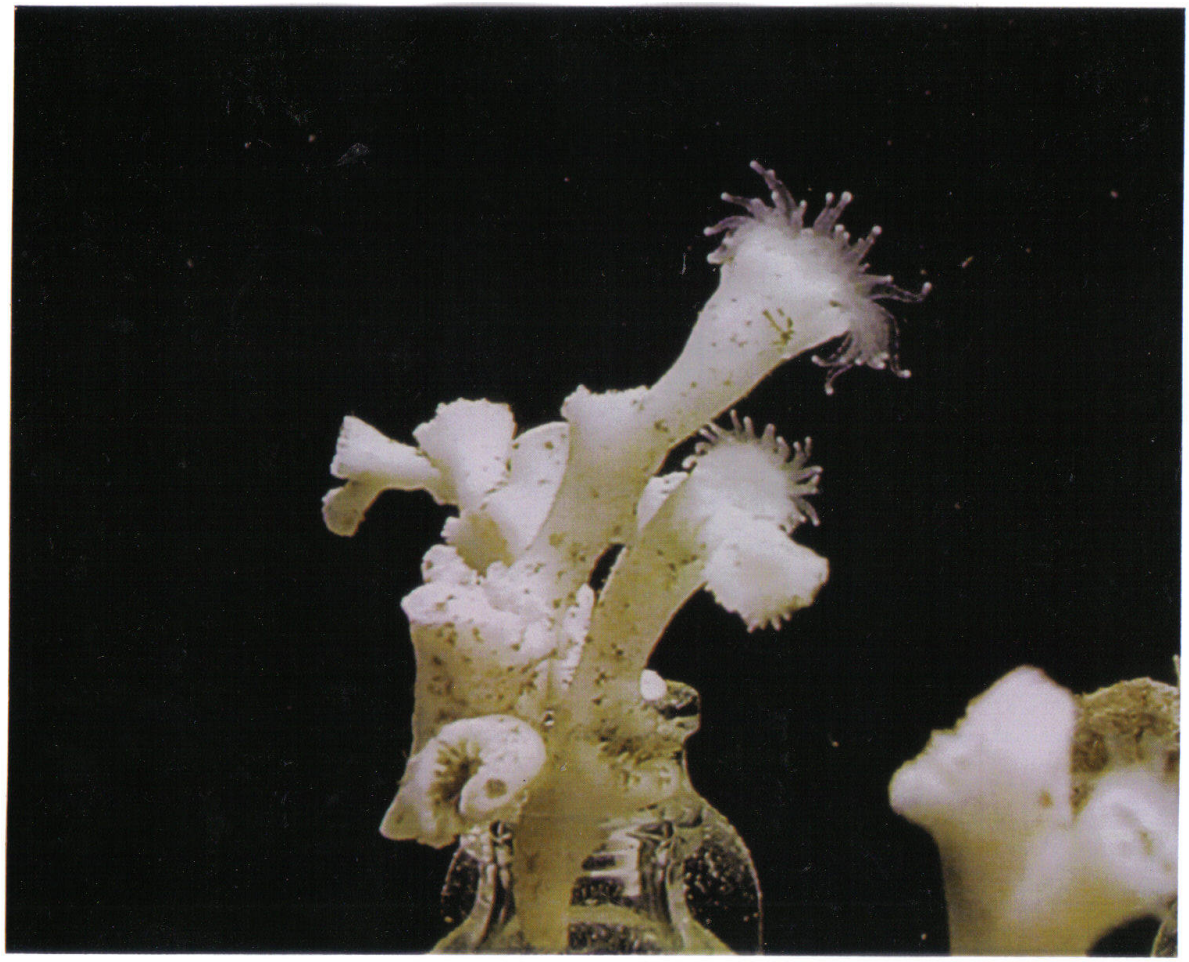
OCS Study
MMS 2008-024

Executive Summary: 3rd International Deep-Sea Coral Symposium in Miami



MMS
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

OCS Study
MMS 2008-024

EXECUTIVE SUMMARY: 3rd INTERNATIONAL DEEP-SEA CORAL SYMPOSIUM IN MIAMI

GIBS TECHNICAL MEMORANDUM

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Submitted by:
George Institute Biodiversity
and Sustainability
www.GIBSconservation.org

Lophelia pertusa (Linnaeus, 1758)

Prepared for:
MMS U.S. Department of the Interior
Minerals Management Service

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US EEZs marked in red.

I. INTRODUCTION

This document highlights some of the major discoveries and research findings presented during the 'Third International Deep-Sea Coral Symposium', held in Miami from Nov. 29 – Dec. 2, 2005, with emphasis on US EEZs (see Figure above). In the opening session, the symposium organizers, Dr. Robert Y. George of GIBS and Dr. Robert Brock of NOAA pointed out the goal of the symposium as follows:

"To provide a forum for both informal and formal scientific information exchange and also explore new and innovative concepts for future collaboration amongst the nearly 300 symposium participants from 28 nations".

The formal and peer-reviewed scientific information is now accomplished by publishing the proceedings of the 2005 Miami symposium as a book (with 23 peer-reviewed papers): "Conservation and Adaptive management of Seamount and Deep-Sea Coral ecosystems", edited by Robert Y. George and Stephen D. Cairns, was dedicated in honor and memory of Dr. Robert Avent of Minerals Management Service, the Department of Interior, (photo below), who first discovered the *Oculina* Cold Coral Reefs off the Atlantic coast of Florida.

MMS Oceanographer late Dr. Robert Avent entering deep-sea submersible Johnson-Sea-Link

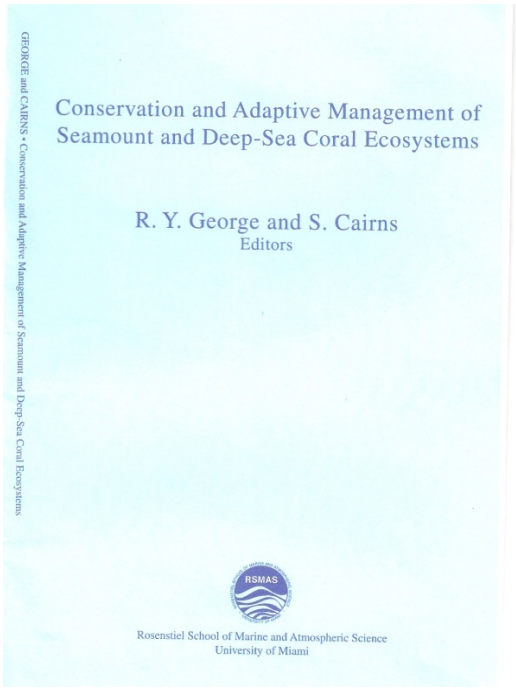
In the University of Miami, 300 delegates from 28 nations assembled from Nov. 28 to Dec. 2. 2005 to participate in the 3rd International Deep-Sea Coral Symposium (3rd ISDSC). First ISDSC was held at the Dalhousie University in Nova Scotia and the 2nd ISDSC took place in Erlangen University in Germany.

The 'Miami Deep-Sea Coral Symposium' proceedings also included 18 peer-reviewed papers, published as "Deep-Sea Coral ecosystems: Biology and Geology", Vol. 81 No. 3 of the *Bulletin of Marine Sciences*, edited by Robert Y. George and Stephen D. Cairns.

This document, published with contract support from the Minerals Management Service (MMS) of the Department of the Interior to the George Institute for Biodiversity and Sustainability (GIBS), reports on the high lights of the findings of the Miami symposium.

GIBS acknowledges the following two individuals: Dr. Tom Ahlfeld (MMS, Herndon, VA) and Mr. Greg Boland (MMS, New Orleans) for their enthusiastic support in sponsoring this synthesis of the Miami Symposium. This international event became an extraordinary success largely because of the cooperation of many government agencies and non-profit organizations (logos are portrayed below).

Symposium sponsors and co-sponsors.



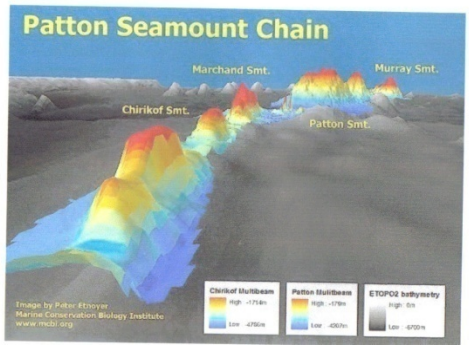
Cover Page of the Book

Front Page of the BMS.

II. HIGHLIGHTS OF THE MIAMI SYMPOSIUM

1. NORTHWEST PACIFIC: ALASKA
LME # 1
(Large Marine Ecosystems)

The seascape of the Alaskan coast and offshore islands are known to have many seamounts and octocoral gardens off the Aleutian Islands. Our knowledge on seamounts ecosystems such as the spectacular Patton Seamount Chain (See figure) is very limited. However, the conventional text book view of low diversity in high latitude ecosystems seems somewhat questionable with the discovery of high species number of octocorals in the Aleutian cold coral zones. These numerous newly discovered octocoral species are yet to be described and lack of taxonomists to do this task presents a problem.

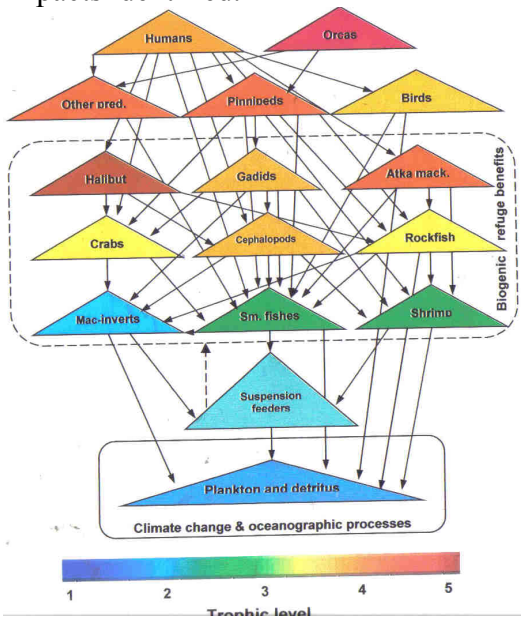


Seamount Chain off Alaska

In the very first paper in the book on conservation and adaptive management of deep-sea coral ecosystems, George et al., (2007) make an appeal for establishing conceptual models prior to precautionary models with emphasis on food chain and impact of climate change (eg. Pacific decadal cycle). This model for the octocoral gardens off Aleutian Islands, presented in the Miami symposium, is largely based on the work of Dr. Robert Stone of the NOAA Auke Bay Laboratories in Juneau, Alaska.

Photo of Dr. Stone holding a large and impressive *Paragorgia* cold coral tree.

It is essential that we need to understand the biological components in an ecosystem and therefore, a conceptual model is important with potential human threats and environmental impacts identified.



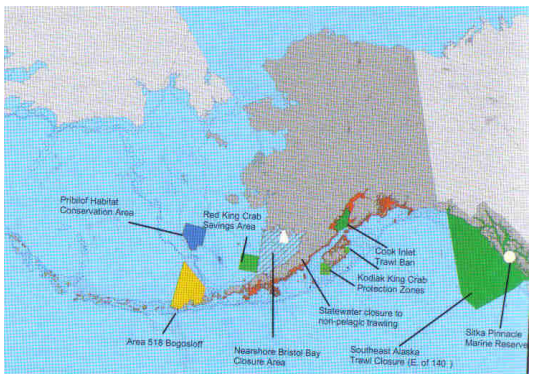
Trophic spectrum and conceptual model for Aleutian cold coral ecosystems

Aleutian octocoral beds are dominated by Atka mackerel *Pleurogrammus monopteygius* that feed on shrimps and rockfish on the sea

bottom. Bottom trawling impacts on the populations of the Atka mackerel as well as Pacific Ocean perch *Sebastes alutus*. Long lining fishing adversely impacts the Pacific Halibut *Hippoglossus stenolepis*. It is not clear whether the halibut decline is associated with climate change or over-fishing. Single pot fishing affected the Pacific cod *Gadus macrocerphalus*.

