 CFR 600  
(Title 50: Wildlife and Fisheries, Code of Federal Regulations, Part 600—Magnuson-Stevens Act Provisions, Subpart H—General Provisions For Domestic Fisheries)  
<<http://law.justia.com/us/cfr/title50/50-8.0.1.1.1.html#50:8.0.1.1.1.8>>

Hawaii state law concerning black coral is published in:  
HAR 13-91  
(Hawaii Administrative Rules, 13-91) <[http://www.hawaii.gov/dlnr/dar/library/har\\_toc.htm](http://www.hawaii.gov/dlnr/dar/library/har_toc.htm)> [Accessed August 15, 2007].

Black coral has been listed in Appendix II of CITES since 1981. In the United States, CITES is implemented through Section 9 of The Endangered Species Act of 1973, as amended. Regulations implementing this Act are published in:  
50 CFR Parts 10, 13, 17, and 23  
(Title 50: Wildlife and Fisheries, Code of Federal Regulations, Chapter I—United States Fish And Wildlife Service, Department of the Interior, Parts 10—General Provisions, 13—General Permit Procedures, 17—Endangered and Threatened Wildlife and Plants, and 23—Endangered Species Convention  
<<http://law.justia.com/us/cfr/title50.html>>

### **3. UTILIZATION AND TRADE FOR RANGE STATE FOR WHICH CASE STUDY IS BEING PRESENTED**

#### **3.1. Type of use (origin) and destinations (purposes)**

Currently, the only CITES-permitted black coral being exported from the United States is harvested from Hawaiian waters (Patricia De Angelis, Division of Scientific Authority (DSA), U.S. Fish and Wildlife Service, Arlington, Virginia). Historically, black coral was used in medicines and religious artifacts. Commercial black coral harvest is primarily for jewelry. The process of working raw black coral into finished products historically was reported to only have about 1% efficiency. This would suggest 4,265 lb) of raw coral would yield only approximately 43 lb finished product. However, Maui Divers (the main producer in Hawaii) claims that waste has been nearly eliminated because

they use lasers to cut material. A small trade in live specimens for aquarium organisms has been reported (NOAA 2002), but the size of this trade is unknown.

Beginning of the industry in Hawaii: Of 14 species known to occur in Hawaii, 12 are found below 100 m (330 ft) depth (which is too deep for traditional SCUBA diving) and only three (all shallow water species) are large enough to be of commercial value for coral jewelry (Devaney and Eldridge 1977; Grigg 1993; Grigg and Opresko 1977). Two major commercial beds of black coral were discovered off Hawaii (off Maui (Au'au Channel) and off Kauai (Makawaena Point)) in 1958 at depths between 30 and 75 m (Grigg 1993). One commercial entity established a small black coral jewelry industry in 1960, and as much as 10,000 kg were harvested annually from this bed during the 1960s and 1970s. During the late 1970s and early 1980s the demand for black coral in Hawaii was greatly reduced, but since 1986 the demand has steadily increased, in part because of its designation as Hawaii's state gem. In 1993, this one commercial entity accounted for more than 50% of all locally-produced black coral jewelry in the State (Grigg 1993).

The industry today: The three shallow water species of black coral that are commercially harvested in Hawaii are: *Antipathes grandis*, *A. dichotoma*, and *Myriopathes ulex* (Oishi 1990; Montgomery, personal communication 2007). Hawaiian coral is almost exclusively fished from Maui's Au'au channel, mainly from state waters, where it is most accessible (Montgomery, personal communication 2007). Annual landings average 1,014 kg/year; about 90% of this is for domestic use (Grigg 2004). Trade is no longer dominated by one entity, but 2-3 entities that deal mostly in smaller volumes. In 2007 and 2008, DSA provided NDFs for approximately 4 applicants, for export permits totaling up to 2,439 kg (5,377 lb) raw black coral and 4 kg (8.82 lb) of worked material (P. De Angelis, pers. comm. 2008).

