Third International Symposium on

Deep-Sea Corals

Science and Management

PROGRAM AND ABSTRACT BOOK

November 28-December 2, 2005

University of Miami
Rosenstiel School of Marine and Atmospheric Science
Miami, Florida, USA

UNIVERSITY OF FLORIDA
IFAS

Project # 0507

November 28, 2005

Dear Symposium Participant,

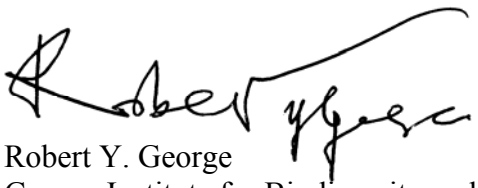
It is a great pleasure to welcome you all to the 3rd International Symposium on Deep-Sea Corals. The purpose of the symposium is to provide a forum for scientific information exchange and explore new concepts and future collaboration among the participants. What will be discussed over the course of the next few days promises to be an exciting insight into the significant advances in ocean science and management of coldwater corals, sponges, seamounts, and associated fauna. We hope that you will participate in the creative discussions that will expand our collective understanding of the complex array of topics under the eight themes developed by the symposium advisory committee.

Increasing interest in understanding and protecting deep-water ecosystems is clearly evident in discussions taking place at the United Nations and in several countries around the world. Interest in presenting and discussing scientific advances and ways to protect these areas has grown as well. In 2000, the 1st International Symposium on Deep-Sea Corals took place in Halifax, Canada, with 42 oral presentations and 22 posters comprising the agenda. Three years later in Erlangen, Germany, the symposium had grown into 67 oral presentations and 42 posters. Realizing that the amount of interest and scientific advances in deepwater ecology was quickly expanding, the International Steering Committee decided to hold this symposium two years later, not three. This decision seems to have been warranted as we received approximately 200 abstracts from 29 countries, translating into 9 keynote addresses, 102 oral presentations, and 88 posters.

We wish to thank the various sponsors and co-sponsors of this symposium as well as the host institution, the prestigious Rosenstiel School of Marine and Atmospheric Science of the University of Miami. The University of Florida/IFAS Office of Conferences and Institutes has worked hard to ensure that all of the symposium's activities meet your expectations.

On behalf of the members of the international steering committee, symposium core committee, advisory committee, local arrangement committee, and the 16 co-conveners who all contributed time, enthusiasm, and resources. Welcome to the international city of Miami, Florida, USA!

Robert J. Brock
NOAA Fisheries Service
Co-Organizer



Robert Y. George
George Institute for Biodiversity and Sustainability
Co-Organizer

MUSEUM OF COMPARATIVE ZOOLOGY
The Agassiz Museum

Edward O. Wilson University Research Professor Emeritus and Honorary Curator in Entomology
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28 November 2005

TO: All participants of the Third International Symposium on Deep-Sea Corals
Rosenstiel School of Marine and Atmospheric Sciences
University of Miami

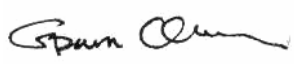
Dear Deep-Water Coral Scientists:

As an advocate of conservation of biodiversity on Earth, I am thrilled to learn from Prof. Bob George (co-organizer of the symposium) that 250 deep-coral researchers and science managers from 30 nations are assembling today in Miami, to synthesize existing knowledge on habitat-forming azooxanthellate cold corals. I realize that numerous described and undescribed invertebrate species and fish fauna area associated with these colorful and spectacular seamounts and undersea gardens in the world oceans. I wish you all a successful conference and confluence of ideas (consilience) that can pave the way for wise management of these ecosystems by national and international governments.

When Bob invited me to address this assembly of scientists in Miami, I realized that I have a field trip scheduled in the same time in the Dominican Republic, not too far from Miami. This conflict of schedule did not allow me to be with you all today. However, my thoughts are with you for achieving the goal of preventing biodiversity decline. The ecosystem collapse can be caused by habitat destruction due to bottom commercial trawling (physical destruction). It can also happen by silent extinction of even undescribed deep-sea species (such as unknown) species of sharks in the abyss, due to changes in thermohaline distribution (as induced by climate change-man's activities included) or disruption of ecosystem structure and function (long-line fishing of predatory species in the top of food pyramids in seamounts).

The "Storm over Amazon" and "Unmined Riches," which I describe in my book on 'Biodiversity' (1992), are equally true for land and marine ecosystems. Time has come for scientists in all nations to take every action possible to conserve and protect biodiversity. I wish all a pleasant time in Miami and a productive outcome of this international conference.

Sincerely

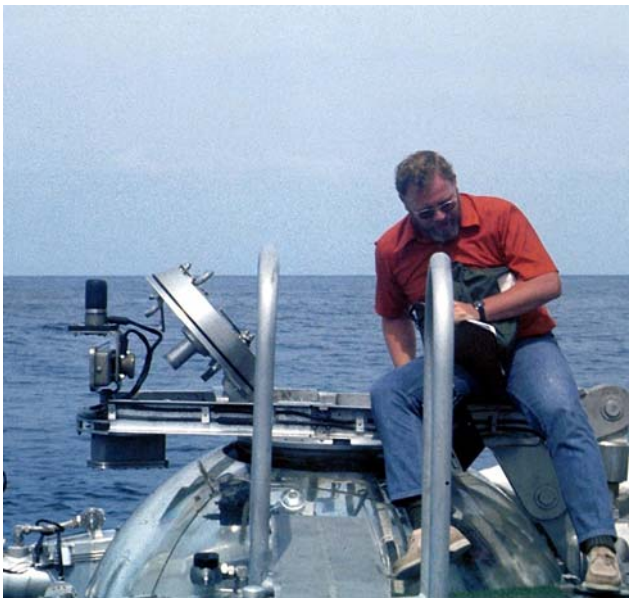


Edward O. Wilson
EOW:kmh

Table of Contents

Dedications

Symposium Dedication to the Late Dr. Robert Avent



It is with great pleasure I recognize the contributions to our knowledge of cold coral ecosystems by the late Dr. Robert M. Avent of the Mineral Management Services (MMS), a co-sponsor of the 3rd ISDSC in Miami. This international symposium is dedicated to the memory and honor of Dr. Avent. The accompanying photo shows Dr. Avent in his youth while entering the *Johnson Sea-Link* submersible which he used to study the *Oculina* coral reefs over continental shelf edge off the Florida Atlantic coast.

You all have received the 'OCS Report' on MMS "Biological Investigations in the Gulf of Mexico-1973-2000" that Dr. Avent compiled when he supervised this program from New Orleans, Louisiana.

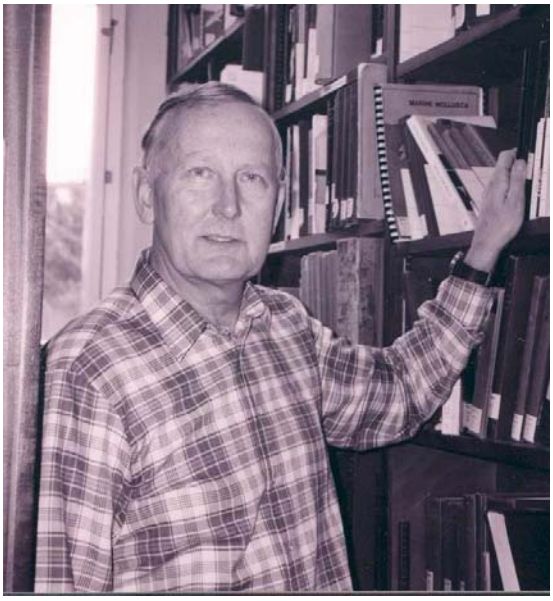
Please read it to get a glimpse of his devotion to marine conservation biology with particular emphasis to the deep-sea ecosystems including cold coral *Oculina* and *Lophelia* reefs.

Just a few months before he died prematurely after a lung cancer operation in December 2002, Bob discussed with me enthusiastically about the discovery of *Lophelia* coral lithoherms and chemoherms in the Gulf of Mexico. Dr. Avent received his Ph. D. from the Graduate Department of Oceanography at Florida State University. He worked for 27 years in the Environmental Sciences program of MMS. His comprehensive research paper, published in the "International Review of Hydrobiology" on the benthic communities associated with hard bottom off Florida Atlantic coast, speaks for his depth of knowledge of species associated with cold coral ecosystem.

I sailed with Bob on many cruises in the Gulf of Mexico and off US East Coast. His colleagues and friends will remember him for his charisma, enthusiasm and an affable personality.

-- Robert Y. George

Symposium Dedication to the Late Prof John Gage



John was a Research Fellow at the Scottish Association for Marine Science (SAMS) at Dunstaffnage near Oban where he led the Deep Sea Biology Group until his retirement in 2004. John joined the Scottish Marine Biological Association (later to become SAMS) in 1967 after post-doctoral fellowships at Woods Hole and the Marine Biological Association, Plymouth. He started work on coastal ecology, in particular the animals living in sea lochs on the west coast of Scotland. Following the availability of deep-sea research vessels in the mid 1970s, he extended his studies into deep water. He was a keen biologist and was always happiest when he was behind a microscope. He was one of the world's leading deep-sea experts, pioneering investigations into seabed ecology, particularly the northern NE Atlantic off Scotland and Ireland. Much of our current knowledge about the growth and reproduction of deep-sea organisms resulted from his work on the time series of samples at fixed stations, which he established. This was a theme, which continued until his retirement, many of his papers being in collaboration with Professor Paul Tyler at the University of Southampton.

He participated in countless research cruises from the early 1970s including dives in the Johnson Sea-Link submersible off Bermuda. He also led many cruises, including an investigation of the Oman oxygen minimum zone in the Arabian Sea. On his last cruise in 2003, he returned to the Arabian Sea to study the oxygen minimum zone at the Pakistan continental margin. His scientific output exceeded 150 publications. John held an Honorary Professorship at the University of Aberdeen and Honorary Visiting Professorship at the University of Southampton and contributed significantly to public debates on issues relating to deep ocean ecosystems. During the Brent Spar controversy he gave expert evidence to the House of Lords Select Committee. Before his death John was working, with Professor Paul Tyler, on a revision of their popular deep-sea book, Deep-sea Biology: A Natural History of Organisms at the Deep-Sea Floor, a requisite textbook for all undergraduate and postgraduate marine biology students. He initiated work on cold-water corals at SAMS in the mid-1990s and became a champion for their conservation. John died on the 18th July 2005; he leaves behind a wife, Christine, and three children William, Victoria and George. He will be sadly missed by all who worked with him.

-- J. Murray Roberts

Opening Session VIPs

Timothy R.E. Keeney

Deputy Assistant Secretary for Oceans and Atmosphere
U. S. Department of Commerce
National Oceanic and Atmospheric Administration

On April 8, 2002, Timothy R.E. Keeney was sworn in as Deputy Assistant Secretary for Oceans and Atmosphere. In this capacity, Mr. Keeney is a key member of the National Oceanic and Atmospheric Administration's (NOAA) management team. NOAA is the nation's top government science and environmental management agency and is led by Under Secretary of Commerce for Oceans and Atmosphere Vice Admiral Conrad C. Lautenbacher, Jr., USN (ret.).

At NOAA, Mr. Keeney is responsible for environmental policy, strategic planning and program analysis. Mr. Keeney's major responsibilities include crosscutting programs such as coral reefs, invasive species, habitat restoration, and observation systems.

Mr. Keeney earned a bachelor's degree from the Wharton School of Business at the University of Pennsylvania in 1970 and a Doctor of Laws degree from the University of Connecticut School of Law in 1976. He also completed the environmental leadership program at Yale University's School of Forestry and Environmental Studies.

Mr. Keeney has served in numerous public and private positions throughout his career. Most recently, he served as director of environmental services for Northeast Utilities Service Company in Hartford, CT, beginning February 1998.

During his career, Mr. Keeney has held several environmental management and regulatory positions, including NOAA general counsel, and director of Ocean and Coastal Resource Management at NOAA's National Ocean Service. He served as commissioner for the Connecticut Department of Environmental Protection and director of the Rhode Island Department of Environmental Management. Mr. Keeney was also president of Dufrane Nuclear Services, Inc. in Avon, CT.

A retired captain in the United States Navy, Mr. Keeney's last duty assignment concluded in June 2005, was commander of Naval Reserve SEAL Forces, Naval Warfare Command, at Coronado Naval Amphibious Base San Diego, CA.

Mr. Keeney and his wife, Mary, have five children: Clinton, Timothy, Jr., Emily, Lucy, and Grace.

Suzette M. Kimball

Regional Director of the USGS Eastern Region
U.S. Geological Survey (USGS)

Dr. Suzette M. Kimball has been with the U.S. Geological Survey (USGS) since 1998 and is presently the Regional Director of the USGS Eastern Region. Dr. Kimball received her bachelor's degree in English and geology from the College of William & Mary; an M.S. in geology and geophysics from Ball State University; and a doctorate in environmental sciences with a specialty in coastal processes from the University of Virginia. She was assistant professor of environmental sciences at the University of Virginia; co-director of the Center for Coastal Management and Policy and marine scientist at the Virginia Institute of Marine Science; and managed coastal morphology and barrier island studies in the U.S. Army Corps of Engineers. She entered the National Park Service as a research coordinator in the Global Climate Change Program, became Southeast Regional Chief Scientist, then Associate Regional Director. She is a recent recipient of the Presidential Rank Award and the Secretary of the Interior's Meritorious Service Award. Her professional affiliations include the Earth Care Connection, The Coastal Society, American Geophysical Union, George Wright Society, Society of Economic Paleontologists and Mineralogists, American Association of University Women, Sigma Gamma Epsilon, and Sigma Xi.

In 2002, Dr. Kimball received Presidential Rank Award (Meritorious).

James Kendall
Chief Scientist
U.S. Department of the Interior
Minerals Management Service (MMS)

Dr. James Kendall serves as the Chief Scientist of the U.S. Department of the Interior's Minerals Management Service (MMS) and coordinates the MMS Environmental Studies Program (ESP). The ESP is tasked with providing the environmental and socioeconomic information necessary for the MMS to make informed decisions concerning offshore oil and gas and marine mineral activities. Prior to joining the MMS Headquarters Office, Dr. Kendall served as the Studies Chief for the MMS Gulf of Mexico OCS Region. He received his bachelor's degree in biology from Old Dominion University and his Ph.D. in oceanography from Texas A&M University. He has conducted research on corals in the Gulf of Mexico, the Caribbean, and the Red Sea.

The symposium organizers express their thanks to the following sponsors:

Environmental Defense

George Institute for Biodiversity and Sustainability

International Council for Exploration of the Sea

Marine Conservation Biology Institute

National Oceanic and Atmospheric Administration

Pew Institute for Ocean Science

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National Museum of Natural History

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Bulletin of Marine Science (BMS) (No. 6 Dec. 2006)

"Deep-Water Coral Ecosystems: Science and Management"
Proceedings of the **3rd International Symposium on Deep-Sea Corals** held November 28 – December 2, 2005, at the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS), Miami, Florida

All contributors (oral and posters) to the symposium are encouraged to submit a paper to the proceedings of the symposium for publication in March 2007 as a regular number of the *Bulletin of Marine Sciences*. Manuscripts should be a minimum of six pages and a maximum of ten pages. Deadline to submit a manuscript is February 16, 2006. Editors will meet with the BMS Editorial Board on Nov. 28, 2005, in Miami during the symposium. Further details will be given to all symposium participants during the symposium.

GIBS Medals and Awards

George Institute for Biodiversity and Sustainability (GIBS) has established the following medals of honor and special awards for recognition during the **3rd International Symposium on Deep-Sea Corals** in Miami, Florida.

1. **"Robert Avent Medal"** was founded by George Institute for Biodiversity and Sustainability (GIBS) in 2005 in memory and honor of late Dr. Robert M. Avent who served in his life as a scientist and manager, combining this professional career with brilliant success with his enthusiasm and devotion. Bob studied cold coral reef Ecosystems off the Florida Atlantic Coast using the submersible *Johnson Sea-Link*. He authored the OCS report "Mineral Management Service Environmental Studies Program: A History of Biological Investigations in the Gulf of Mexico, 1973-2000". (Symposium participants received). The 3rd ISDSC is dedicated to Dr. Avent. The first recipient of 'Avent Medal" is his former colleague John Reed, a renowned cold coral researcher at the Harbor Brach Oceanographic Institute, Fort Pierce, Florida. Dr. Thomas Ahlfeld of MMS, who worked with Dr. Avent for many years, will present the Medal during the symposium banquet.

2. **"Don McAllister Medal"** was founded jointly by the Marine Conservation Biology Institute (MCBI) and George Institute for Biodiversity and Sustainability (GIBS) in memory and honor of late Dr. Donald E. McAllister who was a dedicated marine conservation ecologist and an outstanding ichthyologist. Don founded the journal 'SEA WIND' that carried the banner "Toward harmony of humankind, the sea and its life". The first McAllister medal was presented to Prof. J. H. Martin Willison of Dalhousie University, Nova Scotia, Canada at the AAAS meeting in Seattle, Washington in 2003. Dr. Willson was recognized for his role in organizing the 'First International Symposium on Deep-Sea Corals'. During this symposium the second 'McAllister medal' will be awarded to the world-renowned seamount biologist Dr. Tony Koslow of Australia in recognition of his scholarly work on orange roughy ecology and seamount conservation. Dr. Elliott Norse, President of MCBI, will present the medal during the symposium banquet.

Best Poster Awards

The symposium organizers, sponsors, host and the advisory committee recognized this symposium as poster-friendly and decided to recognize one poster for each of the eight themes for the "best poster certificate". Only student posters are eligible for this recognition. Judges, selected from the international steering committee, will evaluate the posters and will recommend the best for each theme. The winners will be announced and recognized during the symposium banquet. Symposium organizers will send the winners the certificates.

GIBS Distinguished Foreign Scholars to 3rd ISDSC in Miami

GIBS announced in the symposium website special fellowships to enable cold coral scientists from developing nations and Russia to attend the 3rd ISDSC. 15 scientists applied and GIBS science advisory board selected the following 7 scientists for this award.

1. ***Dr. Tina N. Molodtsova***, RUSSIA
2. ***Dr. K. Venkataraman***, INDIA
3. ***Dr. Debora Pires***, BRAZIL
4. ***Dr. Marccello Kitahara***, BRAZIL
5. ***Dr. Alberto Lindner***
6. ***Dr. Juan Sanchez***, COLUMBIA
7. ***Dr. Gunther Forrestera***, CHILE
8. ***Dr. Javier Reyes***, COLUMBIA

Funding for these fellowships was made possible from a grant from United States Geological Survey (USGS) to GIBS. These cold coral researchers will be recognized and Dr. Gary Brewer of USGS will present award certificates during the symposium banquet.

Post-Symposium Field Trip Information

Harbor Branch Oceanographic Institution

Saturday, December 3, 2005

Itinerary

7:30am	Depart Doubletree Hotel
10:30am	Arrive HBOI
	Education Center - Tour outside showing marine railway, ship, Deep Diver (first lockout submersible in history)
	Education Center Auditorium - Welcome presentation, history of HBOI, and HBOI overview video (***Dr. Dennis Hanisak***, Director of Marine Science and Education)
11:30am	Link Engineering Building - Split into three groups of 10:
	1) Division of Biomedical Marine Research (***Dr. Peter McCarthy***, Director)
	2) Division of Marine Engineering (***Ladd Borne***, Director)
	3) Submersibles and Marine Operations (***Don Liberatore***, Chief Sub Pilot)
12:30pm	Link Engineering Building - Lunch in Cafeteria
1:15pm	Bus to Aquaculture South (split into two groups):
	1) Tour Ornamental Reefs and Aquaria facilities (***Kevin Gaines***, President)
	2) Tour of Aquaculture (***Dr. Megan Davis***, Director)
2:00pm	Bus to Research Vessel Seward Johnson (split into two groups)
2:30pm	Education Center Auditorium
	1) ***Dr. Edie Widder*** - Bioluminescence, Eye in the Sea deep sea camera
	2) ***Dr. Peter McCarthy*** - Deep Sea Biomedical Research
	3) ***Dr. Tracey Sutton*** - Deep sea fish research
	4) ***John Reed*** - Deep Oculina Reefs - Destruction by Trawling (video)
3:30pm	Depart HBOI
6:30pm	Arrive Doubletree Hotel

Keys Diver Snorkel Tours

Saturday, December 3, 2005

99696 Overseas Hwy. Unit #1
Key Largo, Fl. 33037-2432
Email: info@keysdiver.com
Web Site: www.keysdiver.com

For those seeking a snorkel adventure in the shallow reefs of the Florida Keys National Marine Sanctuary and John Pennekamp State Park, we have arranged discounted rates with Keys Diver Snorkel Tours. They offer two daily tours aboard their 40ft. US Coast Guard inspected passenger vessel designed and built for snorkeling.

9:00AM Tour
The boat departs at 9:00am for one destination (over an hour of water time), and returns to the dock around 11:45am. The price is $21 per person + taxes.

12:15PM Tour
The afternoon tour stops at three different locations, and allows for more than 2 hours of water time. This tour features the Christ Statue, weather permitting. Return time is around 5:00pm. The group rate is $27 per person + taxes.

The price of each tour includes gear: mask, fins, snorkel and safety vest, and instructions by PADI licensed Dive Masters.

Reservations should be made in advance to hold your space on the boat. Please call Keys Diver Snorkel Tours at 1-305-451-1177 or 1-888-289-2402. They are open daily from 8:00am-4:00pm, and can be reached by email at info@keysdiver.com.