In situ photo of Aleutian coral garden

For the purpose of protecting these cold coral ecosystems off Alaskan coast several areas are closed for bottom trawling as shown in the figure below.



Closures off Alaskan coast. Note the vast (bottom left) Bower's Ridge 'Conservation Area' all around the Aleutian Islands and the Marine Reserve (bottom right) in the Gulf of Alaska. This picture is from Lumsden et al., 2007 (NOAA Technical Memorandum, p. 94).

George (2007), in the summary report on the 2nd Large Marine Ecosystems (LMEs) Conference in Qingdao- China, clearly pointed out that there is a significant regime shift off Alaska as a consequence of climate change, particularly after the 'Pacific Decadal Oscillation' (1989 – 1998). Significant decadal warming events impacted octocoral physiology and also changes in the ecosystem dynamics and fisheries.

2. NORTHEAST PACIFIC: BRITISH COLUMBIA LME # 2

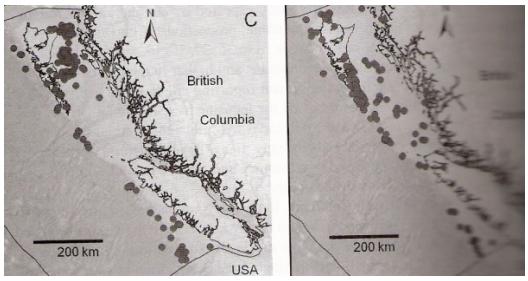
Ardron et al., (2007) recommended spatial establishment of closures for groundfish trawl fishery in the British Columbia waters to reduce by-catch and destruction of habitat-forming species of cold corals and sponges. This study led to the discovery that there are 12 areas (see figure below) that represent only 7.5 % of the shelf and slope off British Columbia but constitute 97 % of all the cold coral and sponge biomass. These authors argue that closing an area doers not necessarily mean that mobile target fish or crab species would not be caught elsewhere. They concluded in this study that, overall these 12 areas, when closed, will represent about one quarter of historic trawl sets (1996-2002).

Zoogeography of the cold coral species off British Columbia was the subject of the paper by Jamieson et al., 2007. The number of cold coral species known in the Canadian Pacific is 59, belonging to 24 families and 5 orders. Nevertheless, there may be about 36 or so undescribed cold coral species. Moreover, it is important to point out that many of the species that occur off British Columbia and also inhabit the waters south of this region, namely the Washington and Oregon coast. Likewise,

several cold coral species in this region also extend northward into the waters in the Gulf of Alaska and off Alaska, particularly the numerous seamounts that are yet to be fully investigated.

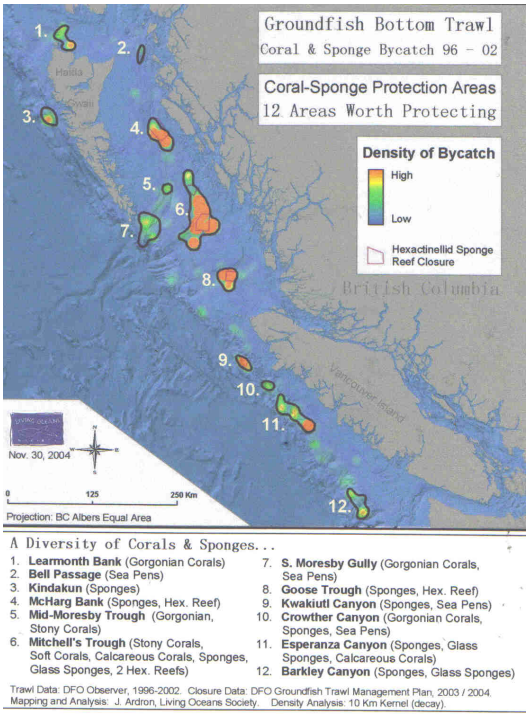
This lack of full knowledge of the taxonomy of the cold coral species is presenting a fundamental problem because of the incomplete picture of biodiversity of cold corals in general. In this context, it is relevant to point out the concern expressed by the Cairns' (2007) paper in the *Bulletin of Marine Science* (Miami symposium proceedings) wherein he clearly identifies the paucity of practicing taxonomists (particularly students) that include only 15 experts on a global basis (2 retired, one now administrator and few students. This situation calls for funding agencies to consider filling this deplorable gap in the taxonomic expertise.

Another point that Jamieson et al., (2007) paper brings up related to cold coral species is that they are not necessarily all habitat-forming but mostly solitary or even occurring on soft bottom substrata. The figure, presented below, shows the abundance and diversity of the sea pens Pennatulacea in the soft bottom areas off British Columbia (left) and the abundance and diversity of hard coral Scleractinia (right) on the hard bottom areas.



Sea-Pens (left) and hard coral (right) distribution off the coast of British Columbia.

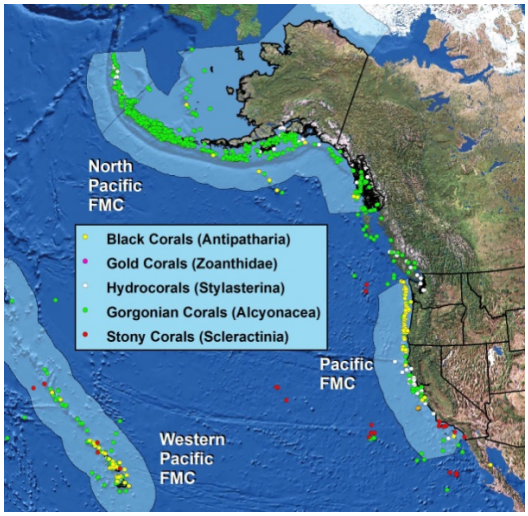
The influence of climate change and the impact of bottom trawling on the cold corals and associated communities (including commercially important fishes) off British Columbia poses another intriguing problem concerning the question, what caused the decline? Is it climate change or over-fishing. The decline in Halibut population is one such example. Evidently the southern areas of the Pacific US (Oregon to California) experiences since increased upwelling since 1998 but areas from British Columbia to Alaska in the Northeast Pacific experienced intensification of atmospheric pressure systems (Alaskan Low and North Pacific High), thus causing 2 different effects George, 2007).



Ardron et al., (2007) –Recommended 12 areas for protection of deep-water corals

3. COLD CORALS OFF OREGON AND CALIFORNIA COAST LME # 3

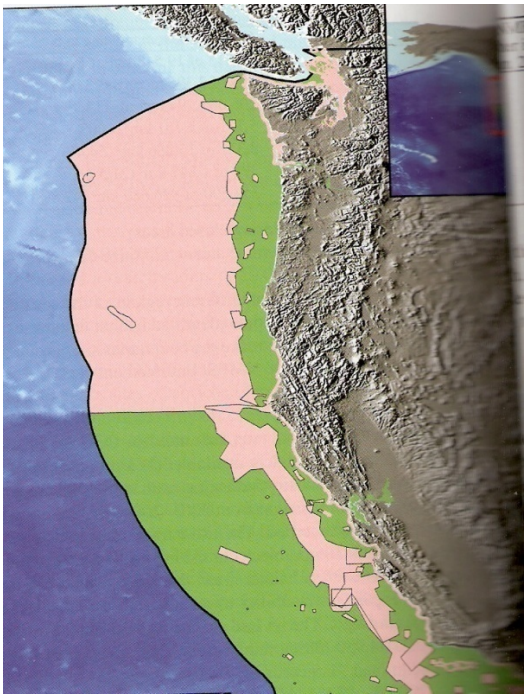
Off the US west coast, the composition of cold corals seems to be strikingly different from that of the US southeast coast where scleractinian corals are far more dominant. Off California and Oregon, the black corals (Antipatharia) and hydrocorals appear to be significantly higher in species diversity (Morgan et al 2007, see figure below). Scientists have also observed large invertebrates and fishes among the newly discovered Christmas tree coral (*Antipatharia dendrochristos*) colonies off Southern California. The fish fauna included 106 species but only 8 species exhibited some affinity with the corals. The Pacific Fisheries Management Council (PFMC) designated this antipatharian coral area off Southern California as EFH (Essential Fish Habitat) in 2005.



Cold Corals off US Pacific coast

Ecosystem-based fishery management is the major NOAA-NMFS initiative on the basis of the Magnusson-Stevens Fisheries Management Act-Reauthorization in 2007 in the United States. Scientists have successfully convinced managers to close many areas to prevent by-catch and biodiversity decline on the Pacific coast. Several MPAs (Marine Protected Areas) were recently established. Shester and Warrenchuk (2007) describe in their paper the interactive process through which proposals were considered by decision-makers and discuss the factors that led to closing selected cold coral areas where bottom trawling was prohibited.

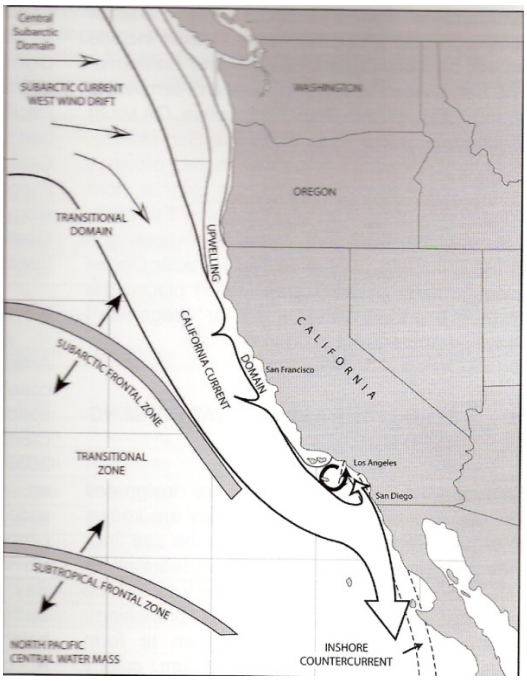
Fishermen now target dover-sole *Microstomas pacificus*, sablefish *Anoplopoma fimbria*, shortspine thornyhead *Sebastolobus alascanus*, Petrale sole *Eopstta jodrani* and Pacific cod *Gadus macrocephalus* with bottom trawls in the cold coral seascapes off Pacific coast with annual ex-vessel value of about $25 million. The proposal by Shester and Warrenchuk (2007) to PFMC to designate EFH-HAPC (Habitat Area of Particular Concern) off the coast of Washington, Oregon and California mitigated the impacts of fisheries.



Map of the final EFH protection areas off the US West Coast. Bottom trawl closures are shown in light pink color and green areas are open zone for bottom trawling.

It is important that the PFMC should develop methods to prevent illegal fishing in these closed areas by way of filed and landing site inspections and also by satellite or VMS (Vessel Monitoring System) methodology. However, several other fisheries Councils including the North Pacific Fisheries Management Council off Alaska do not mandate use of VMS in fishing vessels.

Recently Pacific International Council for Exploration of the Seas (PICES) reported evidence for regime shift in tune with the Pacific Decadal Oscillation –1989-1998 (King et al, 2005) in the North Pacific Large Marine Ecosystem (LME). George (2007) discussed the significant 1998 regime shift with increased anchovy abundance in upwelling zones in the California Current systems (shown in Figure below). Surface waters cooled in the southern region of the California current. Because of the fact that in the Southern region dominant atmospheric systems have intensified (Aleutian Low and North Pacific High), winds got strong and caused the deep-water to rise to the surface. Biological production increased with consequent changes in lower trophic levels such as phytoplankton, zooplankton and invertebrate pelagics.



California Current Ecosystem

4. COLD CORALS OFF HAWAII LME # 10

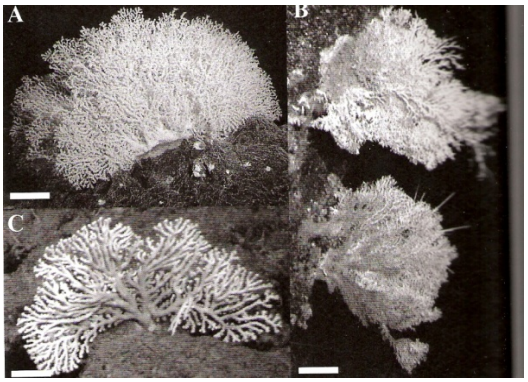
Two important catalysts for public concern for conservation of marine ecosystems are visible indices such as presence of an endangered marine mammal and a vast monetary resource such as tuna fishery or jewelery corals. Recent explorations off Hawaii islands revealed the presence of the endangered monk seal using the cold coral reefs as refuge or resting grounds.