## 3.2. Harvest:

### 3.2.1. Harvesting regime

Colonies are selectively harvested from up to 75 m depth using SCUBA; Advanced diving techniques including re-breathers, mixed gases and ROVs allow selective harvesting from deeper water, but these methods are not used in Hawaii. Tangle net dredges have also been employed for non-selective harvest, but this is not permitted in Hawaii.

Currently, there are three commercial fishers (harvesters) that are licensed to harvest black coral in Hawaii. Fishers selectively harvest colonies using SCUBA with axes, hammers and saws (Grigg 1993); about 90% of the catch consists of *Antipathes dichotoma*, 9% is

*A. grandis* and 1% is *Myriopathes. ulex*. From 1981-1990 the state of Hawaii reported that landings of black coral amounted to 6200 kg (13,706 pounds), with an annual take of 72-1977 kg (158-4,351 lb) (Oishi 1990). The total black coral landings increased to over 20,000 lbs over the next seven years (1992-1998) and total catch more than doubled for the seven year period from 1999-2005; overall, landing between 199-2005 comprised 58% of the total harvest since 1985 (Parrish 2006). These increases are due, presumably to increased consumer demand and improved fishing techniques. Given the decrease in biomass, invasion by *Carijoa* and recent increases in demand, Grigg (2004) suggested that the MSY should be adjusted downward by approximately 25% (Parrish 2006).

### 3.2.2. *Harvest management/ control* (quotas, seasons, permits, etc.)

There continues to be little black coral harvest from EEZ waters. Today, most harvest (85%) occurs in state waters, in Au'au channel within 3 miles of shore where black coral is accessible with SCUBA gear (Montgomery, personal communication 2007). State coral resources are managed under a state management program, which has adapted as information on the biology of the species and the effect of harvest has become available.

Licensing: The DLNR requires black coral fishers to obtain a state license to harvest from state or federal waters (Commercial Marine License); NOAA requires a federal license for fishing in federal water only (Pacific Precious Coral permit). The number of permitted commercial divers has remained small and stable over the last decade, varying between 3-5 licensed divers (72 FR 44074; Western Pacific Regional Fishery Management Council 2005).

In addition, improvements in the efficiency of cutting and polishing of black coral has led to a several hundred percent decline in the amount of coral consumed to produce the same value of finished product (Grigg 1998). The state is currently considering amending their regulations to respond to recent information on the effect of harvest in the Au'au Channel, including removing minimum size exemptions, and to respond to infiltration by invasive coral (72 FR 44074). Other conservation strategies include a suggestion to prohibit harvest of coral from depths where conventional SCUBA becomes unsafe (e.g. 80 m) (Rick Grigg, personal communication).

### 3.3. **Legal and illegal trade levels**

Global: According to the CITES trade database, black coral trade consists primarily of worked jewelry reported by number of pieces, with a small portion of raw coral traded by weight and less than 1% traded

live (WCMC 2008). Overall, 11 genera have been reported; for four genera, trade has been reported in 13 species (Table 1). Over 90% of all records are *Antipatharia* spp., *Antipathes* spp. and *Cirrhopathes* spp., with *Cirrhopathes anguina* and *Antipathes densa* most commonly in trade: *Cirrhopathes* is considered of inferior quality, however it is the most widespread and abundant species. Between 1982-1998 a total of 72 metric tons and 7,400,000 pieces of black coral were recorded as being traded, with most exported from Taiwan, the Philippines, and the Dominican Republic. During this period international trade in black coral, according to the CITES trade database, has averaged 430,000 items per year, with the maximum trade in 1994, and 320,000 items traded in 1998. Trade in processed black coral was lower between 1999-2003 (a minimum of from 126,000 in 2002 and a maximum of 255,000 in 2003), while trade in unprocessed black coral (by weight) ranged from 140 kg (2000) to 475 kg (2002). The United States is the major importer, followed by Japan. Exports from the United States have remained consistently very low, with less than 1000 pieces exported per year. The world's largest supplier of worked black coral is Taiwan (>90% of the total), with most reported to be harvested in the Philippines. Trends in the annual volume of trade from the CITES database are shown in Figure 1.