When contacting Keys Diver, please provide the following:

1. Saturday, December 3, 2005
2. Indicate 9AM or 12:15PM tour
3. Number of people in your party
4. Your last name
5. State you are with the International Symposium on Deep-Sea Corals

Transportation will not be provided because this tour option is on your own. We suggest that participants car pool to Key Largo, which is about 80 km one-way from the Doubletree Hotel. Discounted rental car rates are being offered by **AVIS**.

Program Agenda

Abstract page numbers are indicated at the end of listings when applicable
[example: "…(p. 2)"]

Monday, November 28, 2005 (Doubletree Hotel Coconut Grove)

3:00pm–7:00pm	Registration
5:00pm–6:00pm	Opening Session & Welcome
	Conveners: ***Dr. Robert Brock***, NOAA Fisheries Service and ***Prof. Robert George***, George Institute for Biodiversity and Sustainability
	Dr. Otis Brown, Dean, University of Miami Rosenstiel School of Marine and Atmospheric Science
	Mr. Timothy Keeney, Deputy Assistant Secretary for Oceans and Atmosphere, U.S. National Oceanic and Atmospheric Administration
	Dr. Suzette Kimball, Regional Director of the Eastern Region, U.S. Geological Survey
	Dr. James Kendall, Chief Scientist, U.S. Minerals Management Service
	Symposium Dedication
6:00pm–7:30pm	**Welcome Reception**

Tuesday, November 29, 2005 (University of Miami RSMAS)

7:00am–8:00am	Bus Shuttle from Doubletree Hotel to the University of Miami RSMAS
7:30am–12:00pm	Poster Presenters Set-Up Displays
7:30am–5:30pm	**Registration Open**
8:30am–12:00pm	**Theme 1: Systematics and Zoogeography**
	Conveners: ***Dr. Stephen Cairns***, National Museum Of Natural History, Smithsonian Institution (USA) and ***Dr. Timothy Shank***, Woods Hole Oceanographic Institution (USA)
8:30am–9:00am	**Keynote: Deep-Water Corals: A Primer – *Stephen Cairns*** (p. 3)
9:00am–9:15am	**Low Sequence Variability within Anthozoan Mitochondrial Genomes: Are Antipatharian Noncoding Regions the Exception? – *Mercer R. Brugler*** and *Scott C. France* (p. 4)
9:15am–9:30am	**Genetic Analysis of Bamboo Corals: Does Lack of Colony Branching Distinguish *Lepidisis* from *Keratoisis*? – *Scott C. France*** (p. 5)
9:30am–9:45am	**A Molecular Phylogenetic Perspective on Diversity and Species Boundaries of Deep-Sea Scleractinian Corals from the Southeastern U.S. and Gulf of Mexico – *Cheryl L. Morrison***, *Robin Johnson*, *Steve W. Ross*, *Kenneth J. Sulak*, *Robert J. Toonen* and *Tim L. King* (p. 6)

Tuesday, November 29, 2005 (continued)

9:45am–10:00am	**The Cinderella of the Nuclear Sequences? Contribution of ITS2 Sequences and Predicted RNA Secondary Structures to Octocoral Systematics – *Juan Armando Sánchez*** (p. 7)
10:00am–10:30am	Refreshment Break
10:30am–10:45am	**Population Genetic Structure of the Deep-Sea Precious Coral *Corallium secundum* from the Hawaiian Archipelago Based on Microsatellites – *Amy R. Baco*** (p. 8)
10:45am–11:00am	**Nuclear Sequences Distinguish *Oculina* Species by Geography, not Classical Taxonomy – *Michael E. Hellberg*** and *Margaret W. Miller* (p. 9)
11:00am–11:15am	**Ecology, Systematics, and the Evolution of Stylasterid Coral Diversity (Cnidaria: Hydrozoa: Stylasteridae) – *Alberto Lindner*** (p. 10)
11:15am–11:30am	**Corallum Growth Modifications in Black Corals as an Effect of Associated Fauna: Implications for the Taxonomy – *Tina Molodtsova*** and *N. Budaeva* (p. 11)
11:30am–11:45am	**Shape Variation Analysis of the Deep-Sea Star Coral (*Deltocyathus calcar*) – *Javier Reyes*** (p. 12)
11:45am–12:00pm	**Studies on Azooxanthellate Hard Corals in India – *Krishmanmoor Venkataraman*** (p. 13)
12:00pm–2:00pm	Lunch On Own

8:30am–12:00pm	**Theme 3A: Geology: Paleontology**
	Conveners: ***Dr. Michael Risk***, McMaster University (Canada) and ***Dr. Peter Swart***, University of Miami RSMAS (USA)
8:30am–9:00am	**Keynote: The Climate Record From Deep-Water Corals Rules, Because Geochemistry Finally Married Paleontology – *Michael Risk*** (p. 17)
9:00am–9:15am	**Danian Bryozoan and Coral Mounds in Denmark - Ancient Analogues to Modern Deep-Sea Coral Mounds? - *Morten Bjerager*** and *Finn Surlyk* (p. 18)
9:15am–9:30am	**IODP Expedition 307 Unravelled the Deep Secrets of the Cold Water Coral Banks in the Porcupine Seabight - *Ben De Mol***, *Timothy Ferdelman*, *Akihiro Kano*, *Trevor Williams*, *Kohei Abe*, *Miriam S. Andres*, *Morten Bjerager*, *Emily L. Browning*, *Barry A. Cragg*, *Boris Dorschel*, *Anneleen Foubert*, *Tracy D. Frank*, *Yuji Fuwa*, *Phillippe Gaillot*, *Jamshid J. Gharib*, *Jay M. Gregg*, *Veerle Ann Ida Huvenne*, *Philippe Léonide*, *Xianghui Li*, *Kai Mangelsdorf*, *Xavier Monteys*, *Akiko Tanaka*, *Ivana Novosel*, *Saburo Sakai*, *Vladimir A. Samarkin*, *Keiichi Sasaki*, *Arthur J. Spivack*, *Chizuru Takashima*, *Juergen Titschack*, *Jean-Pierre Henriet* and shipboard party of IODP LEG 307 (p. 19)

Tuesday, November 29, 2005 (continued)

9:30am–9:45am	**The Influence of Bottom Currents and Cold-Water Corals on Mound Growth on the Irish Continental Margin – The Recent Situation and Initial Results from IODP Expedition 307** - ***Boris Dorschel***, *Dierk Hebbeln, Anneleen Foubert*, *Martin White* and Expedition 307 scientific party (p. 21)
9:45am–10:00am	**From Surface Coring to Deep Drilling on Challenger Mound in the Porcupine Seabight, W of Ireland** – ***Anneleen Foubert***, *Boris Dorschel*, *Veerle A.I. Huvenne*, *Juergen Titschack*, *Jean-Pierre Henriet*, and the IODP Expedition 307 Shipboard Scientific Party (p. 22)
10:00am–10:30am	Refreshment Break
10:30am–10:45am	**Distribution of Cold-Water Corals in the Gulf of Cádiz under Changing Late Quaternary Climate Conditions** - ***Dierk Hebbeln***, *Claudia Wienberg* and *Boris Dorschel* (p. 23)
10:45am–11:00am	**The Initial Stages of Large Coral Bank Formation: New Insights from Present-Day Analogues and from the First Results of IODP Expedition 307 in the Porcupine Seabight** - ***Veerle A.I. Huvenne***, *Boris Dorschel*, *Anneleen Foubert*, *Ben De Mol* and the IODP Expedition 307 Shipboard Scientific Party (p. 24)
11:00am–11:15am	**Azooxanthellate Coral Communities on a Diapiric Continental Margin (Colombian Caribbean)** - ***Nadiezhda Santodomingo***, *Javier Reyes*, *Adriana Gracia*, *Germán Ojeda* and *Juan Ramón Peláez* (p. 25)
11:15am–11:30am	**Pliocene Deep-Water Coral Limestones from the NW Apennines (Italy) and Their Links to Hydrocarbon Seepage** - ***Marco Taviani****, S. Cavagna*, *P. Clari*, *F. Dela Pierre* and *M. Lopez Correa* (p. 26)
11:30am–11:45am	**Description and Depositional History of the Plio-Pleistocene Deep-Water Coral Facies from Messina (southern Italy) - Comparison with Recent Environments** - ***Agostina Vertino***, *André Freiwald*, *Italo Di Geronimo* and *Paolo Pino* (p. 27)
11:45am–12:00pm	**Sediment Mounds at the Shelf Margin of the East China Sea, Possible Deep Water Coral Reefs?** - ***Ping Yin***, *Serge Berne* and *Zhenxia Liu* (p. 28)
12:00pm–2:00pm	Lunch On Own

2:00pm–5:30pm	**Theme 2A: Habitat Mapping, Sampling and Characterization**
	Conveners: ***Dr. Kathy Scanlon***, U.S. Geological Survey (USA) and ***Dr. Anthony Grehan***, National University Of Ireland-Galway (Ireland)
2:00pm–2:30pm	**Keynote: Distribution and Status of Cold-Water Coral Ecosystems in Coastal Channels in the NE Skagerrak, Norway and Sweden** – ***Tomas Lundälv*** (p. 31)
2:30pm–2:45pm	**Deep-Water Sponge and Coral Habitats in the Coastal Waters of British Columbia, Canada: Multibeam and ROV Survey Results** – ***Kim W. Conway****, J. Vaughn Barrie*, *William C. Austin, Phillip R. Hill*, and *M. Krautter* (p. 32)

Tuesday, November 29, 2005 (continued)

Tuesday, November 29, 2005 (continued)

2:45pm–3:00pm **Productivity and Abundance of Invertebrate-Associated Microbes in Sponges of Cold Water Coral Reefs (Rockall Trough, NE Atlantic)** - ***Fleur C. van Duyl***, *Cornelia Maier*, *Astrid Hoogstraten* and *Jan Hegeman* (p. 47)

3:00pm–3:15pm **Clearance and Respiration Rates of the Deep Living Bivalve *Acesta excavata* (J.C. Fabricius, 1779)** - ***Johanna Järnegren*** and *Dag Altin* (p. 48)

3:15pm–3:30pm **Trends in the Biodiversity of Benthic Macrofauna from Deep-Water Carbonate Mounds in the Porcupine Seabight, West of Ireland** - ***Lea-Anne M. Henry***, *Rosanna Milligan* and *J. Murray Roberts* (p. 49)

3:30pm–4:00pm Refreshment Break

4:00pm–4:15pm **Key Species of Cold-Water Coral-Associated Fauna** - ***Tim Beck*** and *André Freiwald* (p. 50)

4:15pm–4:30pm **Patterns of Association of Octocoral Commensals: Comparisons Between Warm and Cold Water Atlantic and Pacific Gorgonians** - ***Les Watling*** (p. 51)

4:30pm–4:45pm **Bamboo Corals in North America** - *Peter J. Etnoyer* (Presented by: ***George Schmahl***) (p. 52)

4:45pm–5:00pm **Habitat Utilization and Species-Specific Associations between Galatheids and Deepwater Corals off the Southeastern United States** - ***Martha S. Nizinski***, *Steve W. Ross* and *Kenneth J. Sulak* (p. 53)

5:00pm–5:15pm **Invertebrate Assemblages on Deep-Sea Corals on Seamounts in the Gulf of Alaska** - ***Thomas C. Shirley***, *Amy R. Baco*, *Danielle Parker* and *Jon Warrenchuk* (p. 54)

5:15pm–5:30pm **Biodiversity and Biogeography of Communities Associated with *Lophelia pertusa* in the Northern Gulf of Mexico** - ***Erik E. Cordes***, *Michael P. McGinley*, *Elizabeth L. Podowski* and *Charles R. Fisher*.. (p. 55)

5:30pm–7:00pm Poster Reception
*Poster presenters must be stationed by their poster from 5:30pm-6:30pm.

6:15pm–7:15pm Bus Shuttle from the University of Miami RSMAS to the Doubletree Hotel

7:30pm–9:00pm DVD Night (Doubletree Coconut Grove)

Wednesday, November 30, 2005 (University of Miami RSMAS)

7:00am–8:00am	Bus Shuttle from Doubletree Hotel to the University of Miami RSMAS
7:30am–5:30pm	**Registration Open**

8:30am–12:00pm	**Theme 3B: Geology: Climate Change**
	Conveners: ***Dr. Michael Risk***, McMaster University (Canada) and ***Dr. Peter Swart***, University of Miami RSMAS (USA)
8:30am–9:00am	**Keynote: Are Deep-Sea Corals Threatened by the Decline in Aragonite Saturation State in the Ocean – *Chris Langdon*** (p. 59)
9:00am–9:15am	**Geochemical Profiles of Corals from a Dynamic Habitat: Charleston Bump, NW Blake Plateau - *C. Fred T. Andrus***, *George R. Sedberry* and *Christopher S. Romanek* (p. 60)
9:15am–9:30am	**Will Changes in Seawater Chemistry Negatively Affect Deep-Sea Coral Ecosystems? - *John M. Guinotte***, *James Orr*, *Robert George*, and *Lance Morgan* (p. 61)
9:30am–9:45am	**Antarctic Rosetta Stone: Towards a Recent Paleoceanographic Reconstruction from the Southern Ocean Using a Deep Sea Coral - *Michael Lutz***, *A. Meibom, B. Roderick*, *P. Chamberlain*, *R. Dunbar*, *D. Mucciarone*, and *Stephan Cairns* (p. 62)
9:45am–10:00am	**Preliminary Evidence of Oceanic Climate Change around New Zealand over the Last Century: The Pole-Equator Seesaw - *Helen Neil***, *Ronald Thresher*, *Di Tracey*, *Peter Marriott*, *Allen Andrews* and *Juan Sanchez* (p. 63)
10:00am–10:30am	Refreshment Break
10:30am–10:45am	**Development of Radiocarbon, Trace Element, and Stable Isotopic Records From a Deep Sea Coral: *Isididae sp.*- *E. Brendan Roark***, *Stewart Fallon*, *Thomas P. Guilderson*, *Robert B. Dunbar*, *Malcolm McCulloch* and *B. Lynn Ingram* (p. 64)
10:45am–11:00am	**Deep Sea Corals as Recorders of North Atlantic Radiocarbon Variability - *Laura F. Robinson***, *Jess F. Adkins*, *John Southon*, *Diego P. Fernandez* and *S.L. Wang* (p. 65)
11:00am–11:15am	**Isotope Screening on *Lophelia pertusa* (L.) – Reconstruction of Temperature vs. Growth Rate - *Andres Rüggeberg***, *W.-Chr. Dullo*, *A. Eisenhauer*, *J. Fietzke*, *André Freiwald*, *B.R. Schöne* and *N. Andersen* (p. 66)
11:15am–11:30am	**A 1200-Year History of Labrador Slope Water off Nova Scotia from Nitrogen Isotopes in Deep-Sea *Primnoa* Corals - *Owen A. Sherwood***, *Kumiko Azetsu-Scott*, *David B. Scott* and *Michael J. Risk* (p. 68)
11:30am–11:45am	**Temperature-Dependence of Mg/Ca Deposition in Keratoisis spp.: Evidence and Application to Reconstruction of Deep-Water Oceanography and Climatology in the Australian/New Zealand Region - *Ronald Thresher***, *Helen Neil*, *Jess Adkins*, *Colin MacRae*, *Nick Wilson*, *Rob Gurney* and *Di Tracey* (p. 69)

Wednesday, November 30, 2005 (continued)

11:45am–12:00pm	**Deep-Water Antipatharians and Gorgonians: Proxies of Biogeochemical Processes? - *Branwen Williams***, *Mike Risk*, *Ken Sulak*, *Steve Ross* and *Robert Stone* (p. 70)
12:00pm–2:00pm	Lunch On Own
2:00pm–5:30pm	**Theme 4: Coral Biology: Feeding, Growth and Reproduction Characterization**
	Conveners: ***Dr. Sandra Brooke***, Oregon Institute Of Marine Biology (USA) and ***Dr. Tomas Lundälv,*** Tjarnoe Marine Biological Station (Sweden)
2:00pm–2:30pm	**Keynote: Morphology, Growth and Feeding in Cold-Water Corals- *Pål B. Mortensen*** (p. 73)
2:30pm–2:45pm	**The Exploration of the Trophic Foodweb of a Cold-Water Coral Community of the Rockall Trough by Means of Analysis of Stable Isotope (δ15N) Signatures of the Main Biota - *Marc S.S. Lavaleye*** and *Gerard C.A. Duineveld* (p. 74)
2:45pm–3:00pm	**Potential Food Sources for Deep Water Corals from Rockall Trough (NE Atlantic) Assessed by Aquarium Feeding Experiments and Stable Isotopic Composition - *Cornelia Maier***, *Anna de Kluijver*, *Wolf-Rainer Abraham*, *Fleur C. van Duyl*, *Martin Agis* and *Markus Weinbauer* (p. 75)
3:00pm–3:15pm	**The Physiological Ecology of the Reef Framework-Forming Coral *Lophelia pertusa* - *Lyndsey A Dodds***, *J Murray Roberts* , *Alan Taylor* and *Francesca Marubini* (p. 76)
3:15pm–3:30pm	**Skeletal Growth and Chemistry of Two North Atlantic Deep Water Scleractinia - *Anne L. Cohen***, *John Crusius*, *Bruce H. Corliss*, *Robert Y. George* and *Tomas Lundalv* (p. 77)
3:30pm–4:00pm	Refreshment Break
4:00pm–4:15pm	**Trace-Element "Vital Effects" are a Ubiquitous Feature of Scleractinian Corals – New Data from *Lophelia*, *Oculina* and *Desmophyllum* – *Daniel. J. Sinclair***, *B. Williams* and *M. Risk* (p. 78)
4:15pm–4:30pm	**Lead-210 Dating Bamboo Coral (Family Isididae) of New Zealand and California - *Allen H. Andrews***, *Dianne M. Tracey*, *Helen Neil*, *Gregor M. Cailliet* and *Cassandra M. Brooks* (p. 79)
4:30pm–4:45pm	**Age and Growth, and Age Validation of Deep-Sea Coral Family Isididae - *Dianne M. Tracy,*** *Juan. A. Sanchez, Helen Neil, Peter. Marriott, Allen. H. Andrews* and *Greg. M. Cailliet* (p. 80)
4:45pm–5:00pm	**Growth Pattern of Deep-Water Gorgonian (*Primnoa resedaeformis pacifica*) in Japan - *Asako K. Matsumoto*** (p. 81)
5:00pm–5:15pm	**Reproduction of *Lophelia pertusa* from Norway and the Northern Gulf of Mexico** - *Sandra Brooke*, ***Johanna Järnegren*** and *Martin Ludvigsen* (p. 82)

Wednesday, November 30, 2005 (continued)

Wednesday, November 30, 2005 (continued)

5:15pm–5:30pm	**Seaways of the Bahamas Archipelago: A Vast Natural Laboratory for Research on Biophysical Parameters Controlling the Development of Deep Sea Buildups (Banks and Lithoherms)** – ***Robert N. Ginsburg*** and *Steve J. Lutz* (p. 98)
5:30pm–6:00pm	Bus Shuttle from the University of Miami RSMAS to Doubletree Hotel
7:00pm–9:00pm	Public Lecture (University of Miami RSMAS Auditorium)
	Bioprospecting on Deep Reefs: Unexpected Treasures - ***Shirley Pomponi***, President and CEO, Harbor Branch Oceanographic Institution
	Journey to the Days of Alexander Agassiz - ***Charles Messing***, Professor, Nova Southeastern Oceanographic Institute
	Film on cold coral reefs off Florida Atlantic Coast - *John Reed*, Senior Scientist, Harbor Branch Oceanographic Institution

Thursday, December 1, 2005 (University of Miami RSMAS)

7:00am– 8:00am	Bus Shuttle from the Doubletree Hotel to the University of Miami RSMAS
7:30am– 5:30pm	**Registration Open**
8:30am–12:00pm	**Theme 6: Fish Ecology**
	Conveners: ***Dr. Tony Koslow***, Commonwealth Scientific And Industrial Research Organization (Australia) and ***Dr. Ken Sulak***, U.S. Geological Survey (USA)
8:30am–9:00am	**Keynote: Patterns in the Biogeography and Endemism of Seamount Biotas as the Basis for Their Conservation and Management: Update from the September 2005 ISA/CoML CenSeam Workshop - *J. Anthony Koslow*** (p. 101)
9:00am–9:15am	**Coral Distribution on NE Atlantic Seamounts, Continental Slopes and Oceanic Islands Prior to Industrial Deep-Water Trawling** - ***Jason Hall-Spencer*** and *Alex Rogers* (p. 102)
9:15am–9:30am	**Patterns of Groundfish Diversity and Abundance and Deep-Sea Coral Distributions in Newfoundland and Labrador Waters** - ***Evan N. Edinger***, *Vonda E. Wareham* and *Richard L. Haedrich* (p. 103)
9:30am–9:45am	**The Distribution of Fishes Over Seamount Landscapes in the Western North Atlantic Ocean** - *Peter J. Auster*, ***Kari Heinonen*** and *Jon Moore* (p. 104)
9:45am–10:00am	**Benthic Fishes Occupying Deep Coral Habitats along the Southeastern United States Continental Slope** - ***Steve W. Ross***, *Kenneth J. Sulak* and *Andrea M. Quattrini* (p. 105)
10:00am–10:30am	Refreshment Break