Monk Seal in Hawaii cold coral reef

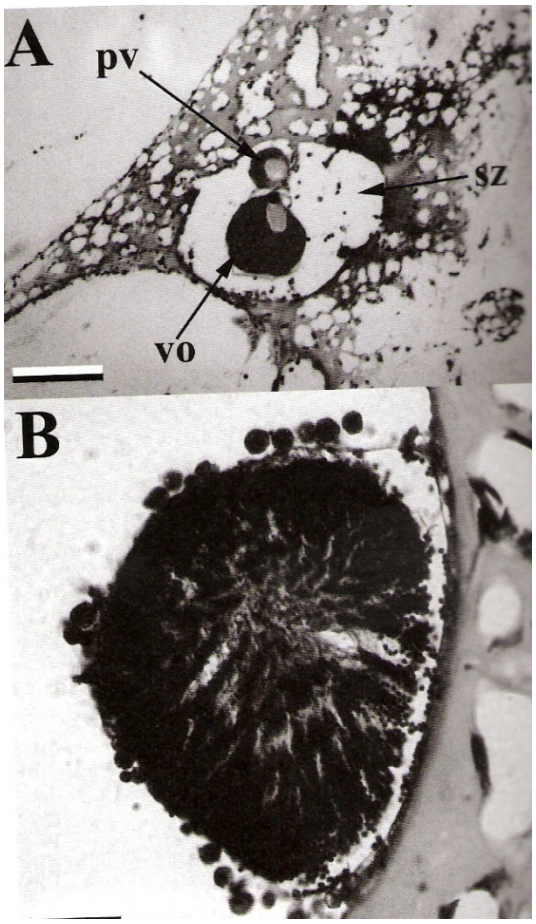
In the 2005 Miami symposium, Waller and Baco (2007) reported on the precious corals *Corallium secundum* and *Corallium lauuense* in the Hawaiian Archipelago. Histological examination of the reproductive tissues of these corals revealed that the reproductive material was found in the siphonozooids rather than the main polyps (autozoids). Oocytes were large (see figure below), exceeding 60 microns in both species of the *Corallium* caught between August and November from 1998 to 2004.

Jewelry industry targeted the exploitation of precious corals to the point that there is need to keep an eye on the illegal harvest of these valuable coral resources. I have seen both precious corals and also bamboo corals marketed in Spain, China and in many Latin American countries including Panama and also Mexico. I have deposited at the Smithsonian Natural History Museum a large specimen (nearly 2 feet wide, one foot tall) bamboo coral *Isis hippurus*, which was sold in a store at Virgo, Spain. In collaboration with Dr. Rhian Waller, I am now getting this coral's DNA finger-printed to determine where this coral was illegally trawled. We need to stop this commercial harvest of the cold corals before this process leads to possible extinction of species.

Precious coral *Coralliun*



Corallium lauuense colony and *Corallium secundum* colony from Hawaiian reefs.



Histological sections of *Corallium lauuense* A. Siphonozoids containing previtellogenic and vitellgenic oocytes B. Spermacyst (with sperms).

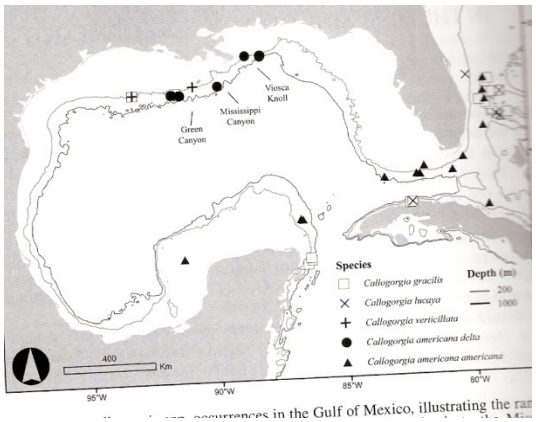
Dr. Frank Parrish, of the Pacific Islands Fisheries Science Center of NOAA in Honolulu, Hawaii, reported in the Miami symposium the density and habitat of the precious corals including the two species discussed above (Parrish, 2007). He examined the density in relation to temperature, substrate and bottom relief. At sites where there is history of harvesting there is variation in density and species composition of precious corals. *Coralium secundum* seems to prefer flat exposed bottom where the largest patches of this species were found. On the contrary, *Corallium lauuense* prefers uneven rocky bottoms. In his paper, Parrish (2007) postulated a hypothesis that the corals prefer areas where bottom relief and configuration enhances or modifies significantly flow characteristics, perhaps improving the colonies feeding success.

5. COLD CORAL ECOSYSTEMS IN THE GULF OF MEXICO LME # 5

George and Ahlfeld (2007) in a paper presented at the conference on 2nd Global Large Marine Ecosystems (LMEs) divided the Gulf of Mexico (LME No.5) into 5 sub regions, namely 1. Central Gulf of Mexico (CGOM) which has over 50% of the oil and gas production and with *Lophelia* corals on lithoherms in areas known as "Blue Hills" (Sulak et al., 2007), 2. Eastern Gulf of Mexico (EGOM) where Florida escarpment cold seep chemosynthetic communities are known, 3. Northwestern Coastal Gulf of Mexico (NCGOM) with the Mississippi River plume zone with hypoxia episodes and coastal bays and shelf edge reefs off Louisiana, 4. Southern Gulf of Mexico (SGOM) where tropical reefs are known from the area designated by US National Park Service as the Dry Tortugas Marine Research Natural Area off southwest Florida and the Flower Garden Banks National Marine Sanctuary in Northwest Gulf of Mexico, 5. Mexico-Yucatan Gulf of Mexico (MYGOM) with deep-sea asphalt and chemosynthetic cold seeps at depths to 3000 m.

In the Miami symposium Etnoyer and Warrenchuk (2007) reported on the unusual discovery of a catshark nursery in a deep gorgonian field in the Mississippi canyon. From the original studies of Bayer (1954) and Cairns and

Bayer (2002) it was known that gorgonian octocorals are conspicuous components of the deep-water fauna of the Gulf of Mexico. The endemic species in the Mississippi canyon *Callogorgia americana delta* is a habitat-forming Primnoid octocoral.



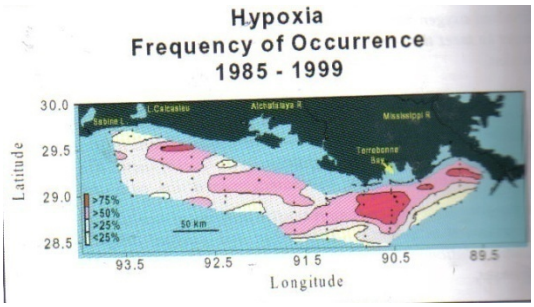
occurrences in the Gulf of Mexico, illustrating the ran

Distribution of species of *Callogorgia* in the Gulf of Mexico and off southeastern Florida.

Previously, catshark *Scyliorhinus retifer* using soft corals as nursery ground was known in the Mid-Atlantic Bight but not from the Gulf of Mexico thus far. Nevertheless, the report in the Miami symposium confirmed such an occurrence of a catshark nursery in the Gulf of Mexico (see photo below)

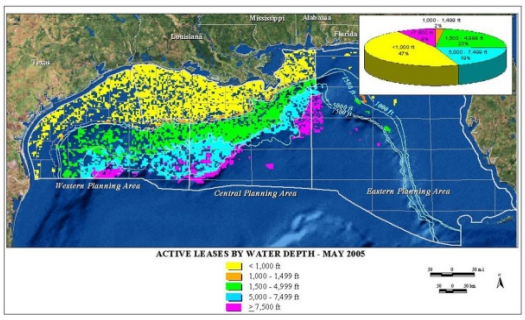
Catshark nursery in the Gulf of Mexico

There are potential threats to the cold coral colonies due to sedimentation impacts from cascading turbid shelf waters after hurricane Katrina (Reid Corbett, unpublished data) and also expanding hypoxic zones in the northeastern sub region of the Gulf of Mexico LME 5 up to 60 m depth (see figure below).



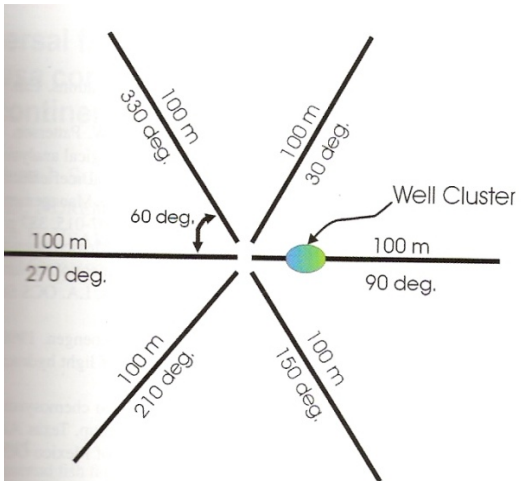
Ahlfeld et al., 2007 reported on an adaptive approach to protect *Lophelia* corals from the ongoing development of oil and gas production in the Gulf of Mexico. Presently, platforms such as the one shown below, extend to depths as high as 1200 m in the central Gulf of Mexico. In a research program in collaboration with US Geological Survey studies, Minerals Management Service-sponsored studies revealed that the largest known *Lophelia* habitat is located 53 nm due east of Mississippi River Delta at 470 m..

$ 2 Billion Oil Production Platform



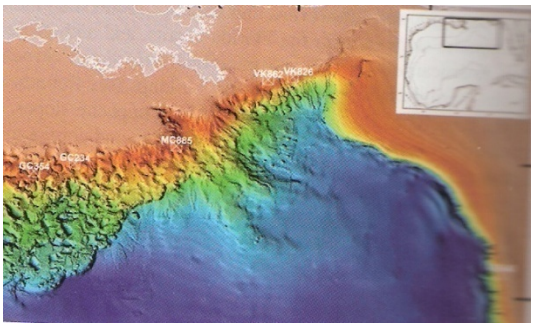
Active Oil and Gas Lease Area in the Gulf of Mexico

Results of the deep-water studies have been used as an adaptive management approach to locate platforms away from both chemosynthetic ecosystems and *Lophelia* aggregations. The diagram below illustrates the plan for ROV surveys that cover a minimum of 100 m from each of 6 directions (see below). MMS requires the oil and gas industries to conduct video-surveys of the sites where these companies intend to drill or produce oil and gas. This protocol enables MMS to make prudent decisions to avoid putting platforms in the vicinity of vulnerable deep-sea ecosystems such as *Lophelia* reefs or chemosynthetic seep ecosystems.



ROV Survey Pattern

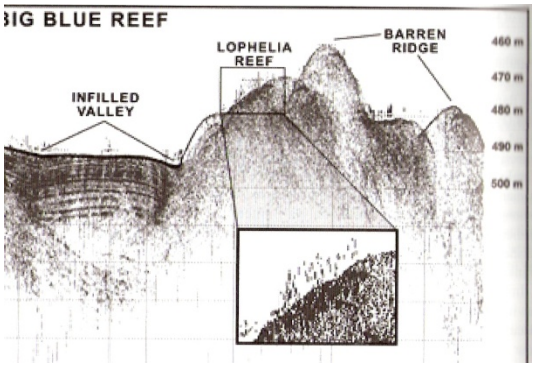
Schroeder (2007) studied 6 locations in the northwestern Gulf of Mexico where *Lophelia* aggregations were found. His note in the Miami symposium proceedings describes the sea-bed characteristics and topography as shown in the multibeam photo given below.