In 1996, 473,000 black coral pieces imported into the United States were reported to be worth \$447,000. According to WesPac (2007) the precious coral fishery in Hawaii is worth about US \$50 million, including an estimated US\$33 million for the black coral fishery alone. Around 1000 people are involved in the fishery, including coral divers, manufacturers and salespeople. The current wholesale value of unworked black coral is about \$35 per pound (Grigg, personal communication). Retail prices for manufactured black coral jewelry ranged from around \$35-300 for earrings, \$50-750 for small pendants, to over \$3000 for more ornate necklaces and bracelets; the higher priced items typically consist of black coral in a gold setting, often with other precious stones and coral.



## II. NON-DETRIMENT FINDING PROCEDURE (NDFs)

1. **IS THE METHODOLOGY USED BASED ON THE IUCN CHECKLIST FOR NDFs?**  
\_\_yes      X\* no

\*Although the U.S. Fish and Wildlife Service-Division of Scientific Authority (DSA) does not strictly adhere to the IUCN checklist, many of the concepts, prioritizations, and analyses used in NDFs for exports of U.S. black coral are consistent with those described in the IUCN document.

2. **CRITERIA, PARAMETERS AND/OR INDICATORS USED**

DSA uses a combination of peer-reviewed science, provincial management measures, dialogue with provincial authorities and experts, industry reporting, and CITES data to determine whether given exports will be detrimental to the survival of the species or if they will affect the role of the species in its ecosystem.

The relatively small scale of the United States black coral industry (five operators and two major processors located within one state exploiting a small number of beds) facilitates provincial management of the fishery and DSAs analysis of the impacts from harvest and export. In making non-detriment findings for given exports, DSA relies on five basic factors: a) licensing and reporting requirements; b) the science-based minimum size limit imposed and enforced by the State of Hawaii; c) estimates of maximum sustainable yield (MSY) from the exploited beds; d) industry information on yields, material stockpiles, and productivity; and e) practical harvest limitations that result in *de facto* refugia. These parameters are discussed below.

- a) Licensing and reporting requirements by DLNR and NOAA: Black coral fishers are required to obtain a state license (Commercial Marine License) to harvest from state or federal waters and a federal license (Pacific Precious Coral permit) to fish in federal waters. CITES applicants are requested to submit copies of these licenses, which are subsequently authenticated by either the Management Authority or Scientific Authority.

The state also requires fishers to submit a "Commercial Catch Report," which includes the date, license number, weight, etc. (Grigg 1993; Montgomery, personal communication 2007). It is difficult, however, to correlate specimens reported on Catch Reports with the specimens to be exported. According to Tony Montgomery (personal communication 2007), this is due to the harvesting process and characteristics of the fishery. The reported

weights are estimated, and include base rock. The coral is cured by drying and sold months, sometimes years later. The purchased weights are exact weights, and buyers and fishers negotiate over the amount of base rock attached. Under these circumstances, the weights will never equal, but this does not suggest any wrongdoing (Montgomery, personal communication 2007).

The state does not require dealers to have a license, but they are required to report first points of purchase from a fisher on the "Commercial Marine Dealer's Report on Purchases of Marine Life" form. DSA requests copies of these forms from applicants.

b) Minimum size limits: As noted in answer 2, the State of Hawaii has instituted science-based size limits for wild specimens that evidently promote robust age structure and protect spawning potential in the exploited coral beds. As the Hawaiian black coral industry has evolved, provincial authorities have instituted adaptive management measures, based on research and monitoring, to respond to changes in the biological status of the species. DSA relies on these regulations, and their provincial enforcement, when making determinations that a given piece of raw or worked black coral proposed for export is derived from sustainably harvested colonies.

c) Maximum Sustainable Yield (MSY): DSA also compares total annual removals to estimates of MSY. The documentation requested of CITES applicants (see a) and d)) allows DSA to monitor the amount of processed coral that is exported and the relative importance of domestic vs. international consumption of United States black coral.