Thursday, December 1, 2005 (continued)

2:00pm–5:30pm **Theme 8: Conservation And Protection Of Deep-Sea Corals**

Conveners: ***Dr. Dorothy Zbicz***, World Wildlife Fund (USA) and ***Dr. Murray Roberts***, Scottish Association of Marine Science (UK)

Thursday, December 1, 2005 (continued)

3:30pm–4:00pm	Refreshment Break
4:00pm–4:15pm	**Developing Ecological Quality Objectives for the Management of Cold-Water Coral Protected Areas** - *Jan Helge Fosså*, ***Anthony J. Grehan***, *Paal Mortensen* and *Simon Jennings* (p. 120)
4:15pm–4:30pm	**The Darwin Mounds – From Undiscovered Coral to the Emergence of an Offshore Marine Protected Area Regime: A History of Interactions and Consequences** - ***Elizabeth M. De Santo*** and *Peter J.S. Jones* (p. 121)
4:30pm–4:45pm	**The Aleutian Islands Model for Deep-Sea Coral Ecosystem Conservation** - ***Geoff Shester*** and *Jon Warrenchuk* (p. 122)
4:45pm–5:00pm	**Tools and Options for the Protection of Deep-Sea Coral Ecosystems** - ***Kristina M. Gjerde*** (p. 123)
5:00pm–5:15pm	**Science Priority Areas on the High Seas – Scientists' Views** - ***Hjalmar Thiel*** (p. 124)
5:15pm–5:30pm	**In Sight, Still Out of mind! — Coral Banks in Chilean Fjords: Characteristics, Distribution, Threats - Günter Försterra** and *Vreni Häussermann* (p. 125)
5:30pm–6:00pm	Bus Shuttle from the University of Miami RSMAS to Doubletree Hotel
8:00pm–10:00pm	Symposium Banquet (Doubletree Hotel Coconut Grove)
	Award of "Robert Avent Medal" – ***Dr. Thomas Ahlfeld***, MMS
	Award of "Donald McAllister Medal" –***Dr. Elliott Norse***, MCBI
	Recognition of GIBS/USGS delegates to 3rd ISDSC – ***Dr. Gary Brewer***, USGS

Friday, December 2, 2005 (University of Miami RSMAS)

7:00am–8:00am	Bus Shuttle from the Doubletree Hotel to the University of Miami RSMAS
7:30am–5:30pm	**Registration Open**
8:30am–12:00pm	**Theme 7: Ecosystem-Based Fisheries Management**
	Conveners: ***Ms. Susan Gass***, Scottish Association Of Marine Science, (UK) and ***Dr. Steve Murawski***, NOAA Fisheries Service (USA)
8:30am–9:00am	**Keynote: Ecosystem Based Fisheries Managment (EBFM): A Primer – *Steve Murawski*** (p. 129)
9:00am–9:15am	**A National Assessment of Deep-Sea Coral Communities and Approaches to their Conservation and Management** - ***Lance Morgan***, *John Guinotte*, *Sara Maxwell* and *Fan Tsao* (p. 130)
9:15am–9:30am	**Technology to Support Ecosystem-Based Fisheries Management in the South Atlantic Region** - ***Tina Udouj***, *Roger Pugliese* and *Myra Brouwer* (p. 131)

Friday, December 2, 2005 (continued)

Friday, December 2, 2005 (continued)

2:00pm–4:00pm Panel Discussion – Protection of Coldwater Coral Habitats And Seamounts – Legal And Political Considerations

Facilitators: ***Dr. Robert Brock*** and ***Prof. Robert George***

Panelists:

Dr. Ronán Long, Manahan Law of the Sea Research Fellow & Jean Monnet Chair European Law, School of Law, National University of Ireland, Galway, Ireland

Dr. Kristina M. Gjerde, Senior Scientist, IUCN—The World Conservation Union, Global Marine Program, Konstancin-Chylice, Poland

Mr. Matthew Gianni, Policy Advisor, Deep-Sea Conservation Coalition, Amsterdam, Holland

Dr. Ellen Pikitch, Professor of Marine Biology and Executive Director, PEW Institute for Ocean Sciences, RSMAS, University of Miami

Dr. James Kendall, Chief Scientist, U.S. Minerals Management Service

Dr. William Hogarth, Assistant Administrator, NOAA Fisheries Service

3:00pm–4:00pm Question & Answer

4:00pm Symposium Adjourns

4:00pm–4:45pm Bus Shuttle from University of Miami RSMAS to Doubletree

4:00pm–5:00pm International Steering Committee of ISDSC (RSMAS Dean's Conference Room)

7:00pm–8:30pm **Announcement:**

GIBS-PIOS Academic Forum on Deep-Water Ecosystems Conservation and Management (RSMAS Auditorium)

Sponsored by George Institute for Biodiversity and Sustainability (GIBS) and PEW Institute for Ocean Sciences (PIOS), RSMAS

Moderated by: ***Prof. Robert Y. George***, President, GIBS and ***Dr. Beth Babcock***, Chief Scientist, PIOS, RSMAS

- Symposium participants and RSMAS graduate students and faculty are invited.

Poster Session Directory

Abstract page numbers are indicated at the end of listings [example: "…(p. 2)"]

THEME 1 – SYSTEMATICS AND ZOOGEOGRAPHY

Poster
No.

Poster
No.

THEME 2 – HABITAT MAPPING, SAMPLING, AND CHARACTERIZATION

Poster
No.

Poster
No.

Poster
No.

THEME 3A – GEOLOGY: PALAEONTOLOGY

Poster
No.

THEME 3B – GEOLOGY: CLIMATE CHANGE

Poster
No.

Poster
No.

Poster
No.

THEME 4 – CORAL BIOLOGY: FEEDING, GROWTH AND REPRODUCTION CHARACTERIZATION

Poster
No.

Poster
No.

THEME 5 – BIODIVERSITY: MICROBIAL AND INVERTEBRATE ASSOCIATION

Poster
No.

Poster
No.

THEME 6 – FISH ECOLOGY

Poster
No.

THEME 7 – ECOSYSTEM BASED MANAGEMENT

Poster
No.

THEME 8 – CONSERVATION AND PROTECTION OF DEEP-SEA CORALS

Poster
No.

Poster
No.

Oral Abstracts

Theme 1 – Systematics and Zoogeography

Listed in order of presentation.
Presenting authors appear in **bold**.

Deep-Water Corals: A Primer

Stephen D. Cairns
National Museum of Natural History, Smithsonian Institution, U. S. A.

The polyphyletic term “coral” is defined as those Cnidaria having continuous or discontinuous calcium carbonate or horn-like skeletal elements. So defined, the group consists of seven taxa (all Scleractinia, Antipatharia, Octocorallia, Stylasteridae, and Milleporidae, one zoanthid, and three hydractiniids) constituting about 4820 species, 65% of which occur in water deeper than 50 m. Although the number of newly described species of deep-water scleractinian corals appears to be increasing at an exponential rate, it is suggested that this rate will plateau in the near future. The majority of azooxanthellate Scleractinia are solitary in structure, firmly attached to a substrate, most abundant at 200-1000 m, and are caryophylliids. Literature helpful for the identification of deep-water Scleractinia is listed according to 16 geographic regions of the world. A species diversity contour map is presented for the azooxanthellate Scleractinia, showing centers of high diversity in the Philippine region, the western Atlantic Antilles, and the northwest Indian Ocean, remarkably similar to high diversity regions for shallow-water zooxanthellate Scleractinia. As suggested for shallow-water corals, the causes for high deep-water scleractinian diversity are thought to be primarily the result of the availability of a large contiguous stable substrate at 200-1000 m depth (the area effect) and secondarily limited by temperature.

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Low Sequence Variability within Anthozoan Mitochondrial Genomes: Are Antipatharian Noncoding Regions the Exception?

Mercer R. Brugler and *Scott C. France*
Department of Biology, University of Louisiana at Lafayette, Lafayette, LA, USA

Antipatharians (black corals) are morphologically variable but few diagnostic characters clearly delineate species. It remains unclear whether this variability is environmentally induced or the result of speciation events. In the past, taxonomic affiliations within the order have been obscured by poor specimen quality and misclassification of several non-antipatharian taxa. Little DNA sequence data has been available to resolve taxonomic problems.

In 2001, Dennis Opresko began a major taxonomic revision of the order Antipatharia. Additionally, we sequenced the complete mitochondrial genome of a deep-sea black coral, *Chrysopathes formosa*, and found large non-coding regions not seen in other anthozoan genomes.

To supplement Opresko's taxonomic revision, we initiated a systematic study of the Antipatharia using DNA sequences. While past studies suggest low variation within anthozoan mitochondrial genomes, data for antipatharians are lacking. We targeted two mitochondrial non-coding regions and the COI 'barcode of life.' Preliminarily, we have found no intraspecific differences among 100+ *Antipathes dichotoma* collected from three different Hawaiian Islands; however, interspecific differences are present (0.46%; *A. dichotoma* vs. *A. grandis*). In some cases intergeneric comparisons show only 0.1% divergence (*e.g.*, *Dendrobathypathes* versus *Parantipathes*). This latter observation may indicate either a recent speciation event combined with low mitochondrial mutation rates, or that a high degree of morphological variability within a single species is confounding taxonomy.

We are currently constructing a recombinant library from whole genomic DNA of several antipatharians to search for nuclear markers variable at the inter- and intraspecific level. Primers based on low-copy DNA sequences are being tested.

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Genetic Analysis of Bamboo Corals: Does Lack of Colony Branching Distinguish *Lepidisis* from *Keratoisis*?

Scott C. France
Dept. Biology, University of Louisiana at Lafayette, Lafayette, LA, USA

Bamboo corals (family Isididae) are one of the more common and easily recognized of the deep-water octocorals due to their articulated skeleton comprised of non-spicular calcareous internodes alternating with proteinaceous nodes. Isididae are morphologically diverse, divided into three to six subfamilies, and some suggest they are a polyphyletic assemblage of two to three families. Most commonly encountered in the deep sea are species in the subfamily Keratoisidinae, including the genera *Acanella*, *Isidella*, *Keratoisis*, *Lepidisis* and *Orstomisis*. Considerable confusion surrounds the distinction of *Lepidisis* and *Keratoisis* species, and many informal designations are made based on whether the colony is branched (*Keratoisis*) or unbranched (*Lepidisis*). Although some taxonomic keys use "colonies unbranched" to distinguish *Lepidisis*, the original description of the genus included both branched and unbranched morphologies, and both morphologies are also classified in *Keratoisis*.

Here I present a genetic analysis of the Isididae focusing on Keratoisidinae collected between 1000–2250 meters depth from the New England Seamount chain, Aleutian Ridge, and Hawaii. These are compared to representatives from the subfamilies Circinisidinae and Mopseinae. DNA sequence data from the mitochondrial *msh1* gene and a non-coding region show four major clades of Keratoisidinae. Coding of INDELs provides further distinction and better support for the clades, and may provide additional useful characters for species identification. Single clades group branched and unbranched morphologies together. The tree topology suggests other morphological characters that may be useful for preliminary distinction of taxa and will serve as the basis for more in-depth analyses of the family.

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A Molecular Phylogenetic Perspective on Diversity and Species Boundaries of Deep-Sea Scleractinian Corals from the Southeastern U.S. and Gulf of Mexico

Cheryl L. Morrison[1], *Robin Johnson*[1], *Steve W. Ross*[2,3], *Kenneth J. Sulak*[3], *Robert J. Toonen*[4] and *Tim L. King*[1]

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[2]Center for Marine Science, UNC Wilmington, Wilmington, NC, USA

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[4]University of Hawaii at Manoa, The Hawaii Institute of Marine Biology, Coconut Island, Kaneohe, HW, USA

Classification of scleractinian coral biodiversity that reflects evolutionary relationships is difficult because corals are speciose, including approximately 1300 species, and because homologies among skeletal characters that have traditionally been used to infer evolutionary relationships among corals are poorly understood. As a result, many relationships among families and suborders remain unclear, especially among the lesser studied deep-sea species.

In order to document biodiversity and explore hypotheses about evolutionary relationships independent of skeletal characters for deep-sea corals from the southeastern U.S. and Gulf of Mexico, phylogenetic analyses of mitochondrial and nuclear DNA sequence datasets will be presented. Deep-sea species from these regions are intermingled with shallow-water hermatypic corals in both major coral lineages, the "robust" and "complex" corals. Although individuals from some morphologically-defined families are well supported by molecular evidence, other families, such as the Caryophyliidae and Oculinidae (including *Lophelia* and *Oculina,* respectively*)*, appear scattered in both robust and complex lineages.

Identification of evolutionarily significant lineages is a basic prerequisite for informed conservation strategies. Many of the deep-water reef-building corals, such as *Lophelia pertusa* and *Madrepora oculata*, have wide distributions, and little is known about continuity of gene flow among disjunct reefs. Utilizing non-coding regions of DNA that evolve relatively quickly, geographic patterns of genetic differentiation will be examined for deep reef-building corals in the southeastern U.S., including *Lophelia*, *Madrepora*, and *Enallopsammia*. Corals found on World War II wrecks in the Gulf of Mexico will be included. Observed patterns will be compared with those seen in other widely distributed hermatypic coral species.

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The Cinderella of the Nuclear Sequences? Contribution of ITS2 Sequences and Predicted RNA Secondary Structures to Octocoral Systematics

Juan Armando Sánchez
Departamento de Ciencias Biológicas, Universidad de los Andes, Bogotá, Colombia

Octocorals are among the largest and most diverse invertebrates on seamounts and the deep ocean. Despite their abundance and ecological importance, most of octocoral systematics remains misunderstood. Molecular studies have brought along new insights regarding octocoral systematics mostly on higher taxa relationships. Unfortunately, most DNA sequences from both mitochondrial and nuclear genomes tried so far have exhibited a great deal of conservation preventing their use for lower taxa and closely-related species phylogeny. Fortunately, the internal transcribed spacers (ITSs) from the nuclear ribosomal-DNA have shown considerable variation among octocorals. Particularly, the ITS2 sequence, a short, ~220-250 bp, has turned out to be a very promising region. However, these sequences showed considerable variation, their alignment produced multiple and variable INDELS (insertions-deletions) depending on the different gap opening and/or extension penalties, which make unreliable the phylogenetic inference. In this study, the problem of ITS2 alignment is solved by reconstructing the predicted secondary structure from contrasting taxa of Octocorallia. The new octocoral ITS2 predicted RNA secondary structures exhibited the highly conserved six-helicoidal ring-model structure found in yeast, insects, and vertebrates. This conserved secondary structure allows using it to correct alignments as well as applying it for recent approaches such as molecular morphometrics. Although ITS sequences have not been considered useful in other invertebrates, mostly due to saturation, excessive INDELS, and/or intragenomic variation, they seem to be a promissory nuclear region for octocorals particularly at the intra-familial level and down to closely-related species, where other known regions are nearly invariable.

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Population Genetic Structure of the Deep-Sea Precious Coral Corallium secundum from the Hawaiian Archipelago Based on Microsatellites

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Deep-sea precious corals (*Gerardia* sp., *Corallium lauuense*, and *Corallium secundum*) on the Islands and seamounts of the Hawaiian Archipelago have supported an extremely profitable fishery, yet little is known about the life history and dispersal of the exploited species. Recent studies indicate significant genetic structure between shallow-water coral populations, including several species capable of long distance dispersal. If significant genetic structure exists in seamount and Island populations of precious corals, this could suggest that the elimination (through overharvesting) of a bed of precious corals would result in loss of overall genetic diversity in the species. Microsatellite studies of *Corallium lauuense* indicated significant heterozygote deficiency in most populations, suggesting recruitment in most populations is from local sources with only occasional long-distance dispersal events. Also, there were two populations that appeared to be significantly isolated from other populations of *Corallium lauuense* and may be separate stocks. Here I discuss results based on microsatellite studies of a second precious coral species, *Corallium secundum*, from 11 sites in the Hawaiian Archipelago collected between 1998 and 2004, and compare the population genetic structure and dispersal capabilities of *Corallium secundum* to the results for *Corallium lauuense*. In addition to having fisheries management implications for these corals, the results of these studies also have implications for the management and protection of seamount fauna.

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Nuclear Sequences Distinguish *Oculina* Species by Geography, Not Classical Taxonomy

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Corals of the genus *Oculina* are facultative zooxanthellates that can be found in shallow Atlantic waters, but also occur at depths between 25 and 100 m, where they build substantial reefs. These reefs have exhibited severe declines despite establishment of reserve areas, leading to a recent nomination of the deep water reef builder *O. varicosa* to Species of Concern status under the U. S. Endangered Species Act. The taxonomic status of the genus *Oculina* is unclear, however.

We aimed to clarify the taxonomic status of the genus *Oculina* in general and the deep reef builders in particular using nuclear gene sequence data. Markers were generated using an Expressed Sequence Tag (EST) approach: random clones were sequenced from a cDNA library. Sequences that aligned to known genes were then used to design gene-specific primers. Primer pairs that amplified and sequenced clearly were then used to survey genetic variation from six sites: Beaufort, North Carolina; central Georgia; and Jacksonville, Ft. Pierce, Sarasota, and Panama City, Florida. These collections included samples identified as four different species: *O.arbuscula*, *O.diffusa*, *O. robusta*, and *O. varicosa*. Sequence variation was not partitioned among recognized species. Instead, sequences clustered geographically, with a split between two phylogeographically distinct clades occurring in the vicinity of Cape Canaveral, where many coastal and marine animals have previously demonstrated phylogeographic breaks.

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Ecology, Systematics, and the Evolution of Stylasterid Coral Diversity (Cnidaria: Hydrozoa: Stylasteridae)

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Stylasterid corals (also called "hydrocorals") are among the most important habitat-forming organisms on hard substrates in the deep-sea and represent the second largest group of extant stony corals. Here, I review the studies on the systematics, ecology and evolution of the Stylasteridae, from the early explorations in shallow waters and in the deep-sea to the recent advent of molecular systematics. In addition, I summarize information on life history and species associations, and conclude that further research, particularly in ecology and phylogeography, is pivotal to better understand the evolution of stylasterid coral diversity and their role in both shallow-water and deep-sea ecosystems.

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Corallum Growth Modifications in Black Corals as an Effect of Associated Fauna: Implications for the Taxonomy

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Antipatharians or black corals are colonial anthozoans characterized by chitinous skeletal axis covered to varying degrees with small spines. The features of taxonomic value in antipatharians are the size and structure of polyps as well as skeleton morphology, including mode of branching and/or pinnulation and spine morphology. Black corals are characteristic component of seamount suspension-feeding fauna. Often they host to associated fauna such as polychaete worms, sponges, ascidians, bivalves, bryozoans, hydroids, crustaceans, echinoderms etc. In this study we focused mostly on associations of black corals with the polychaetes, Polynoidae and Eunicidae, which are often reported as symbiotic.

We examined about 300 specimens of antipatharians from Indo-Pacific area provisionally determined as *Antipathes cylindrica* group of species (with associated Eunicidae) and *A. tenuispina* group of species (with associated Polynoidae). It was found that the morphology of corallum and to some degree even morphology and arrangement of the spines are heavily influenced by associated polychaetes. In case of non-obligate associations even not closely related species can exhibit the same patterns of branching and pinnulation. Traditional taxonomic characters in black corals involved in such associations should be used with a caution.

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Shape Variation Analysis of the Deep-Sea Star Coral (*Deltocyathus calcar*)

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Deltocyathus calcar is a common azooxanthellate coral occurring throughout the Tropical Western Atlantic -TWA- (80-675 m depth). This study aims to explain the wide morphological variation of calice features in relation with their geographical distribution at TWA (Brazil, Lesser Antilles, Great Antilles, South American Caribbean, Central American Caribbean and Florida). Digital images of 267 digital calicular views were taken and 44 landmarks were analyzed by using TPS software. A partial least square correlation (TpsPLS) was performed between shape (columella, septal insertions, pali, etc.) and variables matrixes (latitude, longitude, depth and centroid size), obtaining a 0.797 correlation value. A discriminant analysis (SYSTAT routines) was performed to explore if *D. calcar* morphs distribution is consistent with the TWA geographical regions; a total of 68% of the specimens were correctly placed in their original groups. The geographic arrangement found, suggests a regional distribution for the different morphs. Nevertheless, local environmental conditions may affect the observed shape variation within localities. In a discriminant analysis (shape matrix vs. base type) it was established that calicular shape and base type show a consistent variation pattern; therefore, similar *D. calcar* morphs occur in localities with similar substrate features. Hence, the resulting question is: Are these differences in shape segregated in populations (genetically fixed) or are they exclusively the result of the local environmental conditions (plasticity) where the specimens have grown?