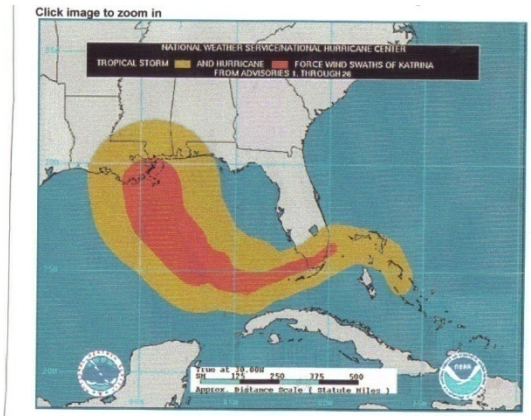
Seabed Topography

Sulak et al., (2007) gave a succinct account of fishes associated with *Lophelia pertusa* coral biotopes in the northern Gulf of Mexico. The Viosca Knoll fish fauna consisted of 53 demersal species, 37 of which were documented by submersible videos. At 325 m, dominant fish belong to Sreomateidae, Serranidae, Trachichthyidae, Congridae, Scorpeinidae and gadiformes.

However, at a deeper depth (500 m), a zeiform microcarnivore *Grammicopelis branchiusculus* dominated and Macrouridae and Squalidae gained in importance in the *Lophelia* "Thicket" biotope. Fish abundance was low at 95 fish per hectare.

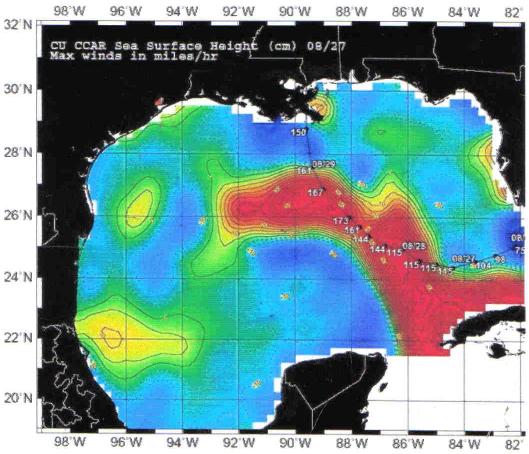


Big Blue Reef at VK-826 study site.



Hurricane Katrina

Dense *Lophelia* Patch in the Gulf of Mexico.



Loop Current of the peak of "Katrina"

The increased occurrence of hurricanes in the last decade in the Gulf of Mexico is often attributed to climate change. In 2005 Hurricanes Katrina and Rita caused severe damage to the Gulf of Mexico ecosystems. The impact of the hurricanes *Katrina* and *Rita* on the Louisiana and Mississippi coastal ecosystems and several platform structures was profound. The figures below illustrate the path of the hurricane *Katrina* and the enhanced intrusion of the loop current into the central Gulf of Mexico.

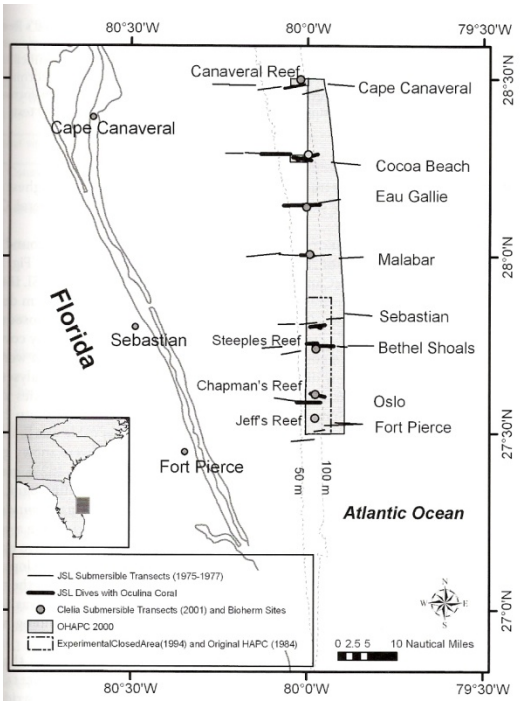
The loop current is the most dominant hydrographic feature in the Gulf of Mexico. It is possible that the introduction of larvae or dispersal of larvae from the Caribbean Sea and the Atlantic takes place but the mechanism of larval transport is poorly understood. There are significant currents at the bottom with speeds as much as 85 cm per second at 2000 m in the Sigsbee Escarpment (Hamilton and Lugo-Fernandez, 2001). The loop current creates a strong north-south flow in the Eastern Gulf of Mexico. The current speed increases at 200 m in the Pourtales Terrace where cold corals are reported in the Florida Strait (Reed et al., 2005).

6. COLD CORAL REEFS IN THE NORTHWEST ATLANTIC COAST: SOUTHEAST UNITED STATES AND THE CARIBBEAN SEA. LME # 6

The most important cold coral ecosystem off the Florida Atlantic coast is the *Oculina* reef, which is protected since 1984 as a Habitat Area of Particular Concern (HAPC). Reed et al (2007), in the Miami symposium, reported that in 1990, despite the protected status, *Oculina* reef grouper snapper fisheries caused severe damage to the reef due to bottom trawl impact.

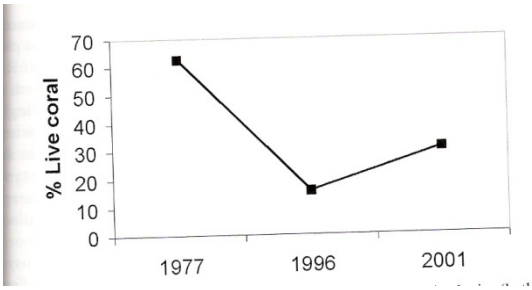
Oculina HAPC off Florida with Scamp grouper (From George et al, 2007).

In the ICES (International Council for the Exploration of the Seas) Annual Science Conference in Vigo, Spain, George (2004) reported the damages done to the *Oculina* reefs of Florida by rock-shrimp fisheries. However, the South Atlantic Fisheries management Council (SAFMC) has made decisions to keep shrimpers away from the Oculina reefs.



Reed et al. (2007) Photographic Transect Area of the *Oculina* HAPC off eastern Florida.

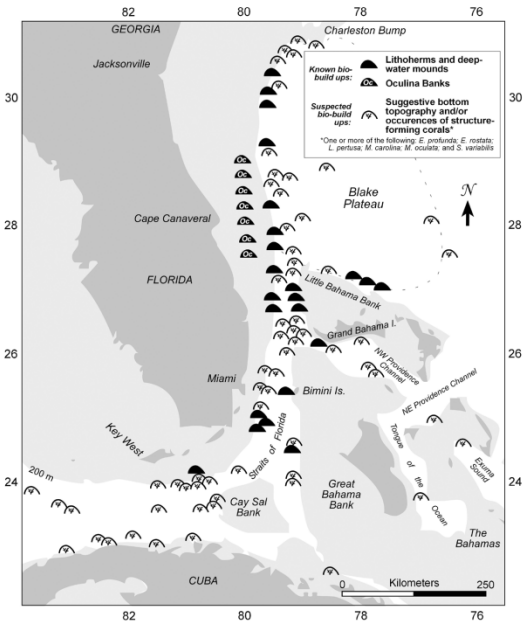
Reed et al (2007) clearly demonstrated that both sports fishing and recreational fishing over the *Oculina* reef between 1977 and 1996 decreased the live coral coverage from 70 to 15 %. However, the live coral coverage increased after 1996 due to protection (see figure below).



Decrease and increase of coral coverage

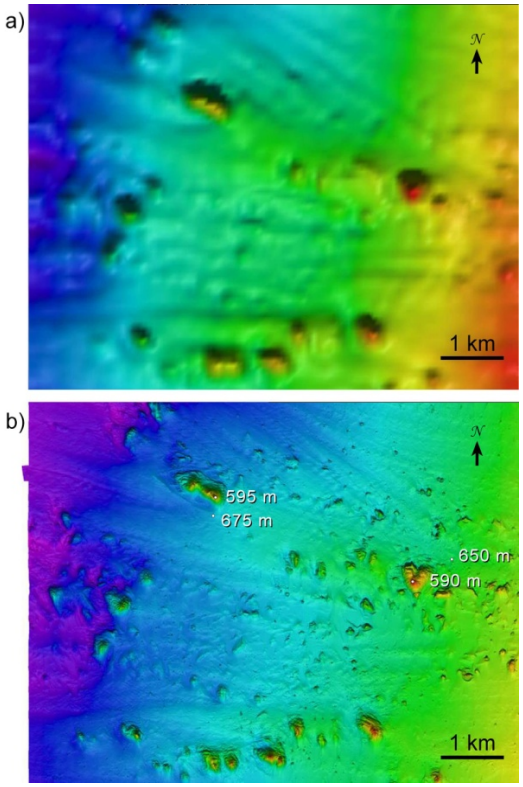
Ginsburg and Lutz (2007) presented in the Miami Symposium a research opportunity and challenges to study the numerous mounds and bio-build-ups

(400 – 1300 m) off the Atlantic coast of Florida and in the channels and banks of the Bahamas, as shown in the figure below.

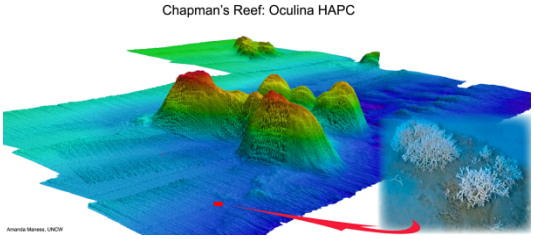


Locations of bio-buildups in Ba-Fla (Bahamas-Florida) Region.

Santodomingo et al., (2007) made a fascinating discovery in the Columbia Caribbean Sea where they found that azooxanthellate cold corals abound adjacent to a shallow fringing reef near the San Bernado and Rosario Islands, This situation is somewhat similar to the occurrence of *Lophelia pertusa* reefs not too far east off the *Oculina varicosa* reefs off Florida where, however, both reefs are azooxanthellate. The habitat-forming coral species in the Caribbean are different, primarily *Madracis myratser* (branching coral). These corals occur in the Caribbean Sea over sandy mud bottom over the shelf break (120 to 180 m). Adjacent limestone hardgrounds support *Madrepora* sp., antipatharians and gorgonians.



Bio-Buildups in multibeam view



Oculina varicosa reefs in multibeam view off Florida Atlantic coast

For the purpose of management of the *Oculina* reefs off Florida, George et al., (2007) developed a conceptual model to reveal the prey/predator relationships within the complex food chain. This model also indicated how the currents, particularly the Gulf Stream meanders, impact this vulnerable cold coral ecosystem as shown in the figure below.

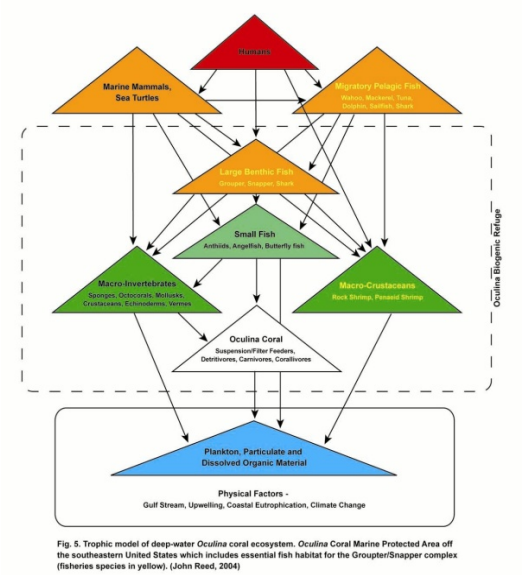
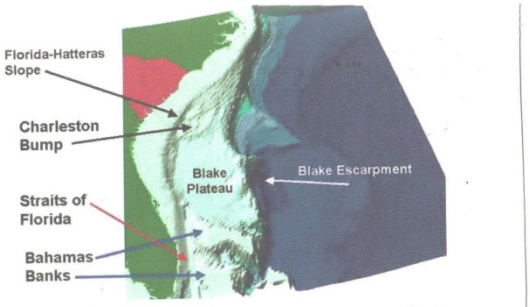


Fig. 5. Trophic model of deep-water *Oculina* coral ecosystem. *Oculina* Coral Marine Protected Area off the southeastern United States which includes essential fish habitat for the Grouper/Snapper complex (fisheries species in yellow). (John Reed, 2004)

Food Chain of *Oculina* Reef.

