

DEEP SEA CORALS

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INTRODUCTION

Coral reefs are among the most spectacular ecosystems on the planet. They support such rich biodiversity and high densities of marine life that they have been referred to as the “rainforests of the sea.” These ecosystems are usually associated with corals having symbiotic algae that live in warm shallow tropical seas within recreational diving depths (30 meters or less). However other coral communities thrive in waters ranging from 50 meters to over 3,000 meters on continental shelves, slopes, canyons and seamounts around the world. These communities are structured by corals lacking symbiotic algae and are referred to as deep sea corals, deep corals or cold-water corals. In this article we will refer to them as deep sea corals.

Even though several species of these deep sea corals have been harvested for jewelry since antiquity and their existence has been known to science since 1758 when Carl von Linne wrote the *Systema Natura*, relatively little is known about their biology, population status, the role they play in enhancing local species diversity or their importance as habitat for deep-water species. Because of recent advances in deep-sea technology, scientists are now able to locate, study and map the distribution of deep sea coral habitat. These advances have resulted in a worldwide rapid expansion of studies of these deep sea communities.

Scientists are discovering that deep sea coral habitats appear to be much more extensive and important than previously known, particularly with respect to supporting biologically

diverse faunal assemblages. These corals can form large highly complex reef like structures, thickets and groves that serve as ecologically important habitats for fish and invertebrates. Deep sea coral communities have been identified as habitat for certain commercially important fishes, some other inhabitants contain bioactive compounds of pharmaceutical interest and several of the corals themselves are valued as the basis of a large jewelry business.

At the same time scientists are discovering the growing importance of these deep sea corals, they are realizing that they are being increasingly threatened by a variety of activities ranging from energy exploration to bottom fishing. These activities are threats because these corals are often extremely long-lived and slow growing animals, and therefore are particularly vulnerable to and very slow in recovering from physical disturbances to their ecosystems.

NOAA has brought together available information on the abundance, distribution and importance of these structure forming deep sea corals that occur in U.S. waters at depth of greater than 50 meters in “*The State of Deep Coral Ecosystems of the United States: 2007*.” The publication deals with data specific to seven geographic areas, Alaska, Pacific Coast, Pacific Islands, Northeast, Southeast, Gulf of Mexico and Caribbean. The facts presented are from this 365 page document and have been selected to provide you a preview of the range of materials included in the publication.



DEFINITIONS OF DEEP SEA CORALS

Corals are a taxonomically and morphologically diverse collection of animals in the Phylum Cnidaria, classes Anthozoa and Hydrozoa that have rigid skeletal structures composed of calcium carbonate or a horn-like proteinaceous substance. The best known are the reef-building stony corals that live in warm shallow water and contain zooxanthellae (symbiotic algae).

Corals that live in deeper, colder waters are azooxanthellate (lacking symbiotic algae). Although different species have different depth and temperature tolerances, as a practical matter, deep sea corals can be defined as azooxanthellate corals generally occurring at depths below 50 meters. Of particular significance are structure-forming species, those colonial deep sea corals that provide vertical structure above the seafloor that can be utilized by other species. Structure-forming deep sea corals include branching stony corals that form a structural framework (*e.g.*, deep reefs) as well as individual branching coral colonies, such as gorgonians and other octocorals, black corals, gold corals and lace corals.

Deep sea coral communities are defined as assemblages of structure-forming deep sea corals and other associated species, such as sedentary and motile invertebrates and demersal fishes.

SOME FACTS ABOUT DEEP SEA CORALS

Where do deep sea corals occur?

- Deep sea corals are found in all the world's oceans but appear to be rare in the Arctic Ocean.
- With the exception of sea pens, deep sea corals typically are found on hard substrata, often in areas of irregular or steep topography associated with continental shelf breaks and slopes, canyons, banks, seamounts and the slopes of oceanic islands.
- In United States waters, deep sea corals occur in every region, generally outside of state waters in the U.S. Exclusive Economic Zone (EEZ). The Southeast U.S. includes the most extensive development of deep sea stony coral reefs. The Aleutian Islands lack such "reefs," but may harbor the highest diversity of deep sea corals in the North Pacific, with at least 50 species or subspecies believed to be endemic to the archipelago.

The biology of deep sea corals

- Deep sea corals include over 3,000 species in two Cnidarian classes, Anthozoa and Hydrozoa.
- Deep sea corals differ from shallow water corals in that they are azooxanthellate, which means they lack the symbiotic algae that most shallow water corals have, and do not require sunlight to grow.