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Studies on Azooxanthellate Hard Corals in India

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Our knowledge about the distribution of azooxanthellate hard corals in India and the seas around is very poor and largely based on detailed studies of a few species in limited geographic areas. Recent biological studies conducted in the Central Indian Basin suggested remarkably rich macro-biota and abundant and diverse meio, macro and megabenthic communities on the deep floor. The presence of diverse macro faunal groups such as hard corals, shrimps, ophiuroids, asteroids, crinoids, holothurians, fishes, polychaetes and bivalves with relatively higher abundance in an around Carlsberg Ridge. However these studies on the mid ocean ridges do not give any representation on deep sea corals. Wood-Mason and Alcock were the first to study the deep water corals of Indian Ocean. Gardiner and Waugh published results of John Murray expedition and H.E.M.S. Mabihiss stations 102-133 discussing 28 species of deep water species. Out of 25 families 1574 species of scleractinian (hard corals) reported from the world, 12 families, 110 genera and 686 species are ahermatypic, azooxanthellate corals, of which, 12 families, 71 genera, 227 species are reported from Indian Ocean by various researchers. The present study includes four families, 16 genera and 27 species of azooxanthellate hard corals of which four species are reported from Lakshadweep, three from Gulf of Kachchh, 13 species from Gulf of Mannar and 18 species from Andaman and Nicobar Islands excluding a recent study during 2004 resulted in the occurrence of six more species from the seas near Chennai coast in Bay of Bengal. The following genera Caryophyllia and Paracyathus under the family Caryophyllidae, Balanophyllia and Dendrophylliam under the family Dendrophyllidae are most common azooxanthellate corals in the seas around India.

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Oral Abstracts

Theme 3A – Geology: Palaeontology

Listed in order of presentation.
Presenting authors appear in **bold**.

The Climate Record from Deep-Water Corals Rules, because Geochemistry Finally Married Paleontology

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At its best, science strives to answer questions of importance to society. (At its worst, it pads resumés.) Some of the most urgent problems facing human society involve the rate and process of climate change, a phenomenon which will affect the lives of everyone on the planet. None of the existing climate models work as well as they could, because there is a lack of long proxy records. The science of extracting climate records from deep-water corals now stands poised to provide the records we need to understand our future, just at the time when their existence is threatened by human activities. One of the reasons the tools to interpret these records are now available is that geochemical techniques are being guided by paleontological insight. In addition, the analytical tools available to us continue to increase in quality and quantity. The results have been an interplay between ideas and instruments.

Climate work on reef corals began several decades ago, with great promise. Notwithstanding the many papers so far in this area, the reef coral record has had limited global impact. The problem is, the data come from restricted geographical regions and depths: too little of the ocean is covered. Early work on climate records from deep-water Scleractinia were inconclusive, largely because key processes of skeletogenesis had not been elucidated. Paleontology was neglected by highly-competent geochemists. Kinetic Isotope Effects continued to dog data sets and obscure the record. The key impetus came from the work of Smith and colleagues (1997, 2000), showing that climatic information could be obtained from corals with huge geographic ranges. Since that work, refinements of techniques in obtaining temperature records from Scleractinia have involved increasing understanding of the process of skeletogenesis. Especially encouraging have been advances in understanding the record in *Lophelia pertusa*, perhaps the most widespread coral on the planet (Blamart et al, Cohen et al., this meeting).

It is likely that the climate records in Scleractinia will be eclipsed by data obtained from other coelenterates, such as gorgonians and antipatharians (Black Corals). In these organisms, skeletogenesis is a two-part process, involving organic and inorganic phases. The morphologist appreciates the advantages of a skeleton which is both strong and flexible, the geochemist salivates at the prospect of obtaining the temperature record from the calcite phase, and the productivity/water mass record from the organic phase. This last technique has shown some exciting results recently: Williams et al have recorded the collapse of North Pacific food chains from overfishing, and Sherwood et al have produced a 1500-year record off Nova Scotia, showing that intrusion of Gulf Stream waters is a recent phenomenon.

That we have come so far, so fast, is a credit to the people in the field, and their understanding of the potential value of the work.

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Danian Bryozoan and Coral Mounds in Denmark - Ancient Analogues to Modern Deep-Sea Coral Mounds?

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Danian bryozoan and coral mounds formed on a distally steepened ramp in a NW–SE oriented seaway covering the Danish basin. The bryozoan mounds are unlithified and asymmetrical, 5–11 m high, and 45–110 m long. They consist mainly of fragmented delicate branching bryozoans, with minor contributions of other bryozoan growth forms set in a muddy carbonate matrix of coccoliths and benthic detritus. Echinoids, crinoids, octocorals and serpulids are local, prominent, skeletal elements. In contrast coral mounds are lithified, 10–35 m high, and up to a few hundred meters long. They consist of framework-forming azooxanthellate scleractinian corals, bryozoans, octocorals and hydrozoans.

The bryozoan mound growth was initiated above a regional erosional surface and hardground in the earliest Danian, whereas the coral mounds formed later in the Danian and are interbedded with bryozoan mounds and chalk. The mounds were formed in highly dynamic cool-water carbonate environment, influenced by dominant along-slope, tidal and wind-induced currents, with prominent seasonal and long term variations. Mound growth was controlled by essentially in-place benthic carbonate production of mainly delicate branching bryozoans or corals which baffled and trapped pelagic and detrital benthic carbonate mud, interrupted by periodical winnowing and erosion. High production in the surface waters combined with an effective tidal-induced mixing of the water column was probably important for transporting nutrients/particulate matter to the bottom waters.
The Danian mounds may possibly serve as ancient analogues to the modern deep-sea coral mounds along the margins of the Atlantic Ocean.

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IODP Expedition 307 Unravelled the Deep Secrets of the Cold Water Coral Banks in the Porcupine Seabight

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The aim of IODP Expedition 307 (April –May, 2005) was to understand the origin and evolution of the cold-water coral banks in Porcupine Seabight and more general the deep-sea carbonate mounds of the Atlantic. Three sites, along a transect have been drilled on and near Challenger mound in the Belgica mound province, to study the paleao- environment before and during the bank development. The lithographic sequence of the mound is composed of coral fragments, clay and nannofossil ooze, in at least 10 distinct layers that may represent development stages in the mound reflecting different palaeo-environmental changes. Initial, shipboard biostratigraphic data demonstrate that the mound developed during the Pleistocene, after a most likely Pliocene regional erosional event and are enclosed by drift sediments. The mound substratum at this site is of Pliocene/Miocene age and consists of overconsolidated siltstones. The seismic units below the mound showing migrating sigmoidal bodies are identified as slightly lithified heterogeneous, dark green glauconite-rich siltstones. The striking lack of any obvious evidence for a microbial

role in the development of the coral bank, either active or historical, dominated the preliminary geochemistry and microbiogical results. Overall indices of microbial activity and abundance in the mound interval were low. No significant quantities of gas in the mound or in the sub-basal mound sediments have been detected. All results obtained during the cruise disprove any relation between coral bank development and hydrocarbon seepage. The results allow refining the oceanographic development of cold water coral banks in the Atlantic.

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The Influence of Bottom Currents and Cold-Water Corals on Mound Growth on the Irish Continental Margin – the Recent Situation and Initial Results from IODP Expedition 307

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Cold-water corals are common elements of many deep water and high latitudinal marine ecosystems. In distinct areas on the Irish continental margin these corals also support the build up of giant carbonate mounds. These mound provinces are located where vigorous bottom currents occur. Indeed, many of the mounds are also associated with current induced features. Whether the currents erode the mounds or support mound growth due to an enhanced contribution of sediments strongly depends on the distribution of coral thickets. Current strength may also dictate coral presence and density with excessive current preventing larval settlement and snapping coral frameworks.

To comprehend the interactions between bottom currents, coral cover and mound development, six sensor units (current meter, CTD) where deployed on the Galway Mound in the Belgica Mound province, eastern Porcupine Seabight. These sensor units have recorded changes in bottom currents and water mass properties thus providing the first high-resolution dataset on flow-field variations around a carbonate mound. In addition, extended grids of video data were recorded over the Galway Mound with remotely operated vehicles (ROV). Based on these grids, we mapped coral facies distributions and defined critical condition for coral distribution and thus mound development.

Here we present the first detailed correlation between the flow-field around a carbonate mound and the coral facies distribution. This information is also applied to the initial results from IODP site U1317 from Challenger Mound neighbouring Galway Mound, to determine the current-coral interactions during carbonate mound ontogeny.

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From Surface Coring to Deep Drilling on Challenger Mound in the Porcupine Seabight, W of Ireland

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The presence of giant carbonate mounds associated with cold-water corals in the Belgica Mound Province at the eastern flank of Porcupine Seabight, W of Ireland is already known for several years. However, the process of mound build-up and mound nucleation is not yet completely understood. What keeps a mound growing over extended time periods? How does the biosphere interact with sedimentary fluxes to make a mound grow?

Research on pre-IODP cores, respectively on top of Challenger Mound and in the sediments next to Challenger Mound, acquired during the Marion-Dufresne cruise in 2001, documented already the full paleoceanographic record down to Marine Isotopic Stages 4 to 5. The on-mound core revealed the alternation of sections without any corals or biogenic fragments and sections with coral fragments in unlithified micrite (which can be described as an unlithified “floatstone” to “wackestone” and “packstone” fabric). Glacial-interglacial changes had probably an important impact on these final, alternating stages on top of mound Challenger.

Deep drilling during the recent IODP Expedition 307 recovered for the first time the whole, probably Pleistocene, mound body. The mound succession is mainly composed of unlithified floatstone, rudstone, packstone and wackestone facies. Physical properties, color reflectance data and CT analyses reflect the presence of pronounced recurring sedimentary cycles on a meter to several meter scale. Poor coral preservation in some intervals indicates that diagenetic processes can overprint the sedimentary signal. The interaction of oceanographic processes with sedimentary fluxes and cold-water coral growth keeps playing a key role in the build-up of the mound during the whole Pleistocene.

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Distribution of Cold-Water Corals in the Gulf of Cádiz under Changing Late Quaternary Climate Conditions

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Recently, the presence of cold water corals in the Gulf of Cádiz, NE Atlantic, has been reported, which in this region are hosted by mud volcanoes whose formation is related to active venting of fluids. We are interested in the history of these cold-water coral ecosystems under changing climate conditions of the Late Quaternary climate cycles. Radiocarbon dating on a number of corals from one single grab sample revealed that apparently different species of cold-water corals inhabited the area through the last 50.000 yrs in specific time intervals. This sample has been retrieved from the Hesperides mudvolcano, which is strongly affected by erosion allowing for such a widespread range of ages in only one surface sediment sample.

In addition, U/Th datings on a number of cold-water coral bearing sediment cores from the Gulf of Cadiz also revealed the importance of erosion. Although showing no obvious evidence for hiatuses within the individual cores, none of these has recent (or Holocene) sediments on top. Based on those U/Th dates and stable oxygen isotope data measured on benthic foraminifera it appears that the presence of cold-water corals in the available records is restricted to intermediate climate conditions not comprising fully glacial or interglacial settings. This has also been found for cold-water coral occurrences at the Irish margin and might relate to changes in the production of Mediterranean Outflow Water driven by glacial/interglacial sea level variations strongly affecting the geometry of the Strait of Gibraltar at the entrance to the Gulf of Cadiz.

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The Initial Stages of Large Coral Bank Formation: New Insights from Present-Day Analogues and from the First Results of IODP Expedition 307 in the Porcupine Seabight

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In recent years, large carbonate mound structures (±100m high) have been mapped from seismic data in the Porcupine Seabight (De Mol et al., 2002). The mounds are partly or completely buried, while (live) cold-water corals were found on exposed mound tops and flanks. Strikingly, all mounds are seated on a regional erosional unconformity. The recent IODP Expedition 307 now revealed that Challenger Mound in the Belgica Mound Province consists of >130m of sediment-clogged cold-water coral fragments and framework. The moundbase is a sharp lithological contact, also identified in the off-mound drill sites. Grainsize analysis, imagery, sedimentological and physical property information are used to characterise this substratum and the overlying interval.

It appears that the mound started to develop when cold-water corals settled and expanded laterally on the compacted erosional sedimentary surface (firmground). No obvious indications were found for the influence of (thermogenic) hydrocarbons or microbial processes on mound initiation, for example in the form of authigenic carbonate crusts. The lowermost strata of the mound consist of a rapid succession of layers with coral fragments, broken and/or displaced to a variable extent (grainstone, floatstone, packstone). This interbedding points to a dynamic, changeable environment during the first stages of mound formation.

The IODP findings allow interpreting small coral mounds in the region (e.g. Moira Mounds) as possible present-day analogues for the initial stages of Challenger Mound. A comparison is made between the lowermost strata of the drilled mound, and these small mound structures, which occur in a dynamical environment characterised by a strong interplay between currents and active sediment transport (Huvenne et al., 2005).

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Azooxanthellate Coral Communities on a Diapiric Continental Margin (Colombian Caribbean)

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Azooxanthellate coral reefs develop under particular oceanographic conditions driven by geological events that modify the seabed landscape, such as moraine deposits, plough-marks levees, pockmarks fields and submarine canyons. During April 2005, an exploration of the seabed features (300-100 m) off Colombian continental margin was carried out in order to characterize the developing conditions of the Southern Caribbean azooxanthellate bioherms. At this area, azooxanthellate corals were settled on seabed dome features, derived from erosion, compression or tectonic folded events of the continental margin sediments and also Plio-Pleistocene Limestone outcrops. Preliminary results showed that coralline bioherms were located mainly between 170 to 120 m, over soft bottoms areas, where *Madracis myriaster* and *Eguchipsammia cornucopia* may be building a carbonate structure, following similar *Lophelia* reefs accretion pathways. At the slope zone, azooxanthellate corals like *Javania cailleti* and *Madrepora* sp., also antipatharians and gorgonians were found settled on limestone outcrops and fossil *Agaricia* spp. rubble deposits. In the areas where carbonate sediments is composed of coarse calcareous algae fragments, a diverse sponge community was found. Seabed landscape features shaped by mud plutonic intrusion (diapirs), mud volcanoes and their related emanating gas might have played a fundamental role in the settlement and accretion processes of the azooxanthellate coral communities in the area, but the involved mechanisms are still unclear. Further research will be needed to solve how these geological processes drive the dynamics and develop of the coralline fauna in the south Caribbean continental margin.

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Pliocene Deep-Water Coral Limestones from the NW Apennines (Italy) and Their Links to Hydrocarbon Seepage

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Deep-water corals are occasionally found associated with sites of active seepage in the modern oceans. The hypothesis of a direct tropic link between such chemosynthetic environments and coral habitats is considered unlikely by most researchers. Instead, it has been suggested that authigenic precipitation of calcium carbonate might be propitious in generating hard substrates suitable to coral settlement.

Mid-Pliocene sequences from the NW Apennines (Italy) contain fossil examples of the intimate association of deep-water corals and methanogenetic limestones. Our case study refers to dendrophylliid and caryophylliid corals associated with marly limestones from two Piedmont localities, i.e. Marmorito (Asti) and Verrua Savoia (Turin), lying in sharp contact with Miocene limestone bedrock. The existence of an initial phase of hydrocarbon seepage at these sites is suggested by the negative stable-carbon isotopic composition of the limestone and the occurrence of chemosynthetic infaunal lucinid bivalves. The deep-water coral biostromal assemblage contain oysters, Spondylus and brachiopods, documenting later exploitation of these same environments by a non-chemosynthetic epifauna. These fossil occurrences share some analogies with submerged deep-water coral habitats in the present Atlantic Ocean and Mediterranean Sea where *Dendrophyllia*-rich assemblages occur between 80-500 m on sediment-starved seamounts and offshore banks.

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Description and Depositional History of the Plio-Pleistocene Deep-Water Coral Facies from Messina (Southern Italy) — Comparison with Recent Environments

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Due to Quaternary strong uplifts along steep fault escarpments, the emerged margins of the Messina Strait (southern Italy) show extensive Plio-Pleistocene deep-water deposits (e.g. Barrier 1987; Di Geronimo 1987). In particular, around the town of Messina deep-sea coral assemblages occur in wedge-shaped sedimentary bodies up to 50m-thick.

Field observations, taxonomic-sedimentological analyses and comparison with Recent deep-sea coral communities, lead to group the Messina deep-water coral facies into four main classes:

1. SCLERACTINIAN RUBBLE FACIES (SRF): Limestones and marls with abundant coral skeletal fragments (mainly *Lophelia pertusa, Madrepora oculata*)

2. OCTOCORAL/SEA-URCHIN FACIES (OSF): Calcarenites and marls with scattered fossil content dominated by isidid octocorals, sea-urchins, brachiopods and cirripeds.

3. DEBRIS FLOW FACIES (DFF): Carbonate-dominated breccias characterized by bioclastic matrix (mainly coral fragments) and polymictic extraclasts over 1m in diameter.

4. BOULDER-RICH TERRIGENOUS FACIES (BTF): Silts and clays containing scattered soft-bottom deep-sea corals (e.g. *Caryophyllia communis, Flabellum messanense, Fungiacyathus fragilis*) and boulders encrusted by hard-bottom deep-sea fauna.

The stratigraphic relationships between these facies suggest the occurrence of two main depositional phases during their deposition:

First phase (?Middle Pliocene-Early Pleistocene): relatively low terrigenous input; prospering of extensive deep-sea coral paleocommunities along fault escarpments or structural highs; occurrence of coral rubbles (SRF), "off-reef" facies (OSF) and debris flows (DFF) involving the SRF, the OSF and their basement.

Second phase (Early-Middle Pleistocene): high terrigenous input; dominance of fine-grained deposits (BTF) and soft-bottom communities; scattered deep-sea coral colonies settled on boulders fallen from adjacent fault escarpments.

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Sediment Mounds at the Shelf Margin of the East China Sea, Possible Deep Water Coral Reefs?

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Roughly circular sediment mounds, varying from tens to hundreds of meters in diameter and from a few meters up to 40 m in height, have been mapped for the first time at the shelf edge of the East China Sea (ECS). Water depth of these mounds varies from 180m to 500m. High resolution seismic profiles, together with swath bathymetric and acoustic data, indicate that these features are common on the ECS outer shelf and on the upper western slope of the Okinawa Trough. They are associated with unusually large pockmarks, up to 40 m in depth and 600 m in diameter. On seismic records, bright spots, phase inversions and other acoustic anomalies indicate that gas and/or fluid escape plays an important role in the formation of these mounds. The seepage process is suspected to be very recent, and probably still active, based on the facts that the mounds are not buried by recent sediments, and that Last Glacial Maximum deposits are reworked at the emplacement of the mounds. Carbonate cemented sediments and deep-water reefs possibly associated with fluid seepage could be the origin of local patches of very high backscattering acoustic facies, mapped with the swath bathymetric system. Coral reef debris collected in the past surveys probably came from the deep water area. Lack of sea-floor sample and underwater images encourage future exploration on the ECS shelf margin to reveal the possible deep water coral reefs.

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Oral Abstracts

Theme 2A – Habitat Mapping, Sampling, and Characterization

Listed in order of presentation.
Presenting authors appear in **bold**.

Distribution and Status of Cold-Water Coral Ecosystems in Coastal Channels in the NE Skagerrak, Norway and Sweden

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Occurrence of hermatypic coral *Lophelia pertusa* in coastal deep-water channels in the Kosterfjord and outer Oslofjord, NE Skagerrak, has been known since the early 20th century. Small reef structures in few areas were reported, but their status and size were unknown.

Recent studies, involving techniques such as multibeam bathymetry, ROV surveys, sidescan sonar surveys, grab sampling and box-coring revealed more significant and complex occurrences of cold-water corals and associated fauna than formerly understood. To date, 19 live reef structures, ranging in size between c. 100 - 250,000 m^2, comprising six larger reef complexes and ranging in depth between 74 - 160m have been found. Additionally, 20 dead reef structures of varying sizes have been documented. Historic records and ROV-observations reveal that some reef areas have become extinct within the last few decades, most likely due to physical damage from local trawl fishery. Also, most of the live reef areas exhibited physical damage from benthic fishing gear. There are indications that some local extinction was related to other factors, possibly changed current patterns, landrise and/or increased sedimentation. All observed live reefs were associated with benthic topographic features expected to locally enhance current speeds. Dense populations of gorgonian corals (*Paramuricea placomus, Primnoa resedaeformis* and *Muriceides kuekenthali*) were documented in highly localised occurrences.

Dating of coral material from upper 2,5 m of deposits revealed ages up to 3000 yrs. Benthic topography suggest the existense of coral deposits 10-20 m deep, indicating presence of corals in the area since soon after the last glaciation.

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Deep-Water Sponge and Coral Habitats in the Coastal Waters of British Columbia, Canada: Multibeam and ROV Survey Results

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Hexactinellid sponges form massive and long-lived reefs in several areas on the British Columbia continental shelf. A characteristic acoustic signature permits unequivocal mapping of these communities using multibeam and other acoustic methods. Sponge reefs occur in areas of low relief glacial deposits while coral communities appear to be associated with steeper bedrock or boulder areas. Deep-water gorgonian coral communities composed predominantly of *Paragorgia pacifica* and *Primnoa willeyi* locally occur on fiord walls or steep bedrock outcrops where currents are relatively strong, and may form dense stands on boulder rich fiord sills. These communities are unassociated with a distinct and recognizable acoustic response and so are much less readily mapped than are sponge reefs. The scleractinian coral, *Solensmyllia variabilis* (or *Lophelia sp.*) has been recovered in bottom samples and observed as a localized debris field in ROV transects in the Georgia Basin and has also been observed on at least two fiord sills. These coral species form reefs in other regions suggesting that undiscovered cold-water coral reefs may be found in the future in BC shelf waters.

Planned multibeam surveys may reveal areas of coral habitat in areas adjacent to the southern Haida Gwaii (Queen Charlotte Islands) archipelago where the steep topography of the continental slope intersects a complex, glacially scoured shelf canyon. Dynamic oceanographic processes of tidal mixing and seasonal wind driven upwelling combined with high biological productivity and steep bedrock topography make this area especially prospective for deep–water corals.