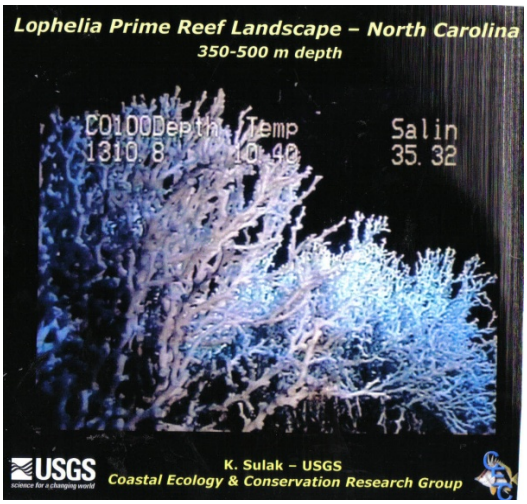
The extraordinary topography off the Southeastern United States includes a continental shelf very narrow off southern Florida and the broad Blake Plateau which narrows toward the north. The *Lophelia pertusa* cold coral reefs are located primarily on the Blake Plateau. The following figures illustrate the *Lophelia* reef locations.



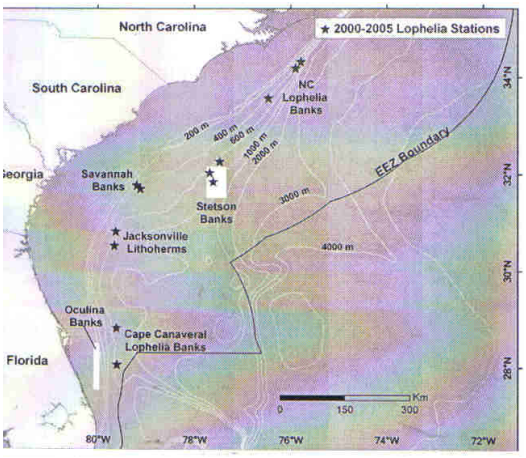
The Charleston Bump is a deep-water, rocky bottom feature on the Blake Plateau southeast of Charleston, South Carolina.

2

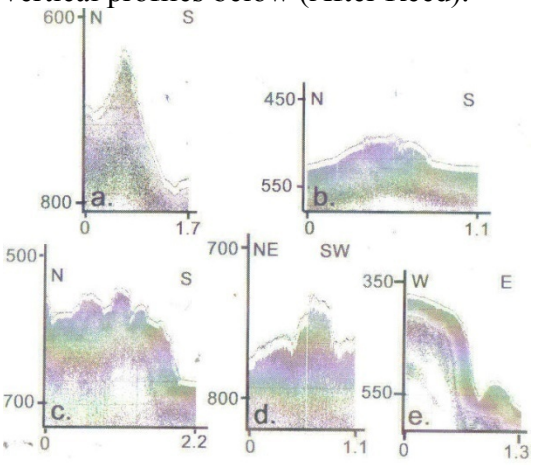
Blake Plateau

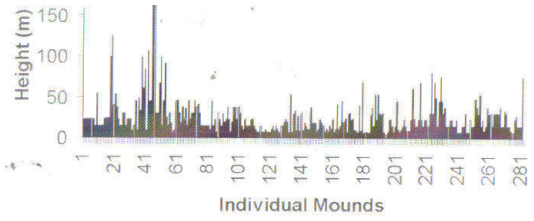


NR-1 Submersible Photo of *Lophel*ia Reef off Cape Look-out, N.C. (photo courtesy of Ken Sulak (USGS)

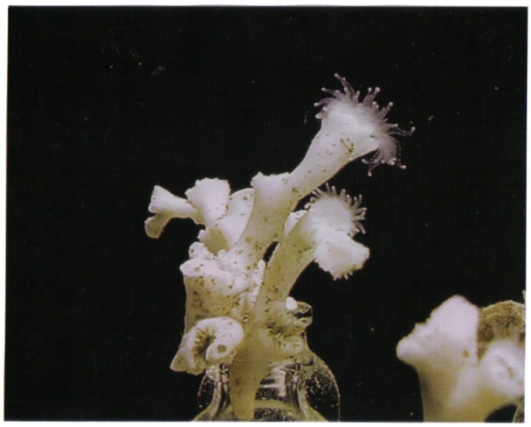


Lophelia Reef locations above and vertical profiles below (After Reed).





Varying heights of individual *Lophelia* pinnacles on Blake Plateau.

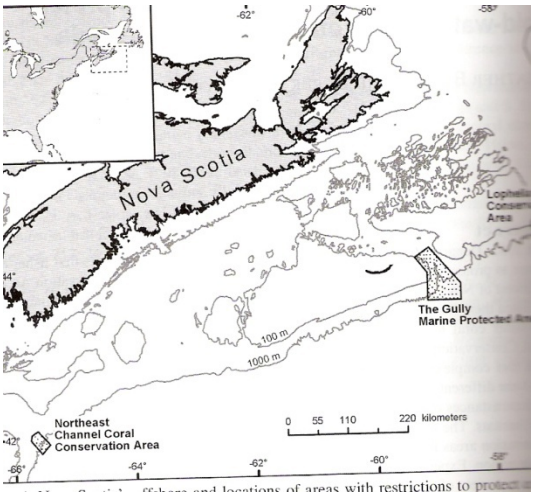


Live *Lophelia pertusa* with open polyps (Photo by the author).

7. COLD CORALS OFF US NORTHEAST AND CANADIAN COAST

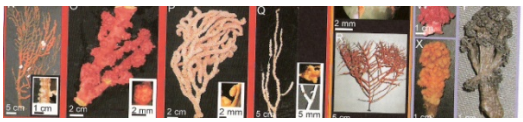
LME # 7 & 8

To protect cold coral ecosystems the Canadian government (Department of Fisheries and Ocean) implemented the first bottom trawl fishery closure in 2002, as a consequence of the first deep-sea coral symposium in 2001 in Halifax. The Northeast Channel Coral conservation Area –southwest of Nova Scotia (see figure below) was put in place to protect the high concentrations of gorgonian octocorals. Subsequently Canadian government also implemented a fisheries closure in a small and damaged *Lophelia pertusa* reef area, *Lophelia* reefs are common further south off US Southeast coast. Breeze and Fenton (2007) discussed these marine protected areas (MPAs) in the Miami 2005 symposium.



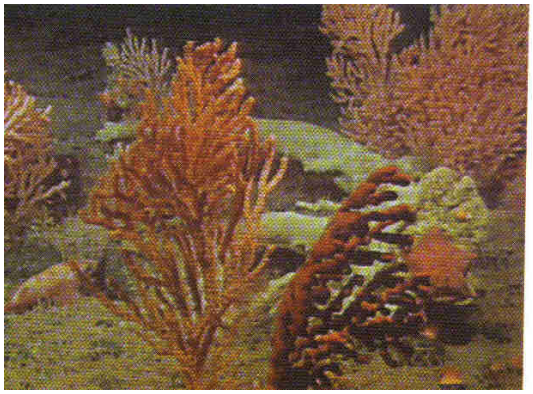
Cold corals off Nova Scotia, Canada.

Warham and Edinger (2007) reported on the distribution of deep-sea corals in the Newfoundland and Labrador region, Northwest Atlantic Ocean. Thirteen alcyonarians, two antipatharians, four solitary scleractinians, and 11 pennatularians were recorded. These cold coral species were primarily confined to the shelf edge and slope. Large branching corals with robust skeletons included *Paragorgia arborea*, *Primnoa resedaeformis*, bamboo coral *Keratoisis ornate, Acanthogorgia armata* and species of *Paramuricea*, as shown in the color photo below.



There are no conservation measures yet in this region to protect the cold corals. These authors identified two coral-rich areas or hot spots: (1)

Southwest Grand Bank (16 cold coral species) and (2) An area of the Labrador slope between Makkovik Bank and Belie Isle Bank.



Gorgonian Corals in the Northeast Channel off Nova Scotia

I had the opportunity in 2000 to go aboard the NOAA ALBATROSS IV during the cruise to survey the scallop beds in the Georges Bank and also survey the closed areas of the Northwest Channel seabed where gorgonian corals abound. Scallop dredges brought to the deck giant gorgonian corals such as *Paragorgia arborea* and huge boulders. Despite the fact that this cruise affirmed that closure for long periods promoted rapid recovery of the habitat biodiversity including cold corals and associated fish fauna, the heavy gears used in the survey (huge otter trawls with heavy metal doors) caused considerable destruction of this vulnerable cold coral ecosystem in the Northeast Channel. Based on my observations aboard ALBATROSS IV, I recommended to NOAA - NMFS that in the future surveys ROVs and AUVs must replace otter-trawls. It is important that we protect these vulnerable Northwestern Atlantic cold coral ecosystems before regime shift due to anthropogenic impact, as what happened unfortunately in the Northeast Atlantic Ocean.

In the Northeast Channel there is also recent evidence of changes in the current regimes, primarily the impact of freshening of the Western Boundary Undercurrent and the weakening of the northern wall of the Gulf Stream (Personal communication at the Miami Symposium, Prof. Mike Risk). This climate change and current shifts are shown in the figure below.

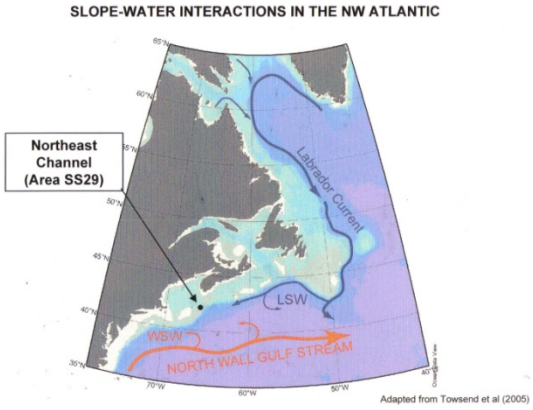


Figure on current shifts off the coast of western Canada and Northeast USA (Courtesy of Dr. Mike Risk).

8. COLD CORALS OFF EUROPEAN COAST

LME # 21, 22, 24 & 25

It is becoming increasingly clear that unlike the US cold coral reefs, the OSPAR (Oslo-Paris Agreement Region) off the European coast and under the jurisdiction of the European Union contains many *Lophelia pertusa* bioherms (particularly off Norway coast) that have been severely damaged by fisheries impact (use of heavy gear and sediment clouds from shrimp trawling). I have participated in many ROV cruises

off the Scandinavian coast to study *Lophelia* reefs, particularly off the coast of Sweden. I am convinced that these cold corals are so damaged that *Lophelia* growth is confined to only patches here and there. The community structure is severely altered with dominance of invertebrate fauna atypical of cold coral ecosystem.

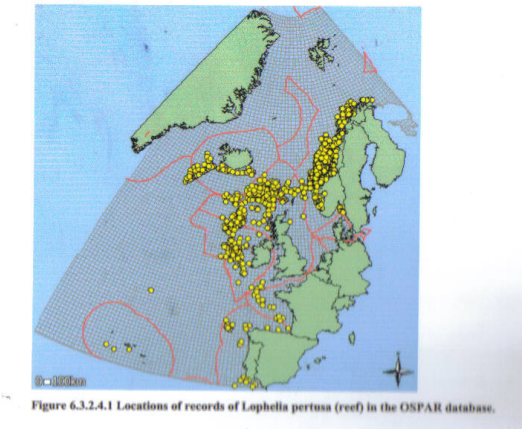


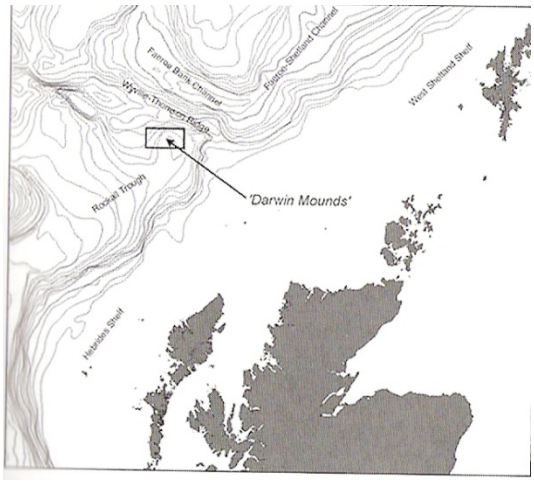
Figure 6.3.2.4.1 Locations of records of Lophelia pertusa (reef) in the OSPAR database.