Why are deep sea corals important?

Deep sea coral communities are hotspots of biological diversity:

- A number of the deep sea coral species form structures that provide habitat for numerous fish and invertebrate species.



Squat lobster on *Lophelia* coral off the Southeast U.S..

Photo credit: S.W. Ross et al., Univ. of North Carolina at Wilmington

- Quantitative surveys of fauna have found over 20,000 individual invertebrates from more than 300 species living among the branches of ivory tree coral colonies off the coast of Florida.
- A census has identified over 1,300 marine species associated with *Lophelia* deep sea coral reefs in the Northeast Atlantic.
- Gorgonian corals in the Northwest Atlantic have been shown to host more than 100 species of invertebrates.

Deep sea corals are valuable resources:

- Red and pink precious corals (Family Coralliidae), black corals (Order Antipatharia) and gold corals (Family Gerardiidae) are highly prized for the production of expensive jewelry and beads.
- The Mediterranean red coral has been used for thousands of years in the production of jewelry and its genus, *Corallium*, is derived from the Greek word for coral, korallion.

- Bamboo corals are being investigated for their medical potential as both bone grafts and possible uses for their collagen-like skeleton.
- Many groups of organisms associated with deep sea coral communities, especially sponges, have been shown to contain bio-active compounds of potential pharmaceutical and industrial value.

Deep sea corals can provide habitat for commercially-important fisheries species:

- Coral habitats, including *Oculina* coral reefs in Florida and gorgonian-dominated deep sea coral communities in Alaska and along the West Coast have been identified as Essential Fish Habitat for federally-managed fisheries species. In other cases, linkages between commercial fisheries species and deep sea corals remain unclear and may be more indirect.
- In Alaskan waters researchers found that commercially valuable species of rockfish, shrimp and crabs use deep sea coral branches for suspension feeding and protection from predators.



A school of fish among *Oculina* corals from the Florida *Oculina* Habitat Area of Particular Concern (2003).

Photo credit: Andy Shepard, NOAA, NURP.

- Scientists have established linkages between *Oculina* coral reefs in Florida waters and the abundance of economically valuable grouper, snapper, and amberjack.
- In Norwegian waters, it has been documented that commercially valuable redfish, ling, and tusk were more abundant and larger in deep sea coral habitats.

Deep sea corals provide clues to past climates:

- Because deep sea corals can live for centuries and incorporate trace elements and isotopes in their skeletons that reflect the physical and chemical conditions in which they grew, scientists are using them to reconstruct historic changes in global climate and ocean current systems.

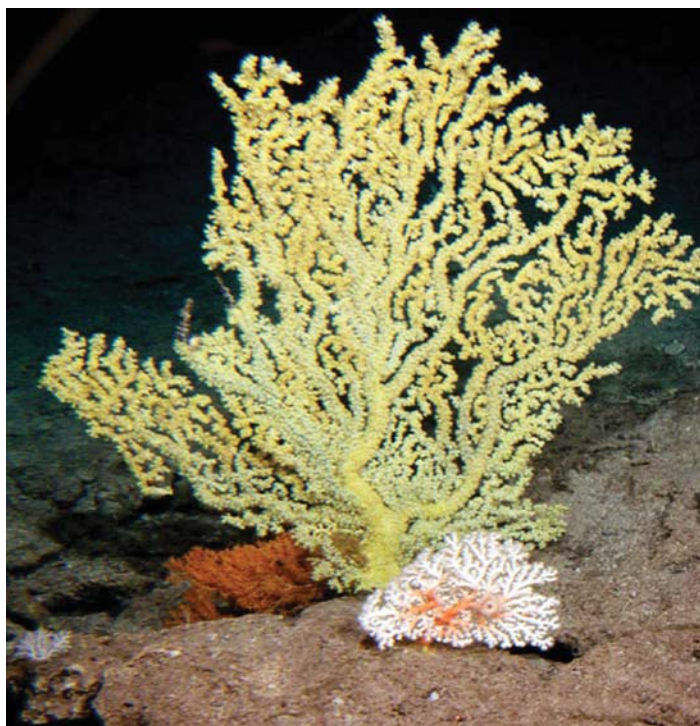
Major groups of deep sea corals

Deep sea stony corals (Order Scleractinia)