For instance, in 1993, the annual reported take was 459.5 kg (1,013 lb) (Grigg 1998). However, one exporter, who purchased over 80% of the total annual harvest, reported to DSA that they purchased 3,719.5 (8,200 lb) from fishers in 1993. Noting this discrepancy, we consulted with provincial authorities. It is important to note that, because purchases may occur up to many years after harvest, the amount of coral purchased in one year, does not necessarily correlate with a harvest toward the MSY in that year (Montgomery, personal communication 2007). This allowed us to modify our permit conditions in order to better capture the information we needed.

d) Industry information on yields, material stockpiles, and productivity: Each CITES applicant wishing to export black coral from the United States must provide detailed accounting of 1) the weight of unworked black coral they purchased in the preceding six months; 2) the amount of unworked coral they have stockpiled; and 3) the number and weight of processed black coral specimens exported in the preceding six months. These data permit DSA to gauge the ton-

nage of wild specimens used by the major processors and make timely comparisons with MSY levels.

- e) The above information is bolstered by the fact that the industry is limited by the time and depth limits of SCUBA equipment during extraction: Areas beyond the reach of standard SCUBA were previously thought to be protected from harvest and serve as refugia for the local populations. However, recent surveys of deeper areas off Hawaii question these findings, as black coral was not found at the depths and sites previously reported (Montgomery, personal communication).

### **3. MAIN SOURCES OF DATA, INCLUDING FIELD EVALUATION OR SAMPLING METHODOLOGIES AND ANALYSIS USED**

The United States Scientific Authority uses information derived from provincial management agencies, fisheries management councils, and researchers. For worked coral, DSA has used the metric black coral finished products has about 1% efficiency to calculate maximum allowable exports given the amount of raw black coral that they verifiably purchased (with evidence such as receipts and reports of first points of purchase. Provincial permits, licenses and reporting forms are important for determining non-detriment. A copy of our most recent non-detriment finding on black coral is provided (Annex 1).

### **4. EVALUATION OF DATA QUANTITY AND QUALITY FOR THE ASSESSMENT**

- Minimum colony size limits and MSY estimates are based on peer-reviewed science and are therefore high quality inputs to NDFs by the United States Scientific Authority. Provincial authorities have demonstrated their commitment to maintaining a sustainable industry by its regulatory responsiveness to changes in industry or the status of the species.
- The remote and extreme habitat for black coral in U.S. waters precludes frequent and exhaustive monitoring of the exploited beds. Ongoing research continues to elucidate additional information concerning the threats to and conservation of the species.
- The practical limitations of SCUBA gear are well-documented, and the concept of deepwater refugia for exploited Hawaiian black coral beds is a reasonable part of the U.S. analyses in NDFs.
- Industry self-reporting on stockpiles, coral intake, and production efficiency are relatively low quality data inputs. This is not considered a significant factor given the findings from 1998 on the viability of the exploited beds.

## **5. MAIN PROBLEMS, CHALLENGES OR DIFFICULTIES FOUND ON THE ELABORATION OF NDF**

The main challenges involve obtaining and correctly interpreting available scientific information, as discussed above (Section II. 3). To this end, communication with management agencies and researchers is imperative. Another issue is that the state of Hawaii and the Western Pacific Fishery Management Council frequently changes the regulations, including size restrictions and MSY, based on new scientific data. It is imperative that US FWS is up to date on these recent changes, so that they can consider these when making NDFs.

## **6. RECOMMENDATIONS**

United States exports of black coral are currently limited to specimens harvested from Hawaii. The Hawaiian black coral industry continues to be limited by the small number of licensed commercial black coral fishers (that must meet the State's licensing and reporting requirements) and by the largely inaccessible depths where black coral lives (in most areas black coral exists at depths below which SCUBA equipment can safely be used). The state (DLNR) and federal (NOAA) agencies managing this resource *in situ* have responded to changing trade pressures and biological conditions by adapting their regulations and management strategy to the changing face of this fishery. These agencies have also been responsive to the United States Scientific Authority regarding questions about the industry and information relative to particular exports. Information exchange and cooperation between the DLNR, NOAA, and DSA is essential to making sound NDFs.