Lophelia pertusa (yellow circles) on seamounts and offshore slope regions in the OSPAR region off the coast of Europe.

In the Miami symposium, Spencer et al (2007) presented results from the data base (>200m) on antipatharian, scleractinian, and gorgonian corals in the Northeastern Atlantic from historical data before fishing gear damaged the *Lophelia* reefs. From 1868 to 1985, 2547 records of cold corals exist in the data file, which includes 83 species of gorgonians, 68 species of hard corals or scleractinians and 22 species of antipatharians in the warm temperate regions. However, the data base is meager with information on the boreal as well as tropical seamounts to evaluate either cold coral species diversity or endemism. They also found that the endemism is low (3%) in the warm temperate seamounts.

DARWIN MOUNDS

It is of interest to note that Darwin Mounds with cold coral seascape (discovered recently in 1998) is the first MPA off the UK coast. De Santo and Jones (2007) in the Miami symposium reported that *Lophelia* grows on sand substratum in the Darwin Mounds rather than hard bottom. In 2003 European Commission imposed a ban on trawling in a 1380 square km area surrounding the Mounds, based on the revised Common Fisheries Policy (CFP). Thus area became the first EU (European Union) model of an offshore fisheries closure area. The precise location of the Darwin Mounds and the fine bathymetry of the region are shown in the figure below.



Darwin Mounds off northwest UK.

9. COLD CORALS IN THE INDIAN OCEAN

LME # 34

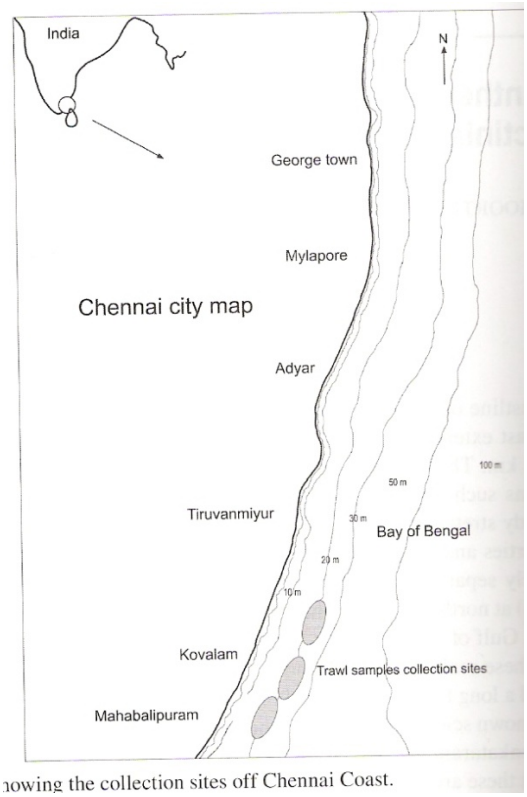
Our knowledge of the deepwater coral distribution from the Indian Ocean is very poor, despite numerous reports on tropical corals both in the Bay of Bengal and the Arabian Sea (see figure below). Venkataraman (2007) reviewed

the reports of azooxanthellate corals that include 6 genera and 17 species of scleractinian corals off the Chennai coast..

LME 32 and LME 34 off India.

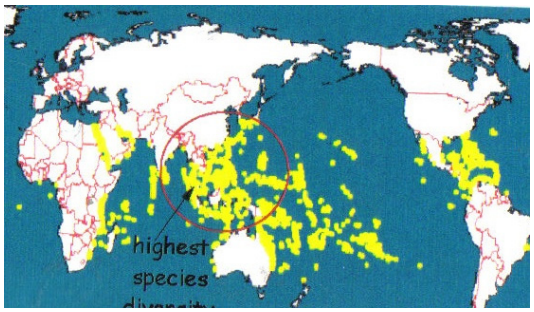
Species such as *Dendrophylia indica*, *Balanophyllia scabra* and *Dendrophyllia minuscule* are endemic to the Indian Ocean. Of the 35 species of Flabellidae in the Indian Ocean, six species, belonging to 4 genera, are known from the deep-water study site off Chennai.

My discussions with FAO (UN Food and Agriculture organization) experts (Dr. Kerverne Cochrane) in China at the LME symposium indicated that there exist several IUU (Illegal, Unregulated and Unreported) deep-sea fisheries in the vicinity of seamounts and submarine ridges where deep-sea corals occur but are poorly studied. In the early years US Government, through the IDOE (International Decade of Ocean Exploration) sponsored research of several American Oceanographers to investigate the least known regions of the Indian Ocean. Dr. Howard Sanders made the big discovery of highest species diversity in the Bay of Bengal LME (Off Chennai) where Miami symposium participant Dr. Venkataraman reported on deep-sea corals.



owing the collection sites off Chennai Coast.
Deep-Water cold coral study site off Chennai, located in the Bay of Bengal.

This deepwater study site is located in one of the hot spots of coral biodiversity in the world oceans (see figure below). Undoubtedly more research on cold corals in the Indian Ocean is necessary to attain a full understanding of the abundance and diversity of deep-sea corals. Venkataraman (2007) in the Miami symposium cautioned about trawl fisheries as a threat to deep-sea corals.

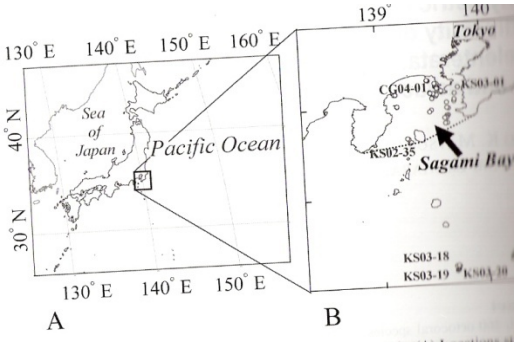


Hot spot of coral diversity in the Indian Ocean as shown in the red-circled area.

Much of the knowledge on deep-sea corals in the Indian Ocean comes from RIMS INVESTIGATOR Expeditions to the Indian Ocean (Wood-Mason and Alcock, 1891). HMS Challenger (1873-76) did not cover the Indian Ocean. John Murray Expedition in the early 20th century collected 28 species of deep-sea corals. In 2009 the 12th International Deep-Sea Biology Symposium will be held in Goa, India and there is plan for a "Round-Table Discussion" on the 2004 impact of the Tsunami on corals in the Bay of Bengal.

10. COLD CORALS IN THE SEA OF JAPAN
LME # 49

Matsumota et al., (2007) in Miami reported on the high diversity of cold-water octocorals in the Sagami Bay and adjacent waters of Japan. See the location of the Sagami Bay below.

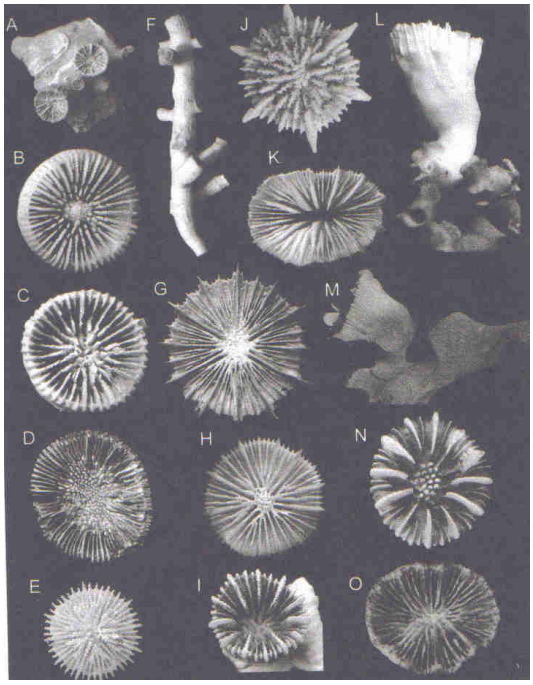


Sagami Bay (100 to 200m) is home for 260 octocoral species, 144 gorgonian species and 80 alcyonarian species. Out of the 260 octocoral species, 114 species are endemic to Japan and adjacent waters. The high species diversity is attributed to the faunal boundary conditions where there is a convergence of species of subarcric, sub-tropical and temperate biogeographic regions.
The authors propose a hypothesis for explaining why so many cold corals occur in the Sagami Bay. This high species diversity is further augmented by the fact that at this depth range of 100 to 200m there is a benthopelagic ecotone, a transitional zone between two ecosystems, which results in a high degree of biodiversity due to bentho-pelagic coupling.

11. COLD CORALS IN BRAZILIAN SEAMOUNTS
LME # 16

Several young scientists from South America (Brazil, Columbia and Chile) presented original results of their research on cold corals in the Miami symposium.

Kitahara (2007) reported on the azooxanthellate Scleractinia from Brazilian waters that included 59 species. The following four species are first recorded in the South Atlantic: *Caryphyllia berteriana*, *C. acrypta, C. acobinosa* and *Dendrophyllia alternata.* This study discovered a strong affinity of Brazilian hard coral species with the Caribbean Sea cold corals. The paper included several detailed photographs of the identified cold coral species, as in the illustration given below.

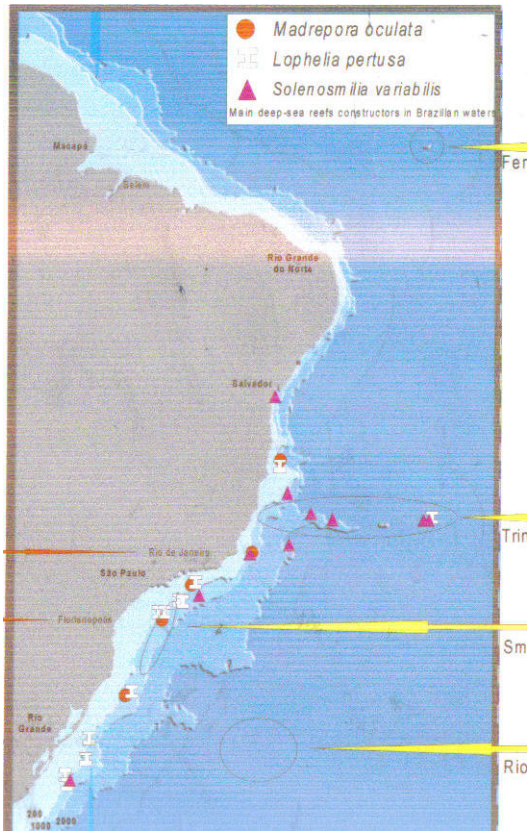


Brazilian Scleratinian corals.

Seamounts off the coast of Brazil (see figure below) seem to offer a challenge for cold coral researchers since there are many unique species, especially the black corals Antipatharians. Loiola (2007) reported in Miami on 18 species belong to the 3 families: Antipathidae, Myriopanthidae and Schizopathidae. This paper included the very first record of the genus *Chrysopathes* in the Atlantic Ocean.

Pires (2007) reported on 56 azooxanthellate coral species off Brazil, including four new records. She also pointed out that zooxanthellate species off Brazil are few, with only 15 species known thus far. At present, the ratio of azooxanthellate to zooxanthellate corals in Brazil is 4: 1, contrasting with the ratio in the tropical - warm temperate western Atlantic (2:1) and the ratio worldwide (1:1).

The ubiquitous presence of the most dominant cosmopolitan scleractinian coral species *Lophelia pertusa* on both sides of the North Atlantic, in both hemispheres of the Atlantic Ocean as well as in the Gulf of Mexico and Pacific Ocean is puzzling. Are the geographically located populations of *Lophelia pertusa* genetically different? This question calls for more DNA studies. Nevertheless Pires' paper pointed out that *Lophelia pertusa,* along with *Solenosmilia variabilis,* is undoubtedly the most dominant species in the seamounts off Brazil (see figure below).