- While more than 90% of the shallow stony corals are colonial structure-forming species – many contributing to coral reefs – there are only about 14 species (2%) of azooxanthellate deep sea stony corals in the world that can be considered major structure-forming species.
- *Lophelia pertusa* occurs worldwide and is the most common reef-building deep sea coral. It has been recorded from depths of 39 meters to 2,170 meters, but most commonly forms reefs at depths between 200 meters to 1000 meters.
- Radioisotope dating of *Lophelia* reefs from seamounts off northwest Africa, the Mid-Atlantic Ridge and the Mediterranean suggest that they may have grown continuously for the last 50,000 years.
- The ivory tree coral (*Oculina varicosa*) is found in the western Atlantic, but is only known to form deep-water reefs in a restricted range under the Gulf Stream off the Atlantic coast of Florida. It is an unusual deep reef-building species because it occurs in both shallow and deep waters. When found in shallow water it contains symbiotic algae but at depths deeper than 60 meters, the algae are absent.
- In deep waters off the east coast of Florida, *Oculina varicosa* forms offshore banks and pinnacles up to 35 meters high.

Deep sea gold corals (Order Zoanthidea, Family Gerardiidae)

- The gold corals (*Gerardia* spp.) are among the least-studied groups of deep sea corals. This coral forms rigid skeletons with large branching, tree-like shapes which are found around Hawaii at depths of 300-400 meters and in the Straits of Florida at around 600 meters. It is considered a precious coral and is used for jewelry.
- Gold corals appear to be very long-lived. Colonies of gold corals from the Western Atlantic and Hawaii have been estimated to reach ages of 1,800 to 2,742 years respectively, placing them among the oldest known marine organisms.



This is gold coral. The age of Hawaiian gold corals have been estimated at up to 2,742 years old.

Photo credit: Hawaii Undersea Research Laboratory.

Black corals (Order Antipatharia)

- There are over 230 known species of black corals. The polyps of these corals may be rust, yellow, green or white but the skeletal material is black or dark brown which gives it the common name. Black corals are found in all U.S. regions.



Recently discovered species of black coral called Christmas tree coral, *Antipathes dendrochristos*. Photographed from Delta submersible during surveys of deepwater rocky banks off southern California.

Photo credit: M. Amend.

- Below 1500 meters, black corals are often the most abundant of the coral species in the tropics. Many species occur in relatively shallower depths and are harvested for jewelry, including in the main Hawaiian islands.
- The age of a Hawaiian black coral occurring in very deep water, *Leiopathes glaberrima*, was recently estimated to be 2,377 years old. Other species have been estimated to live longer than a century.

Deep sea gorgonians (Order Gorgonacea)

- Gorgonians, often known as sea fans or sea whips are among the most varied and important structure-forming deep sea corals. At least 12 families are known to occur in deeper waters, with the families Isididae, Coralliidae, Paragorgiidae and Primnoidae, being among the more important groups in U.S. waters.
- Bamboo corals (Family Isididae) are usually branched or bushy and range in size from tens of centimeters to over a meter. Many species occur below 800 meters and some have been found as deep as 4,851 meters. Several species are collected for jewelry.
- The red and pink precious corals (Family Coralliidae) are relatively wide spread and have been harvested for use in jewelry in many parts of the world, including in Hawaii.
- The bubblegum corals (Family Paragorgiidae) are thought to reach the largest size of any seafloor organism on the planet; a colony in New Zealand has been reported to reach 10 meters in height.
- Red tree corals (Family Primnoidae) produce large branching colonies that can reach 3 meters in height and exceed 500 years of age. They can occur in dense thickets, and in the U.S, they appear to reach their greatest abundance in Alaska.

Sea pens (Order Pennatulacea)

- Sea pens differ from other octocorals by living on soft sediment areas. They have a stem like foot that they anchor in the sand or sediment. Some can uncover themselves if buried by shifting sand and can re-anchor themselves if dislodged.
- There are 16 families of sea pens, most of which live in the deep sea. Sea pens of the genus *Umbellula* have been recorded in depths greater than 6,000 meters.
- Although pennatulaceans are common in the U.S. Exclusive Economic Zone, their contribution as habitat and to diversity of associated species is not well documented or understood.

- In the Bering Sea, dense aggregations of rockfish (*Sebastes alutus*) have been associated with “forests” of the sea pen *Halipteris willemoesi*.