It is important to become familiar with the industry, to stay abreast of current research (some of which may not yet be published), to maintain communication and share information with provincial authorities, and, when necessary, to establish clear permit conditions that allow us to better gauge the impact of international trade on the species.

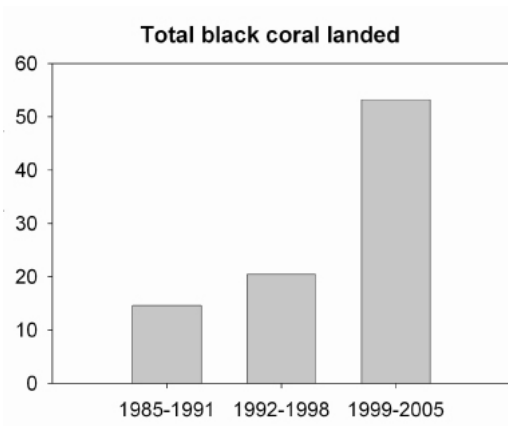
In order to ensure that harvesting is sustainable and it does not significantly limit recruitment, management strategies should include a determination of optimal harvest yields based on measures of abundance, growth, natural mortality and recruitment. Among the guidelines should be a scientifically-based minimum allowable size of harvest that provides sufficient time between age (size) at first reproduction and age (size) at first capture, and an annual, scientifically-based quota. New developments with invasive species and extraction technology (e.g. submersibles) must be monitored closely, and adjustments made as necessary.

The age at maximum yield per recruit 1 for *A. dichotoma* was estimated to be 22-40 years, corresponding to corals that measure 1.7 and 3.2 m in height (oldest black corals can reach 3.5 m across and more than 4 m height). Thus colony height corresponding to MSY was notably larger than what was actually harvested. The reason is an analysis of optimum yield. Harvesting all corals exceeding the height limit of MSY allows 100 % efficiency of the fishery. Less efficiency may result in more profit however, if catch per unit effort and optimum yield are considered. The most economic and yet sustainable strategy often is to fish at low intensity and catch the coral at an 10 earlier age than at maximum sustainable yield. As long as the harvested corals are older than the age at first reproduction, the fishery is sustainable, but care must be taken to control fishing intensity by monitoring programs. This practice does not produce maximum yield, but allows for maximum profit (thus called optimum yield), as yield per fishing effort is maximized (achieving maximum yield may in some cases result in less profit if it requires disproportionately higher fishing effort is necessary) (Georgios Tsounis, personal communication).

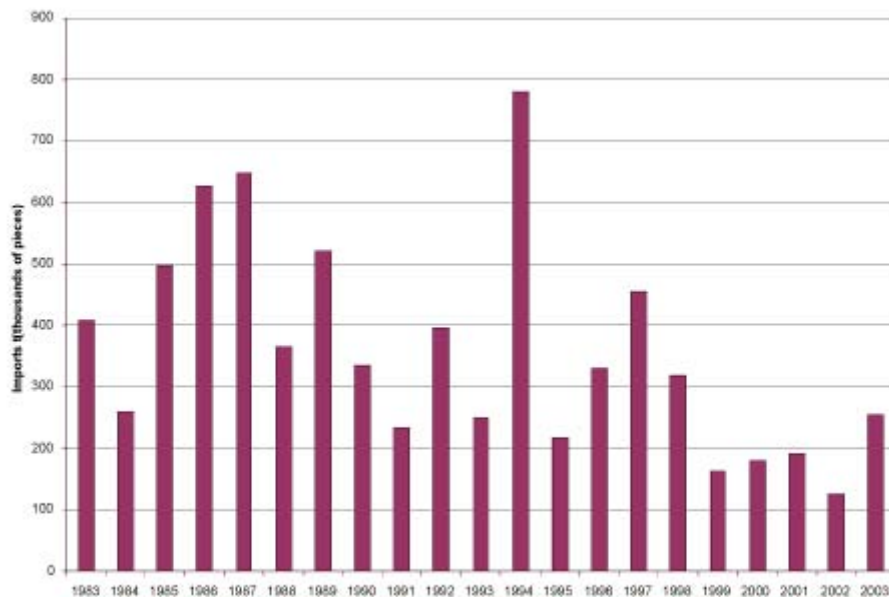
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**Fig. 1. Landings of black coral in Hawaii.** Data are pooled into seven year bins to meet confidentiality requirements for catch reporting. There is also a significant delay between harvest and reporting. Fishermen also commonly collect coral and retain this for several years and only report it after they sell the coral. Landings in the last 7 years comprised 58% of the total catch since 1985. Also, the average annual catch reported for the period 1999-2005 more than doubled the catch for the seven year period prior. Data and figure from Parrish, 2006.