Seamounts off Brazil and EZZ extending to the eastern most seamount.

Kitahara (2007) illustrated the extensions of Brazilian EEZs off the southwest of Bahia going far beyond the 200 miles to the last seamount off Brazil. For conservation purposes such an approach is useful. On the contrary, the US EEZ off New Jersey terminates at the 200 mile limit, thus embracing only 4 seamounts in the New England Seamount Chain. Deep-Sea coral ecosystems were discovered at the slope of the summits of the New England Seamounts where a hot spot of deep-sea fisheries exist with abundance of several species of highly migratory fish species such as Tuna, Shark and Billfish.

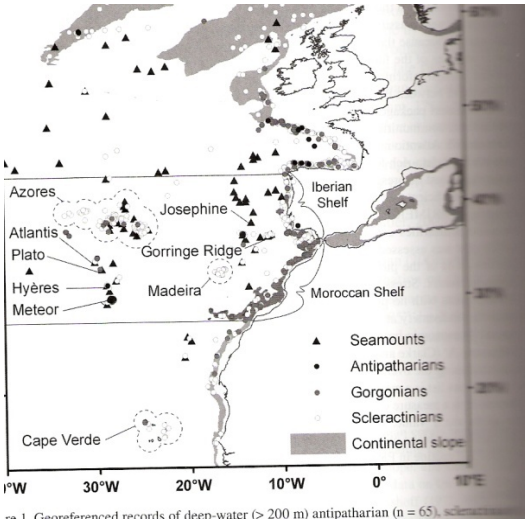
12. COLD CORALS IN AZORE SEAMOUNTS

LME # 27 A

From historical data, Spencer et al (2007) concluded that the composition of seamount corals appears to be different from island slopes around Azores from same depths (200-2,000m). This finding clearly poses the question that rather than mere bathymetry the oceanographic conditions such as current vortex unique to seamounts determine settlement of larvae of sessile organisms such as corals and therefore the composition of these vulnerable cold coral ecosystems on seamounts which experience over the years intense fishing pressure and constant IUU (Illegal Unregulated Unreported) fishing activities from pirate nations that do not obey international laws for conservation.

Seamount deep-sea corals also exhibit high endemism. For example, scleractinian *Paracyathus arcuatus* occurs only on seamounts. Likewise, gorgonian species *Dentomuricea meteor* and *Tubigorgia cylinderica* occur only in the Great Meteor seamount (Grashoff, 1977 and Pasternak, 1985).

It is evident from the figure given below that the seamounts (shown as triangles) show greater diversity of antipatharians (black corals) than other cold corals.



Seamounts around Azores and NE Atlantic Ocean with cold corals.

Molodtsova and Budaeva (2007) in Miami discussed the unique morphology of the black corals from seamounts and pointed out that the Antipatharians are specially adapted to suspension-feeding. Also, these antipatharians harbor symbiotic fauna such as polychaetes. The morphology of the corllium was influenced by the symbiotic polychaetes.

13. COLD CORALS IN CHILEAN FJORDS

LME # 13

Fjords in Norway and Sweden are known to harbor deep-water *Lophelia pertusa* reefs, which are not just bio-buildups (see Ginsburg and Lutz, 2007)

but are true bioherms of age ranging from 3000 to 10000 years (George, 2004). On the contrary fjords in Chile in the southern hemisphere in the Southern Pacific are not monospecific but multispecies aggregations of as many as 23 known species of scleractinian corals, 12 antipatharians, 13 hydrocorals and 10 to 15 gorgonian corals (Hausserman and Forsterra, 2007).

Study Area with corals (triangles)

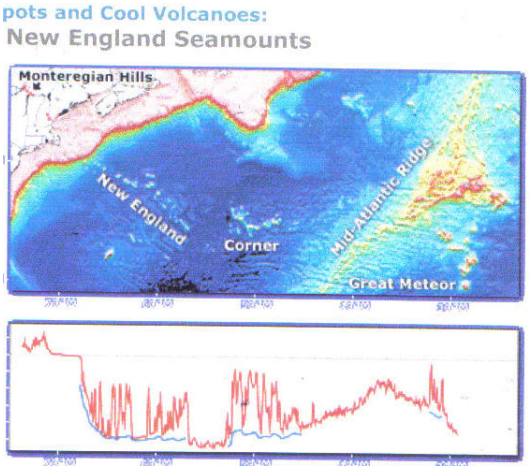
This recent taxonomic study in Chilean Comou Fjord revealed one new species of scleractinian coral. ROV transects down to 255 meters showed the presence of *Desmophyllium dianthus* in the upper depths where the substratum is different. Latitudinaly there is a north to south decline in abundance of cold corals.

In other Chilean Fjords (Puyuhuapi and Aysen Fjords) gorgonians *Primnoella chilensis* dominate between 15 and 50 m. South of the Golfo de Penas, extensive fields of large branched primnoids and acathogorgiids, *Thourella* spp. dominate below 20 m. These authors identify as threats to the cold corals the following three stresses: 1. Bottom Trawling 2. Longline fisheries and 3. Aquaculture

14. COLD CORALS IN ATLANTIC SEAMOUNTS

LME # 8 A

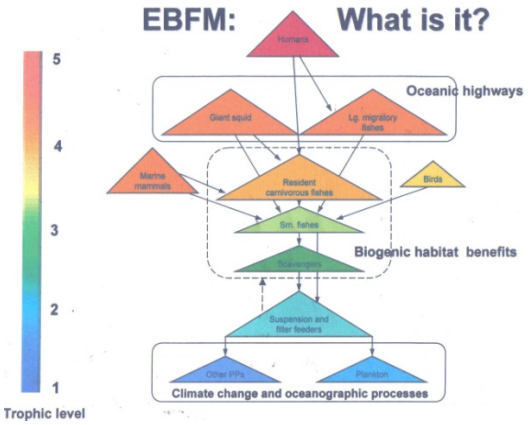
In the Miami symposium George et al., (2007) presented the very first food-chain model for a seamounts ecosystem. These authors discussed the trophic spectrum and oceanographic conditions for the Corner Rise Seamounts, which have been targeted by the Russian trawl fisheries in the recent decade (Vinnichenko, 1997).



Note the Corner Rise Seamounts located between New England Seamount chain west of the Mid-Atlantic Ridge

Kukenthal Peak of the Corner Rise Seamount at 1230 m. Note the sand-covered basalt with large black coral *Pteriodopathes* sp. with squat lobsters. Golden fans are species of *Paramuricia*. Photo courtesy of Deep Atlantic Stepping Stones Expedition team. IFE-URI-IAO and NOAA.

Despite the fact about 100,000 seamounts occur on the ocean floor, mostly in the Pacific Ocean, only 300 seamounts have been sampled thus far. Corner Rise seamount supports populations of many commercially important fish species such as the rattail Coryphaenoi*des guntherii* and orange roughy *Hoplosrethus* spp.



Conceptual Model of the Corner Rise Seamount Ecosystem*

* For details of the food chain, see the original paper George et al., 2007 (cited in the references on the book).

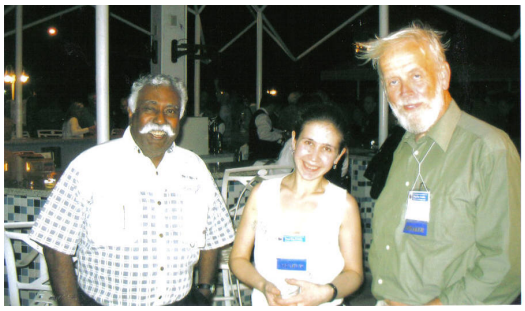
III. SOME INNOVATIVE IDEAS FOR COLD CORAL CONSERVATION:

A: SCIENCE PRIORITY AREAS (SPAs)

Many seamounts in the highseas can support at the slopes of their summits deep-water coral habitats. Currently, UN FAO, in a cooperative effort with flagship states and the RFMOS (Regional Fisheries Management Organizations), has initiated the "Technical Consultation on the Draft International Guidelines for the Management of Deep-Sea Fisheries (DSF). In the 2003 Deep-Sea Biology Symposium in Oregon, Prof. Hjalmar Thiel (Germany) and Prof. Robert George (USA) felt the need for protecting biodiversity in the deep-sea in the light of DSF and other mineral mining such as manganese nodules and oil and gas and appealed to participants to send a petition to the UN. As a consequence of this effort, 140 deep-sea biologists signed an appeal to UN Secretary General Koffi Annan to protect deep-sea biodiversity. Subsequently, the UN General Assembly passed the 'UN GA 61/105 Resolution' and authorized FAO to draw the guidelines for deep-sea fisheries and biodiversity protection.

Prof. Hjalmar Thiel was invited by GIBS to come to Miami to present his views on highseas/deep-sea biodiversity protection of Vulnerable Marine Ecosystems (VME). Thiel (2007) proposed the establishment of 'Science Priority Areas' (SPAs) on the highseas to avoid any disturbance from long-term research activities. According to this proposal, highseas SPAs are independent of highseas MPAs. For example, Meteor

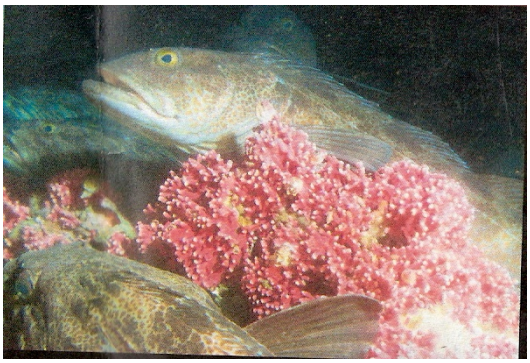
Seamount, east of the mid-Atlantic Rise in the North Atlantic Ocean, is designated as a highseas SPA whereas Corner Rise Seamounts designated as highseas MPA. Thiel's proposal is consistent with the United Nations Law of the Sea Convention and should not be subordinated within the framework of The World Conservation Union's (IUCN) categories for MPAs.



At RSMAS (Miami) during the 3 ISDSC Symposium: Rt. German deep-sea ecologist Hjalmar Thiel, Middle. Russian scientist Tina Molodsova and Lt. American deep-sea ecologist Robert Y. George

B. DEEP-SEA FISH AND DEEP-SEA FISHERIES (DSF) PROTECTION

Sulak et al., (2007) presented a comprehensive account of the demersal fishes associated with *Lophelia pertusa* coral biotopes in the Gulf of Mexico. In the Viosca Knoll (one of the areas for active oil and gas leasing), the fauna consisted of 53 demersal fish species. 37 of these fish species, associated with *Lophelia* corals, were documented by submersible videos. The dominant fish fauna was discussed earlier in this report in the section on the Gulf of Mexico. George and Ahlfeld (2007), in the second Global LME symposium in China, discussed the need for dividing the Gulf of Mexico into 5 separate sub regions of the LME and recommended a workshop to discuss this concept.

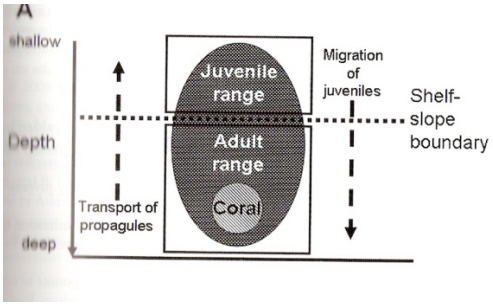


Fish and Deep-Sea Coral Affinity

Commercially important Snowy grouper *Epinephelus nivratus* near *Lophelia pertusa* pinnacle at 312 m in Viosca Knoll in the Gulf of Mexico.

Auster (2007) in his Miami symposium paper brought up the question: Is there a functional link between occurrence of fish populations and deep-sea corals. He argued that this issue is complex and is also connected to several processes including juvenile fish vertical migration (see figure below), prey-predator interactions, seasonal time frames, zooplankton prey diversity etc. Obviously linking fish abundance to deep-sea coral biotope and potential threats from fishing industry to deep-sea coral reefs and seamounts is a subject which evidently calls for further research and adaptive management which may

differ from one geographic locale to another.



Auster Hypothesis.