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Morphology and Sediment Dynamics of Initial Cold-Water Coral Mounds (Moira mounds) in the Porcupine Seabight

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The Moira mounds are small, possibly initial, cold-water coral mounds found in the Belgica Mound Province in the Porcupine Seabight. They were mapped with an ROV-borne high-resolution multibeam system during the Polarstern cruise ARK XIX 3a in 2003. The resulting microbathymetric grid was integrated with video data and sedimentary information collected during the same cruise.

The data clearly show the dynamic environment in which the Moira mounds occur. Different fields of sediment waves and current-related linear features illustrate the effect of the overall N-ward directed current in the area. Small ripples are formed under internal tidal conditions. The mounds are fully integrated in this sediment dynamical system: sediment waves of similar size as in the surrounding off-mound areas occur across the small mounds, although they have a shorter wavelength and their direction is affected by the mound morphology. Sediment ripples have been encountered between the coral colonies, again with directions affected by the corals acting as obstacles in the variable currents. Furthermore, the mounds show an intimate relation with the linear current-related bedforms.

The Moira mounds show that deep-water corals such as *Lophelia pertusa* and *Madrepora oculata* can grow in areas of high sediment transport. Active sand transport may even be essential for the vertical extension of the small mounds; as with every sand wave passing, some of the sediment becomes baffled between the coral frameworks. A positive feedback mechanism controlling mound growth can be confirmed (Foubert et al., 2005).

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ROV Investigations of Cold-Water Coral Habitats along the Porcupine Bank Margin, West Coast of Ireland

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The Irish National Seabed Survey (INSS) has already achieved 100% swath coverage of over 450,000 sq.km of Ireland's seafloor territories. Initial map products were produced at a scale of 1:250,000 however further processing of the raw multi-beam data has revealed features, hitherto unknown, with potential as cold-water coral habitat.

Here, we present preliminary results of ROV investigations of a number of these previously unexplored features found along the Porcupine Bank margin at depths between 600 and 1000m off the west coast of Ireland. The survey which took place aboard the Celtic Explorer in June, 2005, gathered information relating to cold-water coral occurrence, associated fauna and the extent of fisheries impacts. Trials with a ROV mounted RESON 7125 were also undertaken to assess the usefulness of combined micro-bathymetry/video surveys as a means of ground-truthing INSS data.

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Bathymetry Model of a Vertical *Lophelia pertusa* Reef in the Trondheim Fjord, Norway

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In the Trondheim Fjord *Lophelia pertusa* colonies often lives attached to vertical rock walls or underneath overhangs. This study discusses strategies to documents vertical coral occurrence. Optical images are necessary to reveal details of the corals therefore a set of still pictures are put together to a photo mosaic to document the coral distribution. The sculpture of the underlying rock wall is measured using profiling sonar. A terrain model of the areas surveyed is constructed from the sonar data. Photo mosaics and digital terrain models are more intuitive and faster to interpret than conventional video surveys. Both the sonar and the camera are carried by ROV. ROV navigation on vertical walls are contaminated by multi path and lack of bottom track. To cope with the special challenges navigating precisely on a vertical wall, the ROV is positioned using an acoustic baseline system, horizontal Doppler velocity measurement and inertial measurements combined.

It seems like the vertical corals does not have the same zonation as the colonies living on fjord thresholds or the continental shelf. We found areas where the rock wall is clothed with coral and patchy areas where *L. pertusa* is present, less dominating. Dead coral lumps fall of the wall and into the sediments and are buried at the foot of the wall.

Combining photo mosaic and digital terrain model allows for quantitative usage of images. We can see the shape of the wall and we can quantify which species that grows where. This will give information on *e.g*. structural preferences.

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Identification and Characterization of Deepwater Coral Communities on Continental Shelf-edge Reefs and Banks in the Northwestern Gulf of Mexico

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Dozens of reefs and banks rise from the depths of the continental shelf margin off the coast of Texas and Louisiana in the northwestern Gulf of Mexico. Most of these topographic features are seafloor surface expressions of underlying salt domes, formed from complex geological activity. The East and West Flower Garden Banks are two such features, which harbor some of the healthiest shallow water coral reefs in the continental United States. However, most of the area of the Flower Garden Banks as well as numerous other banks in this region lie below the depth range of active scleractinian coral reef development. These areas, occurring in depths from 50 to 200 meters, contain vibrant deepwater coral communities, comprised of a variety of antipatharians, solitary and branching corals, octocorals and associated species, and provide important habitat for a variety of fish species of commercial and recreational importance. In spite of important baseline scientific investigations conducted in the late 1970's and early 1980's, the extent and nature of these communities are still not well known. Recent surveys by the authors and collaborators have further characterized a number of the reefs and banks in this vicinity. A series of investigations has been conducted, utilizing remotely operated vehicles (ROV) and manned submersibles. High-resolution multibeam bathymetry was obtained for 12 of the banks, providing detailed information to target biological surveys. Over 250 antipatharian, octocoral and sponge specimens have been photographed and collected for identification. A description and preliminary characterization of these communities will be provided.

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Seabed Characteristics at Sites Where *Lophelia pertusa* Occur in the Northern and Eastern Gulf of Mexico

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Seabed characteristics at local-landscape (5-25 km^2) and site-specific feature (<200x200 m) scales are presented for six locations where *Lophelia pertusa* occur in the northern and eastern Gulf of Mexico. The descriptions are based on photographic documentation, in situ observations and geophysical data. All sites are situated in upper continental slope provinces at depths between 300-630 m. Local-landscape settings include 1) an erosional scarp at the top of the steepening portion of a carbonate ramp, 2) an isolated knoll on a steepening seaward slope, 3) a submarine canyon – low-relief hummock complex, 4) a broad, smooth low-relief hummock, 5) grabens and half-grabens within a shallow depression and 6) a plateau – scrap complex. Site-specific indurated features at these locations include relict coral mounds (bioherms), lithoherms consisting of limestone boulders and outcrops, and chemoherms (hydrocarbon-derived and microbially mediated authigenic carbonates) which take the form of hardgrounds and isolated slabs, often fractured, irregular shaped mounds/build-ups, blocks, boulders, and rubble. Chemoherm production occurs at cold hydrocarbon seep sites and has been responsible for the construction of widely spaced solitary features to complex topographic formations. Colonization of all these hard substrates by *Lophelia pertusa* has resulted in distribution patterns that range from scattered, isolated individuals to aggregations of varying densities that in some areas are in the initial phase of thicket building.

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ROV-Based Habitat Mapping on Franken Mound, West Rockall Bank, NE Atlantic

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Franken Mound located on an isolated topographic high at the western slope of Rockall Bank in the NE Atlantic was discovered during cruise M 61/1 with RV METEOR in 2004. The elongated carbonate mound arises from about 680 to 630 m water depth with an elevation of at least 50 m above the surrounding seabed. It shows a conspicuous asymmetric shape with a steeply inclined western flank forming some kind of steep-faced embayment on the deeper sea floor, and a largely straight, smoothly dipping eastern flank which grades into the surrounding off-mound sediments.

During a subsequent cruise M 61/3 Franken Mound was surveyed with the Bremen QUEST ROV. Video-footage obtained along ROV dive tracks crossing the mound in a north-south and east-west transect together with grab samples clearly revealed different facies distributions as e.g. dense living coral thickets, dead coral rubble zones, outcropping hardgrounds and what appears to be basaltic bedrock.

The facies distribution also reflects the asymmetry in the shape of Franken Mound. The western flanks are characterised by large banks of outcropping hardgrounds several meters high that gave this flank a step-like character. In contrast, the east-facing flank was covered by sandy sediments that formed sand ripples and sand waves. All observed hardgrounds were overgrown by numerous organisms as for example soft corals, hydrozoans and sponges. Extensive thickets of corals up to several meters high were observed in the crest regions. Those thickets were mainly built by *Lophelia pertusa*, but *Madrepora oculata* was also common.

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Deep-Sea Corals in the New England Seamounts: Habitat Mapping Today and their Distribution in the Past

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In May-June 2003 we conducted a three-week cruise on seamounts in the North Atlantic to sample and characterize the distribution of deep-sea corals in space and time. Using the deep submergence vehicle *Alvin* we spent over 40 hours on the seafloor. With the autonomous vehicle *ABE* and a towed camera sled, we collected over 10,000 bottom photographs and over 60 hours of micro-bathymetry over 120 km of seafloor. While there were very few living scleractinia (*Desmophyllum dianthus*, *Solenosmilia sp*. and, *Lophilia sp*.), we recovered over 3,700 fossil *D. dianthus* and over 60 kg of *Solenosmilia sp*. Corals clearly prefer to grow on steep slopes and at the tops of scarps of all scales. There is a clear preference for *D. dianthus* to recruit onto carbonate substrate. Overall, our sample collection, bathymetry and bottom photographs allow us to create an algorithm for finding corals based only on knowledge of the seafloor topography.

The scleractinia of the New England Seamounts also have a clear pattern in time. With over 100 U-series ages on individual samples, it is clear that our fossil collection is dominated by glacial age corals. Within a glacial period there is a clear preference of *D. dianthus* for times of rapid climate change. Population peaks during the Younger Dryas and Heinrich Event 1 are coincident with an increased influence of Antarctic waters at our sites. Our data support the idea the deep-sea communities "feel" the rapid climate changes seen in ice core records of the last glacial cycle.

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Structure-Forming Benthic Invertebrates: Habitat Distributions on the Continental Margins of Oregon and Washington

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Structure-forming invertebrates belong to a functional group of sessile and sedentary organisms that can significantly enhance the complexity of physical habitats. A number of these organisms, including cold-water corals and sponges, are known to be slow growing and are probably vulnerable to physical disturbance. The degree to which these organisms provide resting and hiding places for fishes, such as those belonging to the genus *Sebastes*, is a topic of ongoing debate. In addition, as filter feeders, these invertebrates can indicate areas of consistently favorable conditions for feeding and growth. Recent efforts to inventory structure-forming benthic invertebrates have been completed in many areas, particularly in northern latitudes, but few studies of this type have been completed off the Pacific Northwest coast. Geological studies on the Oregon margin using the occupied submersible *Delta* during 1992-95 sampled an expansive area along the continental shelf and slope, primarily on and around rocky banks offshore of Oregon. The videos from these surveys are being analyzed to inventory and catalog sessile structure-forming invertebrates and to document their associations with geological habitat types at multiple scales. Detailed data on geological substrate, invertebrate diversity, abundance, and density are being compiled and analyzed in relation to a comprehensive geological map of Oregon. It is hypothesized that geological substrate may be used as a predictor of structure-forming invertebrate types and densities in regions not targeted by the surveys.

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Substrate and Physical Features as Predictors of Deep-Sea Coral Habitats in the Aleutian Islands

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Conservation of coral and sponge habitats in the Aleutian Islands is a key issue for federal and state fisheries managers due to incidental mortality of corals and sponges in fisheries using bottom contact gear. The issue gained public awareness in 2002 when coral gardens were first discovered in this area. This project began in 2003 to assess the distribution and abundance of corals and sponges in the central Aleutians with respect to major environmental factors and to construct a predictive model based on the assessment. Bottom substrates were mapped using multibeam sonar bathymetry and backscatter data in a systematic sample of 17 sites between 50m and 3000m depth in swaths averaging 5 km wide, on both the Pacific and Bering Sea sides of the island chain. Multiple transects were sampled at most of these sites using the Delta submersible (50 to 350m depth) and the Jason II remotely operated vehicle (to 3000m), to estimate densities and distribution of corals, sponges, various other invertebrates, and fish, and to characterize seafloor substrate. This presentation will provide first estimates of a predictive model for observations from the shallower observations of the Delta submersible. Early results show the importance of the volcanic origins of the island chain, the dynamics of sedimentation, currents, depth, and slope angle as determinants of coral and sponge distribution. Corals and sponges were common on hard substrates, including bedrock and cobbles. Exceptions include sea whips, sea pens, and *Radicipes* (an octocoral), which were found on soft substrates.

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Oral Abstracts

Theme 5 – Biodiversity: Microbial and Invertebrate Association

Listed in order of presentation.
Presenting authors appear in **bold**.

Deep-Sea Coral Microbial Ecology

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Recent studies of shallow-water corals have found that most of the associated bacteria were novel species, not present in the overlying seawater. These microbes may be cycling carbon, producing antibiotics, fixing nitrogen, or any number of other beneficial activities yet to be described. The ecology of deep-sea corals is fundamentally different due to the lack of zooxanthellae, so the microbial-community structure is likely to be unusual. Shallow-water corals have been shown to have diverse and sometimes species-specific bacterial communities associated with them, and the aim of this work was to determine if deep-sea corals also have unique bacterial communities.

In 2004 submersibles were used to collect samples of three genera of gorgonians from waters off the Aleutian Islands and multiple colonies of *Lophelia pertusa* from the Gulf of Mexico. The corals were brought to the surface in specially designed containers to prevent contamination from the water column. Additionally, a subset of each sample was preserved at depth, to control for changes in the microbial community that result from the differences in light, temperature, and pressure experienced as the sample is brought to the surface. Microbial DNA was extracted directly from the coral samples and from individual cultured bacteria, sequenced, and then the sequence information was queried against the GenBank database for matches to identify the closest known organism.

These data provide a first look at the bacterial communities associated with deep-sea corals. Characterizing the microbial communities of deep-sea corals is fundamental to understanding the biology and ecology of deep reefs.

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Characterization of Bacterial Communities Associated with Deep-Sea Corals on Gulf of Alaska Seamounts

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The microbial populations (commensal and pathogenic) associated with shallow-water scleractinian corals have been the subject of several studies but to our knowledge there have been no such published reports for deep-water octocorals. We used 16S rRNA-based cultivation-independent methods to determine the microbial populations associated with deep-sea octocorals collected by the DSV *Alvin* from three Gulf of Alaska seamounts. Dominant groups were Alphaproteobacteria, Gammaproteobacteria, Firmicutes, Bacteroidetes, Verrucomicrobia and Acidobacteria. Relatively high numbers of acidobacterial and verrucomicrobial clones conform to previous observations of the ubiquity and numerical significance of these "cosmopolitan" phyla, and extend their known habitats. The four coral samples showed very different microbial community compositions, some being dominated by *Rhodobacteraceae* (Alphaproteobacteria) or Acidobacteria, while another was composed mostly of *Mycoplasmataceae*, known as intracellular pathogens. The *Rhodobacteraceae* were found to be dominated by marine Roseobacters, some of which were closely related to organisms known to have a role in the marine sulfur cycle. The occurrence of the Roseobacters, and also caulobacters and hyphomonads, suggests them as primary colonizers of the coral surface. This study provides a preliminary glimpse of the microbial populations associated with deep-sea octocorals; further investigation is needed to determine the distribution, biogeography, and nutritional relationships of these populations.

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Productivity and Abundance of Invertebrate-Associated Microbes in Sponges of Cold Water Coral Reefs (Rockall Trough, NE Atlantic)

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We recently initiated studies on the potential role of associated microbes in the nutrition of cold water coral reef sponges. It is generally accepted that sponges feed on suspended particles by filter feeding. In studies with tropical reef sponges we found that sponges remove dissolved organic matter from the passing water, possibly as an alternative to particle feeding. In addition, associated chemoautotrophic prokaryotes may play a role in the nutrition of sponges. Nitrifying bacteria (chemoautotrophs) were found in cryptic sponge species originating from tropical coral reefs. For many sponges a substantial part of the biomass (up to 40% of the volume of the mesohyl) is ascribed to associated prokaryotes. We hypothesize that prokaryotes mediate in organic matter accumulation in form of biomass which is transferred to the host by phagocytosis. Sponge fragments and small sponge species are incubated with ^{3}H-leucine and ^{14}C-sodium bicarbonate. ^{3}H-leucine is preferentially incorporated in protein and is used to estimate the production of heterotrophic prokaryotes. ^{14}C-labelled bicarbonate incorporation in the sponge organic matter will be determined. Incorporation rates are related to the abundance of different groups of prokaryotes associated with the sponges determined by fluorescent *in situ* hybridization (e.g. Archaea, Eubacteria, Cytophaga-Flavobacterium cluster, α-, β-, γ-proteobacteria and Nitrospira). Results on carbon uptake rates and functional bacterial groups associated with sponges collected at coral reefs of the Rockall Trough (NE Atlantic) are presented.

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Clearance and Respiration Rates of the Deep Living Bivalve *Acesta excavata* (J.C. Fabricius, 1779)

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Here we report the first study of clearance rate (CR) and respiration rate (RR) of a deep living bivalve, *Acesta excavata* (J.C. Fabricius, 1779) (Mollusca:Limidae). *Acesta excavata*, occurring at depths between 33-3200 m, is one of the many animals taking advantage of the rigid framework of the reef-building coldwater coral *Lophelia pertusa*. Although *A. excavata* often is found on *Lophelia*-reefs is not obligate associated with the coral but also inhabit vertical rock walls and underneath overhangs where it might occur in large densities. In this study we have found that *A. excavata* has a large CR, 16.33 l h^{-1} g^{-1}, the second largest CR ever reported, the RR of 0.14 ml O_2 h^{-1} g^{-1} are among the lowest values reported and the gill area, 7637 mm^2 g^{-1}, is the largest one found in bivalves so far. *Acesta excavata* lacks the eu-latero-frontal cirri which most likely restrict them from absorbing the smallest food particles. The observed values indicate a physiological adaptation to the low and irregular food supply in the deep sea rather that a specific adaptation to depth.

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Trends in the Biodiversity of Benthic Macrofauna from Deep-Water Carbonate Mounds in the Porcupine Seabight, West of Ireland

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We will report trends in the biodiversity of benthic macrofauna (≥ 250 μm) on and off deep-water carbonate mounds in the "Belgica mound province" in the Porcupine Seabight, west of Ireland. Sample sites were selected using the ROV *VICTOR 6000*, resulting in 11 spade box cores being sampled between 798-942 m depth from the RV *Polarstern* in June 2003. Of these, 4 were collected on the large carbonate mound the Galway Mound, and another 4 collected off-mound. In addition, 3 on-mound samples were collected from the smaller Moira and Thérèse mounds. The ROV dives and box coring revealed conspicuous on-mound megafauna such as the framework-building scleractinian *Lophelia pertusa* and the more delicate *Madrepora oculata*, as well as hexactinellid sponges, octocorals, sertulariid and stylasterid hydroids, bryozoans and eunicid polychaetes. We will measure and compare biodiversity (richness, evenness, taxonomic variation, proportion of feeding guilds and mobility groups) between mounds as well as on- and off-mound in order to examine intra-provincial variation and to interpret the effects of cold-water coral reef development on benthic macrofaunal biodiversity in this province.

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Key Species of Cold-Water Coral-Associated Fauna

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Cold-water coral habitats framed by *Lophelia pertusa* and *Madrepora oculata* occur widely distributed along the NW European continental margin in water depths between 40 and 1000 m. In spite of important variations in the colonial growth habit, four major microhabitats can be distinguished for each coral site. In order to reflect the vertical structuring of the microhabitats the term strata is applied. Strata preferences are reported for many species. Many microgastropod species are found to prefer the fresh dead parts of the dead coral framework whereas the shrimp *Pandalus propinquus* as well as juveniles of the three-bearded Rockling *Gaidropsarus* cf. *vulgaris* always search the close vicinity of live coral polyps. The apparent constancy of cold-water coral habitats reported from former faunistic studies is based on the presence of key species, which are defined as species present at all or almost all coral sites. Defined as such key species are for instance the polychaete worm *Eunice norvegicus* that lives in symbiontic relation to both *Madrepora* and *Lophelia* several other species, e.g., the bivalves *Hiatella arctica*, *Delectopecten vitreus* and *Pseudamussium sulcatum,* the gastropods *Alvania jeffreysii*, *Alvania cimicoides* the brachiopod *Neocrania anomala,* the hemichordate *Rhabdopleura normani*a and the ophiurid *Amphipholis squamata*.

The variation in coral habitats is reflected by the occupation of ecological niches by locally different species, e.g., *Chaceon affinis,* a frequent decapod crab in southern coral locations is replaced further north by *Lithodes maja* common in Norwegian waters.

An overview about key species, potential cold-water coral associates and locally important species is given. For many species new observations on feeding biology and niche selection are given.

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Patterns of Association of Octocoral Commensals: Comparisons between Warm and Cold Water Atlantic and Pacific Gorgonians

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Octocorals have been found to inhabit all depths of the ocean so far examined where appropriate substrate types exist. For the most part, gorgonian octocorals have associated with them both facultative and obligate symbionts.

Gorgonians have been sampled by means of the submersibles Alvin and Delta and the ROVs Hercules and Jason in waters along the New England seamount chain and the central Aleutian Ridge, respectively. In both areas care was taken to recover any associates living on the corals. Since suction samplers were not used, it s also possible that the smaller more mobile crustaceans, such as copepods, were not retrieved. Literature studies were used to determine associates of tropical gorgonians, but such literature is limited.

Only parts of three invertebrate phyla routinely occur as gorgonian associates: Annelida (Polychaeta), Arthropoda (Crustacea), and Echinodermata (Ophiuroidea). A few mollusks are also occasionally encountered.

Ophiuroids are common in both the Atlantic and Pacific cold and warm waters. Most of these associations are likely facultative, but some obligate examples are known. Crustaceans are most commonly associated with gorgonians in the Pacific, whether in warm or cold waters, but show the highest diversity of relationships in shallow warm waters. Polychaetes are most often obligate commensals and occur on gorgonians most commonly in colder waters.