**Fig. 2. Total volume of imports of black coral between 1983-2003.** All data are from CITES, and include only reports of black coral by piece. Additional trade in black coral is also reported by weight, with hundreds to thousands of kg reported each year.



TAXA	SOURCE	VOLUME (example years)
<b><i>Antipatharia</i> spp.</b>	<b>All</b>	<b>50,000, 20 kg (2001)</b>
<b><i>Antipathes</i> spp.</b>	<b>All</b>	<b>7000 (2001)</b>
<i>Antipathes crispera</i>	US	100 kg (2002)
<i>Antipathes grandis</i>	All	
<b>**<i>Antipathes densa</i></b>	<b>All</b>	<b>67,000, 19 kg (2001)</b>
<b><i>Antipathes japonica</i></b>	<b>Taiwan</b>	<b>63,000/138,000/43,000 (1988,1992, 1996)</b>
<i>Antipathes columnaris</i>	New Zealand	6 (2003)
<i>Antipathes plantagenista</i>	Cuba	3 (1996)
<i>Antipathes abies</i>	Philippines	42,700 (1996)
<b><i>Antipathes dichotoma</i> (A. cf. <i>curvata</i>)</b>	<b>Papua New Guinea Taiwan, Philippines</b>	<b>10,000 (1986)</b>
<i>Antipathes hirta</i>	TI	2 (2002)
<i>Aphanipathes</i> spp.	U.S., Mexico	1,600 live (1995)
<i>Bathypathes</i> spp.	Philippines	1554 (1986) 6 (2001)
<i>Bathypathes lyra</i>	Russia	18 live (1997)
<i>Bathypathes scoparia</i>	U.S.	5 (1997)
<b>*<i>Cirrhopathes anguina</i></b>	<b>All</b>	<b>65,000 (2001)</b>
<i>Cirrhopathes spiralis</i>	Papua New Guinea Philippines	270 (1987-89) 6,000 (1986)
<i>Cladopathes</i> spp.	Indonesia	16 live (1995); 100 (1986); 2 (2002)
<i>Hexapathes</i> spp.	Taiwan	1 (1996), 2000 (1987) 3 (2002)
<i>Leiopathes</i> spp.	Dominican Republic, Haiti, Thailand	4 (1996; 12 live (1993);152 live (1988); 3 (2001)
<i>Myriopathes japonica</i>	Taiwan	8000 (2003)
<i>Parantapathes</i>	CA	2 (2002)
<i>Sibopathes macrospina</i>	Australia, Fiji	1 (2002), 25 live (1995)
<i>Stichopathes gracilis</i>	U.S.	500 live (1996)
<i>Stichopathes regularis</i>	Mexico	2 live (1997).
<i>Stichopathes longispina</i>	Fiji	1 live (1997); 1 kg (2001)
<i>Schizopathes</i> spp.	CA	3 (1990) 6(2002)

**Table 1. Taxa of black corals reported in CITES between 1988-2003.** The dominant corals are shown in bold. Several additional taxa of black coral are reported to be in trade at low levels, but they have not been listed in the CITES database. These include the following genera: *Hilopathes* *Parantipathes*, *Taxipathes* and *Tropidopathes*