The groundfish fauna in association with deep-sea corals off Newfoundland and Labrador was the subject of discussion in the Miami Symposium paper by Edlinger et al., 2007. This work was based on stock assessment surveys conducted in the years 2003 to 2006. They found for several fish species, numerical fish abundance was greatest in one coral class of shallow depth but weight per tow was different in relation to depth. They recommended MPAs for deep-sea coral biotopes with the goal of protecting both invertebrate species and commercially important fishes.

C. STATUS OF DEEP-SEA CORAL TAXONOMY

One major outcome of the Miami symposium is a greater awareness for azooxatnhellate coral taxonomy and molecular systematics, as evident from many papers addressing this subject. Cairns (2007) set the stage by presenting an overview with emphasis on diversity and distribution of scleractinian corals. He reported that the number of new scleractinian deep-sea coral species has increased exponentially in recent years but now is attaining a plateau. Most of these new hard coral species are actually solitary, primarily caryophiliids. Hot spots of scleractinian deep-sea corals are Philippine region, western Atlantic Antilles and the southwestern Indian Ocean. He concluded that the regions of low diversity are associated with shallow depths of aragonite saturation horizon and high diversity of deep-sea hard coral between 200 and 1000 m is a result of availability of large contiguous stable substrate.

It is also becoming increasingly clear that the octocorals are less known taxonomically with many new species yet to be described. France (2007) made a genetic analysis of bamboo corals (Isididae). Mitochondrial DNA sequence studies suggested that distinction between the genera *Lepidisis* and *Keratoisis* should not be based on whether or not colonies branch.

D. PALEO AND PRESENT CLIMATE IMPACT ON DEEP-SEA CORALS

With climate change science in the forefront, deep-sea corals are used as a tool to tell what the past climate was in the geological past. There have been great concerns that increasing temperature due to global warming can induce changes in the circulation of waters, currents both at the surface at sub-surface depths. More recently, ocean acidification emerged as a threat to all shell-bearing animals in the sea, particularly corals. Scleractinian corals build their skeleton by secreting aragonite and the octocorals by secreting calcite. Laboratory studies revealed that a subtle reduction in pH levels can result in a significant reduction in calcification process and can cause conditions like osteoporosis in corals. It is estimated by some scientists that within 50 to 75

years, at the current rate of carbon emissions, corals will become "naked" without the ability to secrete their shells.

In the Miami symposium, Taviani et al., 2007 reported that the Pleistocene was suitable for deep-sea corals and included the presence of glacial corals such as *Javania insignis*. A subfossil *J. insignis* from the Coral Sea peak has been U-series dated at 26,590 years. This represents the first documentation of the presence of deep-sea corals in the Red Sea.

On the Northwestern side of the North Atlantic, however, deep-sea corals have grown for over 200,000 years on the New England Seamounts. Robinson et al., (2007) studied the depth distribution of the fossil coral *Desmophyllum dianthus* with their presence on seamounts extending from 750 to 2000 m. The ages of *D. dianthus*, as determined by U-series measurements range from modern to older than 200,000 years. Within the glacial period, increases in coral population density at Muir and Manning Seamounts coincided with times at which large-scale ocean circulation changes have been documented in the deep North Atlantic.

E. ISOTOPIC STUDIES: AGE AND GROWTH

In my studies over the Blake Plateau off North Carolina I have encountered huge aggregations of both fossil and live scleractinian cupcoral *Thecopsammia tintinabulum*. In the collaborative research with the renowned geologist late Prof. Caesar Emiliani of the University of Miami, we discovered that the this coral from a depth of 750 m grow an order of magnitude slower than the tropical shallow water star coral *Montastrea annularis*. Oxygen isotopic ratio studies also revealed that the deep-sea corals live much longer in excess of 1000 years as opposed to the short-lived star corals living as much as 415 years (Emiliani et al., 1978).

In a classical study reported in the Miami symposium, Tracey et al (2007) discussed growth and age of four bamboo coral colonies of the genera *Keratoisis* and *Lepidistis* from the East Cape (690 – 800 m), Norfolk Ridge (874 – 1030 m), Chatham Rise (690 – 800 m) and Snares (835 m), all 4 sites off New Zealand. Lead-210 was applied to the skeletal structure of the corals to develop an independent estimate of age and growth. Radial micro-sampling of the skeletal carbonate indicated the mean age of the colony as 43 years, ranging from 26 to 61 years, with a growth of 0.13 to 0.29 mm. This finding suggests that these bathyal corals are K-strategists with slow growth, as opposed to fast growing tropical coral such as *Acropora* sp.

Thresher et al., (2007) examined the impact of the environment on the calcite skeleton of bamboo corals off New Zealand (same two genera as above in the Tracey et al., studies). Gross patterning of magnesium and to a lesser extent calcite, is similar in specimens in one site but differs between the 4 study-sites, suggesting possible environmental effects that are characteristic of the study- areas.

F. FEEDING AND REPRODUCTIVE BIOLOGY

Our knowledge about the feeding and reproductive biology of deep-sea corals is still meager. Buhl-Mortensen et al., (2007) reported on polyp expansion and closing patterns in the scleractinian coral *Flabellum albastrum* from the slope off Nova Scotia. The polyps expanded more than 10 times when offered food (pieces of krill).

To date, no one has ever seen a larva of the most dominant deep-sea coral *Lophelia pertusa* (Personal communication Dr. Sandra Brooke). Nevertheless, Brooke and Stone (2007) contributed some interesting data on reproduction of hydrocorals (Family Stylasteridae) from the Aleutian coral garden off Alaska. Their study discovered that all hydrocorals from the Aleutian island samples were gonochoristic brooders with majority of gonophores containing mature embryos or planulae larvae. The developmental stages within a single specimen was not highly synchronized: females contained eggs as well as planulae and males exhibited a range of gametic development.

Evidently basic knowledge of reproduction and feeding in deep-sea corals needs improvement, particularly calling for funding from agencies such as National Science Foundation (US NSF). This author has made many laboratory studies in Tjarno Marine Biological Laboratory in Sweden, in collaboration with Dr. Tomas Lundalv on the feeding behavior, rhythms and metabolism in relation to temperature, as reported in the 2nd International Deep-Sea Coral Symposium in Erlangen, Germany (George and Lundalv, 2003). However, there is a need to conduct careful *in situ* experiments both on simulated acidification impact on feeding, survival and calcification rate of deep-sea corals.

Lophelia pertusa in feeding posture

IV. POST SYMPOSIUM HARVARD CONFERENCE.

Subsequent to the Miami deep-sea coral symposium, GIBS organized the ‘ Harvard Declaration Conference’ with the goal of recommending the creation of the “Deep-Sea Coral Board” under the auspices of the JSOST (Joint Subcommittee of Ocean Science and Technology). This conference (Oct. 24-25, 2006), co-chaired by Prof. Robert Y. George and Prof. Edward O. Wilson, was attended by representatives from the federal government (MMS, NOAA, USGS), academia (Harvard, Duke, Boston University, McMaster University) and NGOs (PEW Institute, Environmental Defense, GIBS and MCBI).

The recommendations from the Harvard conference were presented on Dec. 4, 2006 at the office of NOAA Deputy Assistant Secretary of the Department of Commerce in Washington DC and was unanimously approved to create the ‘Deep-Sea Coral Board’ which is now in function as an interagency group under the joint

chairmanship of Dr. Thomas Hourigan (NOAA) and Dr. Thomas Ahlfeld (MMS).

V. GIBS PANANAMA CITY CORAL CONSERVATION WORKSHOP

Following the 2005 Miami deep-sea coral symposium, GIBS organized an international marine conservation workshop that brought 5 tropical coral experts and 3 deep-sea coral experts to discuss the merging issues for protection of coral reef ecosystems in the world oceans, both the deep-sea and tropical reefs. This 2006 international event was put together under the auspices of the Fulbright Academy of Science and Technology in Panama City, Panama. A petition was generated at the conclusion of the workshop and signed by the participants and submitted to the UN Secretary General with a request to create an independent authority within UN FAO as:"International Biodiversity and Fisheries Protection Authority" (IBFPA), comparable to the "International Seabed Authority" (ISA). Dr. Thomas Ahlfeld (MMS) was one of the speakers in the workshop in Panama City.

VI. LIST OF PAPERS FROM BOOK

" Conservation and Adaptive Management of Seamount and Deep-Sea Coral Ecosystems" edited by Robert Y. George and Stephen D. Cairns. 323 pp.

A. Management Strategies.

1. George, R. Y., T. A. Okey, J. K. Reed and R. P. Stone. 2007. Ecosystem-based fisheries management of seamount and deep-sea coral reefs in U. S. Waters: Conceptual models for proactive decisions. In: George R. Y. and S. D. Cairns, Eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 9-30.

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B. Fish and Fisheries

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C. Geographic and Regional Management Efforts.

8. Edinger, N. E., V. E. Wareham and R. L. Haedrich, 2007. Petterns of groundfish diversity and abundance in relation to deep-sea coral distributions in Newfoundland and Labrador waters. In: George, R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp.100-123.

9. Breeze, H. and D. G. Fenton, 2007. Designing management measures to protect cold water corals off Nova Scotia, Canada. In: George R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 124 – 134.

10. Hall-Spencer, J., A. Rogers, J. Davies and A. Foggo, 2007. Deep-sea coral distribution on seamounts, oceanic islands and continental slopes in the Northeast Atlantic. In: George R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 135 – 146..

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14. Parrish, F. A. 2007. Density and habitat of three deep-sea corals in the lower Hawaiian chain. In: George R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 185 –194.

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17. Jamieson, G. S., N. Pellegrin and S. Jesson, 2007. Taxonomy and zoogeography of cold-water corals in coastal British Columbia. In: George R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 215 -230.

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21. Santodomingo, N., J. Reyes and A. Gracia, 2007. Azooxanthellate *Madracis*

coral communities off San Bernardo and Rosario Islands (Colombian Caribbean). In: George R. Y. and S. D. Cairns, eds. 2007. Conservation and adaptive management of seamount and deep-sea coral ecosystems. Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, pp 273 –288.

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Bulletin of Marine Science
Vol. 81, No 3
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A. SYSTEMATICS

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2. France, S. F. 2007. Genetic analysis of bamboo corals (Cnidaria: Octocorallia-Isididae): does lack of colony branching distinguish *Lepidisis* from *Keratoisis*? *Bull. Mar. Sci*. 81(3): 323 – 334.

3. Aguilar, C. and Sanchez, J. A. 2007. Molecular morphometrics: contribution of ITS2 sequences and predicted RNA secondary structures to octocoral systematics. *Bul. Mar. Sci*. 81(3): 335 – 350.

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(Keratoisis spp. Isididae*). Bull. Mar. Sci*. 81 (3): 409 – 422.

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D. CORAL BIOLOGY AND NATURAL HISTORY.

10. Williams, B., M. J. Risk, S. W. Ross and K. J. Sulak. 2007. Stable isotope data from the deep-water antipathrians: 400 years records from the southeastern coast of the United States of America. *Bull. Mar. Sci*. 81 (3): 437 – 4448.

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15. Brooke, S. and R. Stone. 2007. Reproduction of deep-water hydrocorals (family Stylasteridae) from the Aleutian Islands, Alaska. *Bull. Mar. Sci*. 81(3): 519 – 532.

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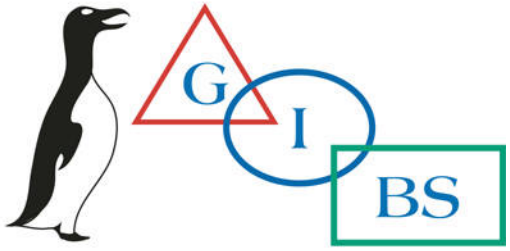
(To view this "GIBS Technical Memorandum", visit:
www.GIBSconservation.org
Click "Contact" on left panel and then click GIBS Viewsletter # 4.).

* References cited in the text, other than the 40 references given above, can be found in the appropriate paper either

from the deep-sea conservation book or the *BMS* volume.



GIBS = POLICIES +
LEADERSHIP
THROUGH BRIDGE-BUILDING

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.