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Bamboo Corals in North America

Peter J. Etnoyer
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Presented by: ***George Schmahl***

Bamboo corals (Calcaxonia: Isididae) are one of the most fascinating families of habitat forming deep-sea corals. They grow in many seas, occurring from the equator to the poles, and from the shallows to the abyss. Bamboo corals are characterized by jointed axes of alternating gorgonin nodes and calcite internodes, with approximately 150 species on record to date. There has been no comprehensive review of North American bamboo coral biogeography since Kukenthal 1919, so I provide that information here. Recent expeditions from NOAA's Office of Ocean Exploration (2002-2005) identified *Keratoisis spp.* and *Isidella n. sp.* communities in the Northeast Pacific, *Acanella spp.* in the Gulf of Mexico, and *Keratoisis spp.* in the West Atlantic. Unbranched *Lepidisis spp.* grows in all these regions. Bamboo corals grow to a height of 30 feet on seamount peaks in some parts of the world, and they form large meadows (> 1km) populated by fish, crabs, and echinoderms. Isidid polyps are non-retractile. These fleshy polyps support microbial communities, and they suffer mortality from seastar predators, not unlike shallow-water tropical corals. Bamboo corals are important habitat formers on many seamounts in the Gulf of Alaska, on shelf breaks along the coast of Oregon, on abyssal plains in the Gulf of Mexico, and on shelf breaks in the Straits of Florida. Living bamboo coral colonies and communities provide important ecosystem structure in oxygen minimum zones throughout the deep Northeast Pacific, possibly throughout the world.

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Habitat Utilization and Species-Specific Associations between Galatheids and Deepwater Corals off the Southeastern United States

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Deep coral banks, composed mostly of *Lophelia pertusa*, are scattered along the continental slope off the southeastern US (350-800 m depth). Diverse fish and invertebrate communities inhabit these hard coral banks, but are poorly known, and the affinity of most of these deep-sea organisms for reef habitat is not well understood. Even less well known are species-specific faunal associations between members of these deep-sea communities and octocorals occurring in the same region. Historically, few accounts have provided detailed information on habitat utilization by deepwater galatheids, and even fewer studies have documented galatheid/coral associations, primarily because direct observations of these animals in situ were not conducted. We surveyed the macrofauna of deep coral banks off North and South Carolina (2001-2004) southward to central Florida (2004) and in north-central Gulf of Mexico (2004) using a research submersible. We recorded diversity, abundances and sizes of galatheids found on and near the coral habitat, and investigated to what extent these species are obligate to the reef. In situ observations provided opportunities to document galatheid microhabitat utilization and species-specific relationships between these crustaceans and the coral substratum. To date, five galatheid species (Galatheidae and Chirostylidae) have been observed associated with hard corals, octocorals, or antipatharians off the southeastern US. In general, galatheids are more abundant on the reef habitat than off the reef. However, associations between these galatheids and corals do not appear to be species specific, rather, the associations are facultative with most galatheid species occurring on more than one species of coral.

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Invertebrate Assemblages on Deep-Sea Corals on Seamounts in the Gulf of Alaska

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Invertebrates associated with deep-sea corals on 5 seamounts in the northern Gulf of Alaska were investigated with the DSV *Alvin* in August 2004. Our goals were to compare differences in species richness, composition, and abundance of macroinvertebrates as a function of coral species and depth, and to compare differences between seamounts. Replicate video transects were made at depths of 700, 1700 and 2700 m on each seamount. Voucher specimens were collected at each depth with hydraulic arms, nets, traps and slurp guns; many specimens were collected on corals in the lab. CTD and oxygen profiles were also collected.

At least 12 metazoan phyla were represented from collections on 43 coral species on the 5 seamounts. Highest abundances of corals and invertebrate assemblages occurred at the shallowest depths; low abundances were associated with oxygen minima zones. Most invertebrates on corals were suspension feeders. Ophiuroids, including unbranched basketstars (*Asteronyx* sp.) were the most conspicuous and abundant invertebrates associated with corals, occurring in high densities on some coral species. At least 10 species of asteroids were identified, with 3 species observed consuming corals. Polynoid polychaets (*Malmgrenniella* sp.) were especially abundant on paragorgid corals. Crustaceans, particularly shrimp (*Heptacarpus* sp.) and chirostylid crabs (*Gastroptychus iaspus*) were common epibionts of some corals. Many invertebrates were restricted to narrow depth ranges, but were replaced by ecomorphs at deeper depths. Some invertebrates were associated only with particular coral taxa. A few invertebrates displayed allopatry: *Gastroptychus iaspus* and *Asteronyx* sp. were allopatric except on one coral species.

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Biodiversity and Biogeography of Communities Associated with *Lophelia pertusa* in the Northern Gulf of Mexico

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In this study, the communities inhabiting *Lophelia pertusa* thickets in the northern Gulf of Mexico are examined. Quantitative sub-sampling of coral and associated communities along with photomosaic analysis of whole carbonate outcrops are used to describe the community ecology of coral-dominated hard-bottom habitats. Within one photomosaic, 18 taxa were identified, with mobile fauna primarily inhabiting mostly-dead coral and other solitary colonial organisms occupying carbonate where *L. pertusa* was absent. In the physical samples, 40 species were collected (between 5 and 19 per sample) including 25 that were not observed in the photographs, for a total of 45 species. Physical sampling provided an increased ability to resolve the taxonomy of specimens and collect smaller or cryptic fauna that were not visible in the photographs. Photomosaics were able to provide information on the habitat preferences of fauna and were better at sampling large, mobile or rare fauna that were not sampled in physical collections.

The fauna inhabiting *L. pertusa* thickets were dominated in terms of abundance by sabellid polychaetes, solitary scleractinian corals, galatheid crustaceans and fishes. Coral-associated communities shared some species in common with nearby vestimentiferan-tubeworm dominated habitats. However, community similarity (measured by the Bray-Curtis index) was greater among tubeworm communities than it was among coral communities or between tubeworm- and coral-associated communities. We will further examine these findings in additional samples and analyses carried out in the summer and fall of 2005.

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Oral Abstracts

Theme 3B – Geology: Climate Change

Listed in order of presentation.
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Are Deep-Sea Corals Threatened by the Decline in Aragonite Saturation State in the Ocean?

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Seawater chemistry and the depth of the $CaCO_3$ saturation horizon in the world's ocean are changing from the addition of fossil fuel CO_2 to the atmosphere. As atmospheric CO_2 invades the ocean it reacts with carbonate ions to produce bicarbonate ions according to the reaction $CO_2 + CO_3^{2-} + H_2O \leftrightarrow 2HCO_3^{2-}$. This reduces the $[CO_3^{2-}]$ and the saturation state defined as the ion concentration product $[Ca^{2+}][CO_3^{2-}]$ divided by the stoichiometric solubility product K'_{sp}. Nothing is known about the impact of decreasing $[CO_3^{2-}]$ or saturation state on deep-sea scleractinian corals. However, a growing number of laboratory studies have conclusively shown that lowering $[CO_3^{2-}]$ or saturation state reduces calcification and skeletal growth rates of tropical reef building corals by 7-40% in experiments simulating conditions in the year 2100. Of particular importance is the finding that the calcification of some coral species goes to zero when the saturation state drops below one. Many deep-sea corals will be exposed to undersaturated water by the year 2020. This talk will address how these experiments are performed and how the methods might be modified for application to deep-sea corals in the laboratory and *in situ*.

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Geochemical Profiles of Corals from a Dynamic Habitat: Charleston Bump, NW Blake Plateau

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Sequential geochemical microanalyses were performed on the aragonite skeletons of several taxa of colonial corals collected at the Charleston Bump (Western Atlantic, northwest Blake Plateau, ~150 km southeast of Charleston, South Carolina, USA - ~600-700m depths). Samples for light stable isotope ($\delta^{18}O$ and $\delta^{13}C$) analyses were micromilled sequentially from thick-sections cut perpendicular or parallel to the axis of maximum growth. Elemental variation was measured via electron microprobe on thin-sections ground from the same samples after micromilling was complete. Elemental and isotopic profiles were found to periodically oscillate through ontogeny in a roughly sinusoidal fashion. Strontium:calcium ratios and $\delta^{13}C$ varied regularly in some portions of the skeleton but were interrupted by zones in which variation was not sinusoidal. The sinusoidal portions of the geochemical records were often abruptly interrupted in several intervals over the life of the colony, sometimes in association with skeletal discontinuities. This pattern suggests episodic growth possibly related to the relatively dynamic environment of this region. The Charleston Bump disrupts the Gulf Stream. Consequently, the habitats here are characterized by strong currents that lead to spatial and temporal variation in several environmental factors greater than that found in many other deepwater coral habitats. As abundant fossil corals have been collected from the Charleston Bump, the possibility to measure past current variation and climate dynamics is supported. The research presented here is focused toward building growth models and assessing environmental factors that control skeletal geochemistry, ultimately benefiting both habitat management and future paleoclimate investigations.

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Will Changes in Seawater Chemistry Negatively Affect Deep-Sea Coral Ecosystems?

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Will climate change negatively affect deep-sea coral (scleractinian) ecosystems?
The answer is uncertain as very few manipulative experiments have been conducted to test how deep-sea corals react to changes in seawater chemistry, temperature, salinity, water motion, and food availability. Seawater chemistry and the depth of the $CaCO_3$ saturation horizon in the world's oceans are changing from the addition of fossil fuel CO_2 to the atmosphere. This influx of CO_2 is causing the world's oceans to become more acidic. Although little is known about the effects of decreasing carbonate saturation state on deep-sea corals, lab experiments have conclusively shown that lowering carbonate ion concentration reduces calcification rates in tropical reef builders by 7 to 40 percent. In fact, all marine calcifying organisms tested to date have shown a similar negative response. As the oceans become less saturated over time, corals are expected to build weaker skeletons and/or experience slower growth rates. This paper puts forth a hypothesis stating the global distribution of deep-sea scleractinian corals could be limited (in part) by the variable depth of the $CaCO_3$ saturation horizon. Preliminary results indicate >95% (percentage will almost surely increase when more highly resolved bathymetric data can be obtained) of known deep-sea scleractinian coral locations occur above the $CaCO_3$ saturation horizon. Projections indicate ~70% of these locations will be below the saturation horizon by 2100. If saturation state is as important to deep-sea coral calcification as it is to shallow reef builders, then this is an important issue that warrants lab experimentation and *in situ* experimentation/monitoring.

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Antarctic Rosetta Stone: towards a Recent Paleoceanographic Reconstruction from the Southern Ocean Using a Deep Sea Coral

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We present a trace element geochemical record derived from a conical scleractinia or deep sea "cup" coral (Flabellum impensun Squires) from the Ross Sea, Antarctica. The primary goal of our study is to increase our understanding of linkages between climate and paleoceanographic hydrography in the Southern Ocean. The coral was collected alive from a sea-mount at 300 m water depth. Radiocarbon dating of the carbonate skeleton suggests the coral began growing at the start of the agricultural revolution, approximately 250 years ago. Radiocarbon analysis was conducted at the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory. We use the Stanford/USGS Sensitive High Resolution Ion Microprobe Reverse Geometry (SHRIMP RG) to measure variations in concentrations of the trace elements B, Mg, S, Fe, Ba, Sr and Ca with a spatial resolution of less than 30 micrometer. Results indicate sub-decadal scale periodicity and centennial scale trends in trace element geochemistry. Hypotheses describing paleoceanographic controls of geochemical results are presented.

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Preliminary Evidence of Oceanic Climate Change around New Zealand over the Last Century: the Pole-Equator Seesaw

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Many stony corals and octocorals occur on seamounts, as well as areas of comparatively flat deep-sea reef. The majority of such corals exist at water depths > 100 m, with many living below 1000 m. Coral ages can extend from decades to hundreds of years and encompass relatively rapid changes in the environment, e.g. fishing practices, climate and associated oceanic patterns, that can effect growth. An understanding of deep-sea coral systematics, ecology, longevity, and growth rates is needed to appreciate the nature, extent and possible mitigationof any impacts. Understanding the carbonate source and what proportion comes from the ocean and metabolism, as well as the effects of climatic events on the laying down of coral matrix is complex.

This paper interprets Mg/Ca and $\delta^{18}O$ data from deep-sea corals collected near 1000 m depth around New Zealand. Coral specimens belong to the Isididae family; namely the bamboo coral species *Lepidisis* spp and *Keratoisis* spp. Results indicate two different climatic patterns: long-term cooling from the mid-19th century and a variable oceanic state. These patterns potentially reflect a response of continental shelf waters to changing coastal sea-surface temperatures, which in turn reflect variability in the East Auckland and East Cape Currents. Correlations between temperate New Zealand and El Niño-Southern Oscillation or Antarctic indices, suggest these long-term changes might also be a significant response to teleconnections between tropical and Antarctic climates.

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Development of Radiocarbon, Trace Element, and Stable Isotopic Records From a Deep Sea Coral: *Isididae sp.*

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Deep-sea corals are an important new archive of intermediate and deep-water variability, and are of interest in the context of decadal to century-scale climate dynamics. Development of reliable paleoceanographic reconstructions will require detailed calibration of environmental biogeochemical proxies as well as age and growth rate calculations. Sequential high-resolution radiocarbon measurements along the protinaceous gorgonin node and carbonate internodes were used to develop independent age model for specimens of *Isidade* from the Gulf of Alaska. $\Delta^{14}C$ data suggest that these specimens were long-lived (75-126 years), and that they acquired skeletal carbon from two distinct sources. The gorgonin nodes had bomb $\Delta^{14}C$ values over the outermost few millimeters while the carbonate internodes had constant $\Delta^{14}C$ values (-180‰) that were indistinguishable from co-located water samples. These results suggest surface-derived POC is the primary source of carbon for the gorgonin nodes while ambient DIC is the primary source of carbon for the calcareous internodes. Independent verification of our growth rate estimates and coral ages was obtained by counting seasonal Sr/Ca cycles and probable lunar cycle growth bands. The inter-species reproducibility of trace element (Cd, Sr, Mg) analysis of the calcareous internodes was tested by laser ablation ICP-MS. Although there appears to be an ontogenetic effect; Cd/Ca ratios exhibit a systematic increase from the oldest (1 ppm) to youngest (3.5 ppm) portions, and there are 0.5 to 1.5 ppm oscillations on what appears to be a 5-10 year period. The utility of $\delta^{13}C$ and $\delta^{15}N$ measurements in the gorgonin sections as proxies of surface water productivity will also be presented.

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Deep Sea Corals as Recorders of North Atlantic Radiocarbon Variability

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The history of the last transition from glacial to interglacial conditions is complex, and to understand why and how it happened we need to be able to compare different parts of the climate system on a common timescale. The deep ocean contains ~sixty times the carbon content of the atmosphere and also transports heat across the equator, so changes in its circulation are likely to have an important effect on climate. Deep-sea corals provide a unique window into of the history of deep-ocean circulation changes. Their aragonite, uranium-rich skeletons are ideal for U-Th dating and ^{14}C measurements, so we are able to reconstruct the radiocarbon history of the water column. By making multiple ^{14}C measurements from each individual coral we can produce decadal-resolution records of deep ocean variability. Our fossil coral collection from the New England Seamounts spans depths of 1000 – 2500m and is well situated for monitoring the depth of the contact between Northern and Southern sourced deep waters. During the deglaciation, the Western North Atlantic water column had radiocarbon gradients many times greater than those observed in the modern ocean. The radiocarbon content at ~2,500m was relatively constant during the deglaciation, but at shallower depths the corals record frequent, rapid switches between radiocarbon-rich water sourced from the North and radiocarbon-poor water sourced from the South. We demonstrate that the timing of these deep ocean events are consistent with the north Atlantic playing a role in modulating both the atmospheric radiocarbon inventory and global climate.

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Isotope Screening on *Lophelia pertusa* (L.) – Reconstruction of Temperature vs. Growth Rate

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Living specimens of the cold-water coral *Lophelia pertusa* were collected from water depths of 100 to 1000 m water depth at four different localities along the European continental margin (Norwegian shelf, Skagerrak, Porcupine Seabight/Rockall Bank, and Gulf of Cadiz). With vertical growth rates varying between 0.5 and 2.5 cm per year this species provides a high-resolution climate archive of a few decades (Freiwald 2002).

Due to a complex microstructure (Rollion-Bard et al. 2003), growth structures of *Lophelia* are difficult to recognize. Thus, 2–3 mm thick cross-sectioned slabs of the coral were mounted on a glass slide, ground and polished, and immersed in a solution of 500 ml 1% acetic acid, 500 ml 25% glutaraldehyde and 5 g alcian blue powder for 22 min at 37–40°C (Mutvei's solution, Schöne et al. 2005). Immersion in Mutvei's solution facilitated the recognition of the horizontal growth rates of the polyp (= calyx diameter). Sampling for isotopes was performed on polished cross-sections of *Lophelia* and followed two different approaches: (1) carbonate powder was drilled from light and dark growth bands of six cross sections of a single polyp using a 100 µm drill bit for $\delta^{18}O$, $\delta^{13}C$, Sr/Ca, $\delta^{44}Ca$, and $\delta^{88/86}Sr$ analyses, and (2) skeleton powder was milled at high resolution (milling steps perpendicular to the direction of growth: 6 to 30µm) from two cross-sections of two different specimens for $\delta^{18}O$ and $\delta^{13}C$ analyses.

The multi-proxy approach and the development of new isotope proxies are highly desirable, as previous studies on $\delta^{18}O$ and $\delta^{13}C$ ratios indicate a complex fractionation and a strong "vital effect" of *Lophelia*. Additionally, first results of $\delta^{18}O$ and $\delta^{13}C$ of the high-resolution sampling indicates a correlation between increments widths (= growth rate) and the stable isotope ratios. Therefore, strontium-calcium ratios (Sr/Ca), Ca-isotopes ($\delta^{44/40}Ca$) and Sr-isotopes ($\delta^{88/86}Sr$) were tested as independent temperature proxies. Future work will focus on the analysis and further development of this new geochemical and paleoceanographic proxy, viz. $\delta^{88/86}Sr$ (Eisenhauer et al. 2003), which presents a temperature dependency of 0.033‰/°C in tropical corals (Fietzke & Eisenhauer 2005). The isotope signatures of living *Lophelia* corals will be discussed with respect to recent bottom water characteristics, like temperature, salinity, pH-value, dissolved oxygen, $\delta^{88/86}Sr_{SW}$, $\delta^{18}O_{SW}$ and $\delta^{13}DIC_{SW}$ of the bottom water.

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A 1200 Year History of Labrador Slope Water off Nova Scotia from Nitrogen Isotopes in Deep-Sea *Primnoa* Corals

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The organic endoskeletons (gorgonin) of deep-sea gorgonian corals are derived from recently exported POM. In some species the gorgonin is deposited in annual rings, much like tree rings. This suggests that geochemical trends measured in corals may be used to reconstruct surface processes over extended periods, at much higher temporal resolution than provided by sediment cores. Trends in $\delta^{15}N$ were analyzed in a suite of recent and fossil specimens of *Primnoa resedaeformis* collected from the NE Channel, a 275m deep canyon between Georges and Browns banks in the NW Atlantic Ocean. Skeletal chronology in the recent specimens was established by counting the annual rings viewed in cross sections, with validation by the bomb-^{14}C method. The fossil specimens were ^{14}C dated. From AD 800-1900, $\delta^{15}N$ remained relatively constant at 11 +/- 0.5 ‰. Since then, it has decreased to 9.7 +/- 0.3 ‰. From 1950 onward $\delta^{15}N$ was inversely correlated with instrumental records of temperature ($r^2 = 0.5$) and salinity ($r^2 = 0.4$). This suggests that $\delta^{15}N$ in *P. resedaeformis* records the history of the Coupled Slope Water System, with higher $\delta^{15}N$ tied to the presence of cold, fresh, and nutrient depleted Labrador Slope Water (LSW). Nutrient depletion of LSW upstream from the NE Channel may leave the residual nitrate isotopically enriched, leading to heavier $\delta^{15}N$ in POM. Overall, the presence of LSW in the NE Channel seems to have been a persistent phenomenon until only very recently.

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Temperature-Dependence of Mg/Ca Deposition in Keratoisis spp.: Evidence and Application to Reconstruction of Deep-Water Oceanography and Climatology in the Australian/New Zealand Region

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Magnesium/calcium ratios in the calcite skeletons of long-lived (300-500 years) deep-water gorgonian corals (Keratoisis sp) have been speculated to vary as a function of ambient water temperature at the time the carbonate was deposited. We tested this hypothesis by, first, doing parallel analyses within the same coral of Mg/Ca and O^{18}, a nominally independent temperature marker, and, second, by comparing the composition of the outer margin of a Keratoisis sp. with a four-year time series of daily temperature records collected at a nearby moored deep-ocean instrument array. There is a good fit between the O^{18} and Mg/Ca trajectories, although absolute temperatures predicted by the two methods differ substantially, most likely due to vital effects on oxygen isotope ratios. Mg/Ca ratios at the margin of the coral also correlate with and appear to track temperatures measured at about 1000 m, at a scale within the coral that is consistent with its age (as inferred from counts of apparent annual growth increments and radiometric techniques) and its date of collection. A similar correlation could not be tested for O^{18} due to the coarser resolution (25 vs 5 microns for the probe analysis) of the mass-dependent isotopic analysis. The correlation between ambient water temperature and Mg/Ca ratios, as well as the corroboration of temperature-dependency of Mg/Ca from the oxygen isotope analysis, indicates it is possible to resolve annual and longer term variability in water temperature at depths in excess of 800 m from the gorgonians. We have begun to apply this method to reconstruct paleo-oceanography in the Australian and New Zealand region over the last 3-4 centuries. Initial results indicate a long-term cooling trend along the coast, overlaid by apparent 7-11year and 40-60 year periodicities in water temperature. These oceanographic patterns appear to reflect regional climatology, and provide an historical context for understanding recent changes in climate and oceanography and for testing the current generation of coupled ocean-atmosphere climate models.