Lace corals (Class Hydrozoa, Order Anthoathecatae, Family Stylasteridae)

- This Class includes mostly marine solitary or colonial jellyfish and hydroid-like organisms. Only three Orders in this Class contain species with calcium carbonate skeletons and are classified as coral-like organisms; the stylasterids or lace corals and the shallow water fire corals are the most common.
- Stylasterid corals occur worldwide in a wide range of depths. However, as a group, about 90% of the 246 known species live exclusively in deep waters of from 79- 2,700 meters.
- In U.S. waters stylasterids have been reported from most regions except the northern Gulf of Mexico and the Arctic Ocean, and appear to be of particularly importance as structure forming components in the Straits of Florida and Alaska.

Deep sea corals are vulnerable to damage from human activities

- Deep sea corals can be extremely long-lived, fragile and slow-growing, which makes them and their associated communities vulnerable to physical disturbance, especially from activities such as bottom trawling for fish and shellfish.
- Disturbances to deep sea coral communities from bottom trawls are well documented and pose the most widespread threat to deep corals in most regions where such fishing is allowed.
- Other fishing gears that can directly impact deep sea coral communities include other bottom-set fishing gears (e.g., dredges, gillnets, longlines, and traps or pots). These can snag, entangle or detach deep sea corals thus altering the habitat.
- Oil, gas and mineral resource exploration and extraction, coral harvesting, and submarine cable/pipeline deployment also can have detrimental effects on deep sea coral habitats without proper management.
- Invasive species, climate change, and ocean acidification represent additional potential threats that have not been adequately explored.
- The snowflake coral, an invasive species discovered in Hawaii’s Pearl Harbor in 1972, has rapidly spread to deep waters where it settles on and eventually smothers black coral colonies.

Management of deep sea coral communities in the United States

- The world’s first marine protected area specifically to protect deep sea coral habitats was the *Oculina* Habitat Area of Particular Concern, established in 1984.
- The Federal waters within the jurisdiction of the Western Pacific Fishery Management Council have the oldest and most comprehensive restrictions designed to protect habitats from adverse impacts of fishing gear of any region in the United States. In 1983, the Council prohibited the use of trawl gear, bottom-set long-lines, and bottom-set gill nets—all identified as threats to deep sea corals—within all waters in their region of the U.S. EEZ.

In 2006, NOAA, in partnership with the Regional Fishery Management Councils, protected from bottom-trawling over half a million square miles of vulnerable benthic habitats designated as essential fish habitat in the U.S. Pacific. Included in those protected areas are major deep sea coral habitats.

FUTURE ACTION PLANS

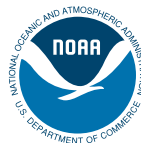
Although the deep sea corals from U.S. waters were recorded in the 1800s by Georges Bank fishermen who found them entangled in their long-line and tub trawl fishing gear, it has only been during the last decade that the importance of these corals has been widely recognized, prompting significant actions to protect them. On January 12, 2007, the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (P.L. 109-479) was enacted that authorized NOAA to establish a “Deep Sea Coral Research and Technology Program” and provides new discretionary authority for Federal fishery management plans to designate zones to protect deep sea corals from fishing impacts. The first biennial report on the progress and significant findings of the “Deep Sea Coral Research and Technology Program” was submitted to Congress in 2008.

Major habitat conservation efforts are currently underway through the North Pacific, New England, and South Atlantic Fishery Management Councils and several National Marine Sanctuaries that have the potential to further protect major U.S. deep sea coral habitats. Further progress in conservation will benefit from improved information on the location and ecology of these resources.

At the top of the deep sea coral research priority list for all regions of the U.S. is the need to locate, map, characterize and conduct a baseline assessment of these habitats.



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It is also important to monitor the impacts of fishing and other activities on deep sea coral habitats. This information can then be used in developing future sustainable fisheries management plans that enhance the protection of these important ecosystems. The

effects of climate change warming of the ocean and the increase of ocean acidification on deep sea coral ecosystems are important areas for future research.

A full color copy of the State of the U.S. Deep Coral Ecosystems with stunning photographs is available for download at the NOAA Fisheries website: www.nmfs.noaa.gov/habitat/dce.html

Citation for the report:

Lumsden, S. E., Hourigan, T. F., Bruckner, A. W., Dorr G. (eds.) 2007. *The State of Deep Coral Ecosystems of the United States*, NOAA Technical Memorandum CRCP-3, Silver Spring, MD. 365pp.