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Deep-Water Antipatharians and Gorgonians: Proxies of Biogeochemical Processes?

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The skeleton of deep-water antipatharians and gorgonians are laid down in concentric, coeval rings, analogous to tree trunks. The rings are formed annually, allowing precise dating control of the skeleton. The isotope abundances of carbon and nitrogen in the skeleton reflect the source of the elements and biological processes affecting their supply to the base of the marine surface food web. In this study, the organic skeleton of deep-sea gorgonians and antipatharians were analyzed for $\delta^{13}C$ and $\delta^{15}N$ to evaluate their potential as a proxy of productivity in the Gulf of Alaska and the southeastern US continental shelf.

A 0.5-cm thick cross-section of skeleton was cut from the base of each specimen. The rings in each section were counted and the section was treated in acid to allow removal of independent rings. Subsamples from each band were then analyzed for $\delta^{13}C$ and $\delta^{15}N$.

Alaskan gorgonian results indicate depletion of $\delta^{13}C$ and $\delta^{15}N$ over the past 100 years. Florida antipatharians results display a depletion of $\delta^{13}C$ but an enrichment of $\delta^{15}N$ over several hundred years. In Alaska, the $\delta^{15}N$ trend shows fishing down the food chain. In Florida, it may result from increased terrestrial effluent reaching the antipatharians through the food chain. The $\delta^{13}C$ depletion trends in both locations likely represent the ^{13}C Suess effect.

These results suggest that the organic skeleton of antipatharians and gorgonians records changes in the nitrogen and carbon reaching the organism and provides information of changes in marine environments over several hundred years.

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Oral Abstracts

Theme 4 – Coral Biology: Feeding, Growth and Reproduction Characterization

Listed in order of presentation.
Presenting authors appear in **bold**.

Morphology, Growth and Feeding in Cold-Water Corals

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Morphology and feeding are strongly linked in cold-water corals. Skeletal growth patterns set the constraints of morphological variation in many species, not only for colonies, but also for the shape of reefs. The morphology serves a multitude of functions and displays the great variety of adaptations to different environmental conditions. Mechanisms of food particle capture and resistance to strong currents are the two most important factors for explaining the functions of azooxanthellate coral morphology. Even though prey selection cannot be a common phenomenon among animals that depend on transported prey, coral taxa display a variety of different morphologies of colonies and polyps. Very little is known about the feeding biology of cold-water corals. However, recent observations from the seabed and laboratory experiments show that they can utilize a wide range of food sources, including fine particulate matter, phytodetritus, and large items such as ctenophores and planktonic crustacean. In general, the polyp size seems to be related to the size range of utilized food particles. The colony morphology gives clues to understand the mechanisms involved in particle capture. This study aims to relate differences in coral morphology to feeding modes, food sources, and environmental conditions. Growth patterns and rates are reviewed in order to better understand ontogenetic differences in corals' feeding biology.

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The Exploration of the Trophic Foodweb of a Cold-Water Coral Community of the Rockall Trough by Means of Analysis of Stable Isotope (δ15N) Signatures of the Main Biota

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The food source of the reef forming cold-water corals *Lophelia pertusa* and *Madrepora oculata* is not yet fully understood. It is known that they are able to catch small crustaceans like Copepoda and Amphipoda. Some recent papers assume or give some prove that assimilate a mixture of phytodetritus and zooplankton. In trying to determine the trophic level and possible food source of the cold-water corals of the Rockall Trough (500-900 m depth in the NW Atlantic)in more detail the trophic foodweb of the whole coral community was mapped. This was done by the analysis of the stable isotope (δ15N) signatures of a whole score of macro-benthic animals including the corals *Lophelia pertusa* and *Madrepora oculata*, but also of the particulate organic matter in the near-bottom water. The 15N stable isotope signature was used in favour of 13C, as it has a higher discriminative power in trophic analysis because of the 3 ‰ enrichment per trophic level in comparison to the ~1 ‰ in terms of δ13C.

The results are coming mainly from samples taken during a cruise with the RV Pelagia to the Rockall Trough in June-July 2005. This cruise and the research forms part of the EU-funded HERMES (Hotspot Ecosystem Research on the Margins of European Seas) project.

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Potential Food Sources for Deep Water Corals from Rockall Trough (NE Atlantic) Assessed by Aquarium Feeding Experiments and Stable Isotopic Composition

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Sources of nutrition for corals (and other sessile invertebrates) of deep water coral bioherms are of central interest when addressing questions of coral growth, reproduction and factors limiting to deep water coral distribution. Tissue stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) are a common tool in trophic level studies and can be used to investigate potential food sources. We will present data on feeding behavior and stable isotope signatures (bulk and amino acids) using different food sources for cold water corals (*Lophelia pertusa* and *Madrepora oculata*) from Rockall Trough (NE Atlantic). Particle size fractions of bottom water from cold water bioherms are analysed for bulk and compound stable isotopic composition. Specifically smaller size fractions such as bacteria, virus-like particles and DOM as alternative food sources are investigated and compared to feeding on zooplankton (natural, *Artemia* and *Acartia* nauplii) and detritus (POM). Additionally, results on feeding experiments with corals kept in aquaria with either filtered seawater (effect of starvation), virus, bacteria or zooplankton enriched seawater will further provide insight in source dependent stable isotopic fractionation and general feeding behavior of deep water corals.

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The Physiological Ecology of the Reef Framework-Forming Coral *Lophelia pertusa*

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The azooxanthellate cold-water coral *Lophelia pertusa* forms reef frameworks from 40 m to well over 1000 m water depth. Over the last ten years significant research effort has been devoted to mapping these areas and describing their formation. However, to date there has been little analysis of the physiological ecology of *L. pertusa*. In this study, samples were collected from an inshore reef site in Scotland and held in aquaria. Respiration rates were recorded using closed chambers and polarographic electrodes. Excretion rates were recorded and O:N ratios calculated, to give an indication of the substrate catabolised by the coral. The environment where this species occurs experiences variations in many biotic and abiotic factors. For this reason the effect of temperature changes and hypoxia on respiration and excretion were assessed. The presence of any diurnal cycles in respiration was investigated, as well as the potential use of respiration rate as an indicator of the coral's condition.

The amount of energy used in respiration and excretion will be used, together with data on the likely source of food, to construct a simple budget of how carbon and nitrogen flow through the live coral framework. By understanding the physiological ecology of the dominant coral species it will be possible to advance, not only our knowledge of the flow of energy and materials through these ecosystems, but also how sensitive they are likely to be to environmental change.

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Skeletal Growth and Chemistry of two North Atlantic Deep Water Scleractinia

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We used SIMS ion microprobe (analysis spot 20 μm) to analyze Sr/Ca ratios of the aragonitic skeletons of two deep water corals, *Madrepora oculata* (650 m depth) and *Lophelia pertusa* (128 m depth) collected live at two sites in the North Atlantic, average water temperature ~8 °C. Analyses along the corallite wall, following the line of calcification centers, reveal large, apparently annual cycles in Sr/Ca, implying extension rates of 2 mm yr^{-1} and 6 mm yr^{-1} resp., matching that of reef-building species in cooler subtropical waters[i]. Monthly oscillations in Sr/Ca are recorded in the *Lophelia* skeleton suggesting a lunar or tidal modulation of skeletal chemistry linked to growth[ii]. These oscillations are not evident in skeleton accreted at 650 m depth.

Mean Sr/Ca ratios (10.5mmol/mol) are higher than observed in symbiont-bearing corals[iii] and approach Sr/Ca ratios of inorganic aragonite precipitated at 8 °C[iv]. The sensitivity of deep coral Sr/Ca to temperature (~ -1.3 mmol/mol Sr/Ca per °C) is an order of magnitude higher than that exhibited by surface corals (~ -0.09 mmol/mol Sr/Ca per °C)[v]. Nevertheless, the Sr/Ca-SST regression equations from the two species are equivalent and can be used to predict the temperature ranges at each site.

The corallite walls are thickened by bundles of needle crystals growing outward from a continuous line of calcification centers. Sr/Ca oscillates across fine bands transecting the needle crystals that most likely represent seasonality in crystal extension rate. Conversely, we find no significant difference in Sr/Ca between the calcification centers and adjacent aragonite fibres, as we do in symbiotic corals, which may reflect the absence of a strong diurnal cycle in calcification.

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Trace-Element "Vital Effects" are a Ubiquitous Feature of Scleractinian Corals – New Data from *Lophelia*, *Oculina* and *Desmophyllum*

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It is often assumed that coral biological processes do not interfere with or bias trace-element paleoclimate records. However, stable isotope "vital-effects" – strong linear correlations between $\delta^{13}C$ and $\delta^{18}O$ (and recently $\delta^{11}B$) – are a ubiquitous feature of Scleractinian coral skeletons, and are clearly linked with biological processes underlying skeletal formation. Strongly correlated *trace-element* "vital effects" have recently been reported in tropical corals, for the first time demonstrating a clear mechanistic link between biology and skeletal trace-elements.

Here we demonstrate that these vital effects (notably strong negative correlations between U/Ca and Mg/Ca) are also found in three genera of deep-sea Scleractinian corals (*Oculina*, *Lophelia* and *Desmophyllum*), making them ubiquitous features of Scleractinian corals. Moreover, we show that these vital effects have a systematic relationship with skeletal structure: U is depleted, and Mg is enriched in the optically dark regions of the coral (septal centers and centers of calcification).

Physicochemical calcification models cannot explain the negatively correlated Mg/Ca vs U/Ca vital effects, nor do they arise from daily photosynthetic cycles of zooxanthellae, since the deep water corals are azooxanthellate. The results are inconsistent with the inclusion of a Mg or U rich trace-phase (eg. organics, calcite), since these would have to be present in the 10s of % level to account for the magnitude of the variations. The origin of these vital effects therefore remains a mystery; however, they promise to be a powerful tool for constraining possible biological/inorganic mechanisms for skeletal formation.

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Lead-210 Dating Bamboo Coral (Family Isididae) of New Zealand and California

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This study investigated the age and growth of bamboo coral (family Isididae) collected off New Zealand and California using skeletal cross sections from partial coral colonies. Age and growth was determined independent of growth zone counts using lead-210 dating. This was accomplished by micro-sampling the skeletal carbonate in a series of radial samples (from the edge to near the center) and applying the lead-210 dating method. The skeletal cross sections for each species were similar in diameter for comparative purposes. The results for the radial sampling indicated the time required for the New Zealand colony (*Lepidisis* sp.) to form a radius of 7.6 mm was 43 years (range of 38 to 48 yr). This equates to a radial growth rate of 0.177 mm/year (range of 0.162 to 0.195 mm/yr). The results for the radial sampling indicated the time required for the Davidson Seamount colony (*Keratoisis* sp.) to form a radius of 7.5 mm was 150 years (range of 97 to 197 yr). This equates to a radial growth rate of 0.05 mm/yr (range of 0.038 to 0.077 mm/yr). Because the sections had a similar radius, we concluded that the *Keratoisis* sp. collected at 1425 m from the Davidson Seamount grew about 3 times slower than the *Lepidisis* sp. taken at 690-800 m from off New Zealand.

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Age and Growth, and Age Validation of Deep-Sea Coral Family Isididae

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This paper summarises deep-sea coral ageing work that has been carried out in the New Zealand region including the application of several methods to both estimate age and validate ages of some deep-sea coral species. Methods include counting radial growth zones, radioisotopic dating, radiocarbon (^{14}C) dating, stable isotopes and climatic records.

Presented is a detailed description of age estimation and lead-210 dating to validate the periodicity of growth zones in partial colonies of the bamboo corals (Family Isididae sub-families Keratoisidinae and Mopseinae, genera *Lepidisis* spp. and *Keratoisis* spp.). Ages for both genera were estimated from assumed annual zone counts made microscopically on skeletal cross sections and from SEM images. Thin section counts of 90 yr for *Lepidisis* and 160 years for *Keratoisis* were estimated, but counts from SEM sections were substantially higher for both genera (over 400 yr).

The independent radiometric technique, lead-210 dating, was applied to the skeletal structure of *Lepidisis* spp. to develop a growth model and validate age estimates. Both radial and linear micro-sampling of the skeletal carbonate were used to determine growth rates. The results for each approach indicated the age of the colony at the largest section (7.6 mm radius) was between 40 and 50 years. Mean ages from the base to colony tip were 43, 35, 33, and 14 yrs. A linear growth rate of about 3 cm/yr was well supported.

Validation results have led us to postulate what the zone deposition seen in the colony represents. It is clear from this study that coral ageing methods need to be validated to confirm age and growth.

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Growth Pattern of Deep-Water Gorgonian (Primnoa resedaeformis pacifica) in Japan

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Deep-water gorgonian *Primnoa resedaeformis pacifica* (Kinoshita 1907) is the species that has been treated as a variation of *P. resedaeformis*. However, the study of *P. resedaeformis* in North-East Pacific and Atlantic has been done by several authors, no ecological study has been done for the coral in North-West Pacific. This is the first study of growth of deep-water gorgonian in North-West Pacific.

The specimens in the National Science Museum, Tokyo that were collected from Shiribeshi Seamount in Sea of Japan between the year 1990-2001 were examined and estimated age with their growth ring counts. They were collected from a depth between 350 and 505 m. The water temperatures of collected area were extremely low (0.78-0.85 °C). This low water temperature is significant trait of this seamount.

It has been validated that the growth rings of *P. resedaeformis* are annual, therefore the growth rings of *P. resedaeformis pacifica* is also thought to be annual in this study. The average radial growth was approximately 0.3-mm/ year. This growth rate is not so different from the other deep-water corals that live in warmer temperature. It was not observed that the limitation of growth in radial increments, but usually several indeterminate colonial organisms have some kind of constraints in their size or growth rate. The hypothesis is that the longevity and maximal size of *P. resedaeformis* (and *P. resedaeformis pacifica*) are very large, therefore the constraints of growth has not been detected in small fragments or the colony with the age of some decade. Alternatively, the limitations is hardly happens in radial growth though it sometimes observed in linear growth.

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Reproduction of *Lophelia pertusa* from Norway and the Northern Gulf of Mexico

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Reproduction in shallow water animals is often influenced by seasonal light, food and lunar cycles, but the factors that drive reproductive cycles of deepwater species is still under speculation. This research examines the gametogenic cycles of *Lophelia pertusa* from two different environments. One set of samples were collected from the Trondheimsfjord in Norway at depths of 40-250 m, and the other set were collected from the Northern Gulf of Mexico (GOM) at depths of 500-550 m. Although the latter series are not complete, it is apparent that the gametogenic cycles from the two locations are offset from each other. The Norwegian corals began the gametogenic cycle in early spring and maximum oocyte diameter was observed the following February, with very little break between successive gametogenic cycles. The GOM *L. pertusa* contained small vitellogenic oocytes in July, but samples from late September showed no gametogenic activity. Primary oocytes were observed in October and November therefore we conclude that spawning occurs in the GOM *L. pertusa* in late August or early September. Additional samples will be collected in September 2005, and will provide more information on the gametogenesis, fecundity and maximum oocyte diameter of GOM coral. Future research will focus on collection of environmental data from each location to investigate factors that may regulate reproduction in this species.

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Reproductive Ecology of Hydrocorals from the Aleutian Islands

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In 2002, scientists from the Auke Bay Laboratory, Alaska initiated a research program to describe the distribution and ecology of coral habitat in the Aleutian Islands. Dense coral 'gardens' dominated by hydrocorals, gorgonians and sponges were observed between 150 and 350 m depth. These habitats had high structural complexity and taxonomic diversity of corals and associated fauna, but habitat disturbance was observed at most sites. One of the project objectives was to describe reproductive traits of hydrocorals of the Aleutian Islands. Small samples of hydrocorals were collected using the 'Delta' research submersible from deep-water sites along the Aleutian Islands during summer 2003 and 2004. Samples of three shallow water species *(Errinopora nanneca, Stylaster brochi and Stylaster verrilli)* were also collected in 2003, using SCUBA. Fragments were fixed, decalcified and processed according to standard histological techniques. All species studied were gonochoristic brooders, with the majority of gonophores containing mature embryos or planulae. The gametes within a single specimen were not highly synchronized; females contained eggs as well as planulae, and males exhibited a range of gamete development. Future avenues for research include taking seasonal samples to determine timing and duration of the gametogenic cycles, and integrating larval biology, environmental information and population genetics to provide insight into larval dispersal. Information on survival and re-establishment of fragmented colonies is also important with respect to recovery from mechanical damage.

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Oral Abstracts

Theme 2B – Habitat Mapping, Sampling and Characterization

Listed in order of presentation.
Presenting authors appear in **bold**.

Analysis of Topographic Change in a Deep Sea Coral Reef Ecosystem Using GIS

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Over the past twenty to thirty years, shrimp trawling over deep sea coral reefs on the Oculina Banks off the east coast of Florida, USA, has destroyed much of the coral habitat. The area was closed to all trawling in 1984, although documented poaching occurred as late as 2004. A major impact of destructive fishing practices is reduction of topographic complexity, which may be manifested in a leveling of the seafloor. Fishermen have anecdotally noted a general deepening of the Oculina Banks over the past three decades, beyond what might be expected due to local sea-level rise. Geographic Information System (GIS) tools are used to analyze acoustic bathymetric surveys before and after the trawling fishery began to see if this change is detectable. Results demonstrate the difficulty in comparing historical habitat mapping surveys, especially single-beam versus multi-beam echo-sounding systems.

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Finding Suitable Areas to Conserve *Lophelia* Habitat on Rockall Bank

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The Rockall Bank lies to the west of Scotland and straddles the boundary between the fishing zone managed by the European Union (EU) and the High Seas, where fishing is managed by the North-East Atlantic Fisheries Commission (NEAFC). The bank supports an important fishery for haddock and other shallower water species (upper slopes and top) and deep-water species (lower slopes).

NEAFC were concerned about the conservation of *Lophelia pertusa* reefs on the Bank, and requested the International Council for the Exploration of the Sea (ICES) to "indicate appropriate boundaries of any closure of areas where cold-water corals are affected by fishing activities." ICES to used three sources of information to identify such boundaries. These were:

a) Records in the scientific literature and elsewhere of the occurrence of coral;
b) The knowledge of fishers using the Bank;
c) Records of fishing activity derived from satellite monitoring systems.

Each of these sources has their advantages and disadvantages, and could not necessarily be relied upon singly to identify suitable closure areas, but when used together provided a powerful tool indicating such areas. This paper reviews this case and provides some considerations for future ways of identifying suitable conservation areas in the absence of full scientific information.

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Distribution of Deep-Water Corals on the Western Margin of Little Bahama Bank, Bahama Islands

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This paper compiles results of three surveys carried out along the margin of Little Bahama Bank. Off Freeport, the bank margin below ~70 m is a chiefly low-relief, sediment-veneered, hardbottom with a ~40-60° slope. Macrofaunal distributions were surveyed via ROV at 1.5-m depth intervals along 7 transects in 40-200 m. Except for a few green macroalgal species above 117 m, paramuriceid octocorals and antipatharians are the most abundant attached macroorganisms at all depths, although sponges are more speciose. The Antipatharia is the most abundant group below 120 m and is dominated by *Stichopathes luetkeni*, which forms dense forests in ~130-150 m. Anthozoans account for 0.82-4.55% of cover at four quantitative sites photographed in 98-146 m. Hard bottom penetrates to 164-200 m, usually ending in talus and followed by chiefly unconsolidated sediment. One transect uniquely supports large solitary corals (probably *Desmophyllum dianthus*) in ~190-200 m. Off West End, a submersible survey in 325-430 m revealed mounds of up to 30-m vertical relief that exhibit a current-mediated biozonation of suspension feeders (e.g., *Madrepora carolina*, stylasterids, primnoid octocorals and crinoids). Crinoids and the isidid octocoral *Keratoisis flexibilis* dominate on intervening pavements. Off Memory Rock in 580-700 m, lithoherms to 50 m in vertical relief support a different current-mediated biozonation dominated by primnoids, crinoids, stylasterids, sponges and ophiuroids. Large lithoherms support groves of the arborescent zoanthid *Gerardia* sp. and extensive thickets of *Lophelia pertusa* accompanied by *Solenosmilia variabilis*. Primnoids, crinoids, stylasterids, sponges and *Corallium medea* dominate on hardgrounds between mounds (Messing et al. 1990).

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Southeastern U.S. Deep Sea Corals Initiative (SEADESC): Characterizing Known Locations of Habitat-Forming Deep-Sea Corals in the South Atlantic Bight

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Since 2001, NOAA Ocean Exploration (OE) has sponsored more than 150 dives with the *Johnson Sea-Link* (JSL) submersibles on the deep-water coral reefs present along the shelf edge and slope from North Carolina to Florida. These reefs are dominated by *Lophelia pertusa*, which typically occurs in the South Atlantic Bight at depths of 400-870 m. Congregations of several economically important fishes and invertebrates have been observed near *Lophelia* reefs and it appears that *Lophelia* reefs may serve as critical habitat for many western Atlantic slope species. An additional 12 JSL dives, sponsored by the NOAA Undersea Research Center (NURC), were conducted on the deep-water *Oculina varicosa* reefs that exist along the shelf edge off central Florida at depths of 70-100 m. *Oculina* reefs typically form dendroid thickets, which have been shown to support a faunal diversity equivalent to many shallow-water tropical reefs. To effectively manage the deep-water reefs of the SAB and their associated communities, further data and information are required on the distribution and ecological function of these habitats. The purpose of the Southeastern U.S. Deep Sea Corals Initiative (SEADESC) is to systematically document the distribution of deep-sea corals in the SAB. The objectives are to: (1) characterize known locations of habitat-forming deep-sea corals with the use of existing data collected during OE and NURC sponsored submersible operations, (2) facilitate the use of this information for management, education, and outreach activities in the region, and (3) prioritize areas for on-going deep sea corals exploration and research in the SAB.

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Coral Habitats on the Mid-Atlantic Ridge

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Deep-sea coral habitats on seamounts on the Mid-Atlantic Ridge between Iceland and the Azores are described based on video surveys using ROV and bycatch from longline and trawl. The study is part of the MAR-ECO project, an element of the research programme Census of Marine Life, and aims to improve the understanding of the ecology of ridge and seamount ecosystems in the North Atlantic. Corals were observed on most sites inspected from depths around 800 m down to around 2600 m. Octocorals dominated the coral fauna which comprised a total number of 15 species. Living *Lophelia pertusa* was repeatedly observed on the seamounts but always with relatively small colonies. The deepest record was at 1340 m, south of the Charlie Gibbs Fracture Zone. We did not observe massive live reef structures, and the largest colony was approximately half a meter across. Remains of former large *Lophelia*-reefs were observed at several locations. The number of megafaunal species was higher in areas where corals dominated compared to areas without coral. Typical taxa that co-occurred with *Lophelia* were crinoids, certain sponges, the bivalve *Acesta excavata*, and squat lobsters. Signs of destructive fishing and lost gillnets were observed at several locations. Different possible reasons of the decease of these reefs such as climate change or destructive fisheries are discussed.

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Distribution of Benthic Species Associations in the Belgica Mound Province, Porcupine Seabight – Ecological Aspects and Relation to Facies and Benthic Habitat Features

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In the Belgica Mound Province at the eastern margin of Porcupine Seabight, west of Ireland carbonate mounds are commonly associated with cold-water corals dominated by *Lophelia pertusa* and *Madrepora oculata*. The distribution of benthic species associations related to different sedimentary facies, seabed structures and benthic habitat features are mapped out. The widely varying species associations including cold-water corals and their associated substrate are investigated by the quantitative analysis based on GIS-selected sequences from video footage collected during two recent cruises, Polarstern ARKXIX-3a cruise (ROV Victor) in june 2003 and Meteor M61/3 cruise (ROV Quest) in june 2004. Additional groundtruthing by giant box cores and Van-Veen grabs allows detailed and reliable identifications of benthic species and quantitative grainsize analyses of their sedimentary environment.

Possible relations between the species associations and the facies types are focused along a west-east transect running from Galway mound up to the shallower Poseidon mound. The contrast of, on one hand carbonate mounds with extensive live coral coverage (Galway Mound) and on the other hand mounds with extremely scattered occurrences of live corals (Poseidon Mound) (Foubert et al., 2005), is highlighted and supported by a quantitative comparison of both sites. A clear increase in megafaunal species concentration and species abundance on mounds with dense live coral coverage is noted.

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Submersible Surveys of Deep-Water *Lophelia pertusa* Coral Reefs off the Southeastern USA: Recent Discoveries and Research

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Deep-sea coral ecosystems (DSCE) are common off the southeastern United States but are poorly known. Recent expeditions from 1999-2004 documented the habitat, benthic fauna and demersal fish diversity on six deep-water reefs, some of which are described for the first time. Fifty-seven *Johnson-Sea-Link* submersible dives and three ROV dives found 58 fish species and 142 benthic invertebrate taxa. We mapped nearly 300 mounds off Florida during echosounder transects, some of which were ground-truthed by dives and proved to be deep-water *Lophelia* reefs, up to 168 m in height. The sites ranged from South Carolina on the Blake Plateau to the Gulf of Mexico and included: 1) Stetson *Lophelia* Reefs along the eastern Blake Plateau off South Carolina (690-780 m), 2) Savannah Lithoherms along the western Blake Plateau off Georgia (530-550 m), 3) East Florida *Lophelia* Pinnacles (670-860 m), 4) Miami Terrace Escarpment in the Straits of Florida (330-570 m), 5) Pourtalès Terrace off the Florida Keys (200-460 m), and 6) West Florida *Lophelia* Lithoherms in the Gulf of Mexico (450-560 m). These are contrasted with the azooxanthellate, deep-water *Oculina* reefs at the shelf-edge off central eastern Florida (70-100 m). Activities involving bottom trawling, pipelines, or oil/gas production could negatively impact these reefs. The National Oceanic and Atmospheric Administration (NOAA) Fisheries and the South Atlantic Fishery Management Council are currently developing priority mapping sites of the DSCEs within this region, and these data may provide potential targets for new Marine Protected Areas and Habitat Areas of Particular Concern.

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ROV Surveys of *Oculina* Banks Marine Reserve: Habitat Mapping and Fish-Habitat Associations

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The *Oculina* Habitat Area of Particular Concern (OHAPC), a marine reserve off the east coast of Florida, was established in 1984 to protect deep coral banks constructed by ivory tree coral (*Oculina varicosa*) from destructive trawling. In 1994, the OHAPC was named the Experimental *Oculina* Research Reserve and closed to all bottom fishing to protect and restore declining grouper stocks. In 2000, the OHAPC was expanded and the original portion renamed the *Oculina* Experimental Closed Area (OECA). In 2001 and 2003, ROV dives were made in the OECA, the OHAPC, and in trawled areas inshore of the OHAPC to characterize habitat and examine the fish community. Small sea basses dominated the fish community. Similar habitat types were observed both years. Reef fish were most abundant on high-relief areas with live or dead standing coral, and least abundant on coral rubble and sand habitats. Grouper species were more abundant inside the OECA. Advances in gear and technology make inter-annual comparisons difficult. ROV tracking, which allowed fish density estimates, was only used in 2003. A multi-beam map of the OECA and a portion of the OHAPC, produced in 2002, was used to guide 2003 ROV dives towards particular bottom features. The resulting habitat map is one product specified in a new Evaluation Plan for the OECA developed by researchers and managers for the South Atlantic Fishery Management Council. The Evaluation Plan set forth consistent methods for examining changes in habitat and fish populations so future data will be comparable between surveys.

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The HURL Database of Deep-Sea Corals in Hawaii

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The Hawaii Undersea Research Laboratory (HURL) operates 2 Pisces submersibles and a RCV-150 remotely operated vehicle (ROV) that are available for a variety of research projects including studies on deep-sea corals. Principal investigators (PIs) awarded dives during the past two decades have conducted studies on coral population genetics, growth rates, distributions on seamounts, effects of invasive species on black corals, and the relationship between monk seals and precious coral beds. Independent of data acquired by PIs, the locations, depths, substrate types, and associated fish and invertebrate communities are logged during HURL's video-processing of dive tapes. These data in HURL's database, coupled with the dive geographic information system (GIS) and the photo-archive, provide a wealth of information regarding the abundance and distribution of deep-sea corals in Hawaii. For this symposium, these data will be presented for example species including relatively shallow antipatharians, (e.g. *Cirrhipathes spiralis*) and deeper water gorgonians (e.g. *Iridogorgia superba*, *Metallogorgia melanotrichos*). Problems we have encountered with this type of database, such as video identifications, updating changes to the deep-sea coral nomenclature, and issues with extracting and analyzing these data will be discussed.

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Prototype Deep-Water Coral Geodatabase: Gulf of Mexico and Beyond

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The US Geological Survey, in cooperation with the National Oceanic and Atmospheric Administration, has designed a prototype geographic database (geodatabase) of deep-water coral locations in the Gulf of Mexico. Although only scleractinian cold-water corals were included in this phase of development, soft corals and associated fauna may be added after the geodatabase has been expanded to include data from the western North Atlantic. Scientists and resource managers will be able to use the geodatabase for research and planning activities.

This multi-user geodatabase was created with Oracle to be used primarily with ArcGIS products. Two feature classes store the spatial and attribute data. A point feature class stores data on individual specimens, whereas a polygon feature class stores data on reefs or other large areas of coral habitat. Attributes for both points and polygons include species name, positional accuracy information, photographs, and source information, such as who identified the sample and references to publications where available. The geodatabase can be displayed, queried, and analyzed to suit the needs of individual users.

Input is solicited from the community of potential users. Is the geodatabase easy to access? Should additional fields be included to make the geodatabase more descriptive and useful? Does it adequately reflect the nature of habitats observed in the field? Are there additional references that can strengthen the current content or create new records?

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Deep-Sea Coral Distributions in the Newfoundland and Labrador Region

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Distributions of deep-sea corals in the Newfoundland and Labrador region were mapped using by-catch samples from Department of Fisheries and Oceans groundfish stock assessment surveys, and by-catch samples and records from the Fisheries Observer Program. Nineteen species of corals were recorded, including seven gorgonians, three alcyonaceans, six pennatulaceans, one antipatharian, and solitary scleractinians. Corals were distributed along the edge of the continental shelf (> 300 m), and were most common in submarine canyons or saddles where the continental shelf is incised. Only alcyonacean soft corals were found in shallow waters (< 170 m) or colder than 1.1 °C. The deepest collections were *Paramuricea* sp. (> 1700 m) in the Labrador Sea. Large, structurally robust, habitat-forming corals included the gorgonians *Paramuricea* sp., *Paragorgia arborea*, *Primnoa resedaeformis*, *Keratoisis ornata*, and *Acanthogorgia armata*, and the antipatharian coral *Bathypathes* sp., which included open-branched and tightly clumped forms. Gorgonian distributions were highly clustered, with most occurring with other gorgonian species, soft corals, or other coral species. Coral hotspots in Labrador occurred in Davis Strait, Ogak Bank, Hopedale Saddle, Cartright Saddle, and Hawke Channel. Coral hotspots in Newfoundland occurred along the edges of the northeast Newfoundland shelf, north side of Flemish Cap, and south-eastern and south-western Grand Banks. The Flemish Cap hotspot was composed exclusively of soft corals, sea pens, and cup corals. Most of the coral hotspots identified here were suggested in earlier work (Gass, 2002). The coral hotspots identified in this preliminary study are not currently protected from benthic fishing activities.

References:

Gass, S.E., 2002. An assessment of the distribution and status of deep sea corals in Atlantic Canada by using both scientific and local forms of knowledge. Masters of Environmental Studies thesis, Dalhousie University, 186 p.

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Seaways of the Bahamas Archipelago: A Vast Natural Laboratory for Research on Biophysical Parameters Controlling the Development of Deep Sea Buildups (Banks and Lithoherms)

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We know that strong current velocities favor the occurrence of these buildups and their subsea cementation. We know that pelagic sediment can be a major component of these structures. We infer that sediment baffling by structure-building corals is involved in their development. What we do not know, yet urgently need to explore, is the relative roles of these parameters and their synergy. What is needed is a natural laboratory, accessible year-round, where we can observe, monitor and quantify these parameters.

Such a natural laboratory exists in the numerous seaways of the Bahamas Archipelago. Four sources of information evidence the extensive occurrence of deep sea corals and associated buildups: 1) well documented descriptions of lithoherms at depths of 500-700 m, extending for 200 km in the eastern Straits of Florida; 2) thorough descriptions of deep-sea banks (100-1300 m deep) north of the Little Bahama Bank occurring in an area of 2500 km^2; 3) dredge reports of structure-forming deep sea corals from four inter-bank seaways; 4) indications that other seaways in the Bahamas also have similar buildups.

An international, multi-disciplinary consortium of institutions is mandatory to take advantage of this unparalleled research opportunity.

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Oral Abstracts

Theme 6 – Fish Ecology

Listed in order of presentation.
Presenting authors appear in **bold**.

Patterns in the Biogeography and Endemism of Seamount Biotas as the Basis for Their Conservation and Management: Update from the September 2005 ISA/CoML CenSeam Workshop

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Biogeographic issues, in particular the spatial scale of species' distributions and rates of endemism, underlie the conservation and management of seamount faunas from the potential impacts of fishing and mining. Wilson and Kaufman (1987) reported relatively modest levels of endemism in seamount fish and invertebrate faunas (12-15 %), but recent studies have found substantially higher levels (~30 – 50%) in the southwestern and southeastern Pacific. This research, together with an enhanced appreciation of the impacts of trawling on seamount faunas, has led to increased research on their ecology and biogeography.

In September 2005, the International Seabed Authority and CenSeam, the Census of Marine Life seamounts project, convened a workshop to examine these issues, using the global seamount database, Seamounts Online. Key findings from the workshop will be presented: a review of global patterns of biodiversity, endemism and biogeographic scales in seamount faunas; the factors underlying these patterns, such as seamount configuration and proximity to continents; and the factors that limit a global synthesis at this time, including the lack of taxonomic consistency between studies and inadequate sampling.

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Coral Distribution on NE Atlantic Seamounts, Continental Slopes and Oceanic Islands prior to Industrial Deep-Water Trawling

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Industrial bottom-trawling has been moving into ever deeper areas over the past 25 years and is currently damaging deep-water coral habitat worldwide. In the past few years several scientific surveys have revealed damage to deep-water habitats on seamounts, continental slopes and oceanic islands. In most parts of the world offshore expansion of the bottom-trawling industry has begun before any habitat assessment has taken place. Fortunately there is a wealth of historical deep-water survey data for the NE Atlantic providing detailed records of deep-water corals dating back to the expeditions of Lightening, Porcupine and Josephine (1868-9). The deep-water coral fauna of the region is far more diverse than that of the coastal waters, creating some of the largest coral reefs on Earth.

This paper presents an analysis of baseline historical information on the diversity and distribution of deep-water corals to provide a comparison of seamount, continental slope and oceanic island faunas of the NE Atlantic region. The role of seamounts in offshore coral ecology is discussed in the context of continued bottom-trawling impacts.

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Patterns of Groundfish Diversity and Abundance and Deep-Sea Coral Distributions in Newfoundland and Labrador Waters

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The degree of association between groundfish and corals in Newfoundland and Labrador waters was analysed on a large spatial and temporal scale. Groundfish diversity and abundance of eleven groundfish species were compared with deep-sea coral distributions using archival groundfish survey data and current coral distribution data. Because most deep-sea corals are long-lived organisms, comparison of archival fish distributions with present coral distributions yields valuable insights into the relationships between corals and groundfish. Coral diversity hotspots were identified in by-catch data from published sources (Gass, 2002) and current research (2003-2005). Groundfish diversity hotspots (trawl sets within the 1970-1994 ECNASAP database with diversity >2 sd above mean) were found along the shelf edge, or on the deep Northeast Newfoundland Shelf. Many of the groundfish diversity hotspots along the shelf edge roughly coincided with coral hotspots, especially hotspots containing gorgonian corals. Many of the groundfish abundance peaks (sets with numerical abundances >2 sd above mean) for Atlantic cod (*Gadus morhua*), deepwater redfish (*Sebastes mentella*), golden redfish (*Sebastes marinus*), rock grenadier (*Coryphaenoides rupestris*), and roughhead grenadier (*Macrourus berglax*) roughly coincided with coral hotspots, especially hotspots containing gorgonian corals. Numerical abundances of Deepwater redfish, Golden redfish, Rock grenadier, and Roughhead grenadier in 2003-2004 trawl survey data were greater in sets containing corals than in sets that did not contain corals. The general coincidence of coral distributions and groundfish diversity hotspots and abundance peaks suggests that corals probably provide important, but not obligate, habitat for a variety of groundfish species, including some commercial species.

References:

Gass, S.E., 2002. An assessment of the distribution and status of deep sea corals in Atlantic Canada by using both scientific and local forms of knowledge. Masters of Environmental Studies thesis, Dalhousie University, 186 p.

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The Distribution of Fishes over Seamount Landscapes in the Western North Atlantic Ocean

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Seamount landscapes vary in attributes based on sediment type, rugosity, current pattern, and depth (=water mass characteristics). The distribution of demersal and semi-demersal fishes in seamount landscapes is non-random and may be related one or more of such attributes. Video transects from dives using ROV Hercules in 2004 in the western New England Seamount chain will be analyzed to determine if particular landscape characteristics are correlated with species distributions.

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Benthic Fishes Occupying Deep Coral Habitats along the Southeastern United States Continental Slope

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Deep water corals occur abundantly along the continental slope of the southeastern United States. In some areas these corals have formed significant mounds, while in other areas they have colonized existing hard substrates, and in most areas they contribute substantial structure to bottom habitats. From 2000-2004 we surveyed the fish communities on and around deep coral habitats between North Carolina and east-central Florida. We have completed 46 Johnson-Sea-Link dives between depths of 370-783 m in this region, recording video data on fish and habitat distributions and ecology. Coral habitats varied throughout the area, ranging from large mounds topped with nearly monotypic stands of *Lophelia pertusa* off North Carolina to more mixed hard coral/soft coral/sponge habitat over most of the Blake Plateau. We have identified 41 species of benthic and benthopelagic fishes on and around the coral habitat, most confirmed with collections of voucher specimens. In general, the coral habitat ichthyofauna is dominated by 8-10 species which were rarely observed away from this habitat: *Laemonema melanurum, L. barbatulum, Hoplostethus occidentalis, Helicolenus dactylopterus, Conger oceanicus, Beryx decadactylus, Idiastion kyphos, Polyprion americanus*. In all areas, coral habitat appeared to concentrate a characteristic fauna; however, some differences related to latitude and/or habitat type were apparent and will be discussed. A companion paper will compare these data to our samples from Gulf of Mexico deep coral banks.

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Megafauna and Fish Community Patterns at Several Carbonate Mounds Dominated by *Lophelia pertusa* along the Porcupine and Rockall Bank, West off Ireland

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Several mounds were surveyed by ROV during the CARACOLE cruise in 2001, a french/irish/EU inter-disciplinary program to study carbonate mounds and deep-coral reefs in the Porcupine Seabight and Rockall Trough, west of Ireland. The use of the ROV Victor 6000 gave the opportunity, for the first time, to estimate the extent of the coral reefs and described from samples and images the associated megafauna composition and distribution. We visited several mounds between 600 and 1000 m depth: Theresa, Moira, Perseverance and Propellor mounds on the Porcupine seabight, the Porcupine Bank mounds along the SE Rockall Trough Margin, and the Logatchev or Pelagia mounds along the SW Rockall Trough Margin. These mounds differed in size, from very small, probably recent, coral patches (Moira "mounds"), to one hundred meter high mounds presently in a coral development phase (Theresa mounds, Pelagia mounds) or in a decline phase (Perseverance mound) (Huvenne et al. 2005, Wheeler et al.2005). The extent of living coral colonies, including *Lophelia pertusa* and *Madrepora occulata* varies from mound to mound and is up to a few hundreds of meters in diameter on Theresa mound and Logatchev mounds. The associated megafauna, including large size filter feeders is surprisingly very different between provinces and between mounds of a same province, particularly in terms of relative abundance of species. Theresa mound is characterized by the abundance of the glass sponge *Aphrocallistes beatrix*, gorgonians *Paramuricea placomus* and antipatharians (*Leiopathes glaberrima*) while Logatchev mound showed mainly encrusted sponges, low densities of gorgonians but comatulids *Koehlerometra porrecta* locally very abundant. The Perseverance mound, considered to be in retirement, is characterized by a number of isolated coral patches of dead or living *Lophelia*, clusters of the solitary coral *Desmophylum cristagalli*, and high density mats of a large actinian. Although most of the fish species were observed at all the sites, specific abundance greatly differs between mounds, e.g. *Neocytus helgae* very abundant on Theresa and Pelagia mounds and absent or rare on other mounds, *Molva dypterygia* absent from Theresa and abundant on Pelagia mounds. These contrasted faunistic composition may be related to latitudinal distribution but other factors such as currents, particulate organic matter supply, that vary spatially and temporally likely structure these communities. This spatio-temporal variability may increase the vulnerability of these ecosystems.

References:

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The Ecology and Ecological Impact of an Invasive, Alien Octocoral on Hawaii's Deep-Water Coral Reef Community

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In 2001, *Carijoa riisei*, an alien octocoral reported as native to the tropical Western Atlantic, was discovered overgrowing large numbers of black corals in the Au'au Channel in Hawaii. In this study, data from a 2001 survey was re-analyzed and combined with new data from 2003 and 2004 to assess the ecological impact in greater detail. *C. riisei* differentially affects reproductively mature black coral colonies with maximum impact between 80-105 meters. *C. riisei* also appears to be overgrowing large beds of zooxanthellate scleractinian plate corals at depths of 65-115 meters. The pattern of *C. riisei* overgrowth on black corals and *C. riisei* on exposed substrata appears to be bounded by high irradiance in shallow water and cold temperature in deep water. Evidence suggests that *C. riisei* settlement on black corals is facilitated by other epifauna. Once established, *C. riisei* spreads vegetatively and smothers the coral. The success of the *C. riisei* invasion appears to be unaided by anthropogenic disturbance and at least partially attributable to Hawaii's depauperate shallow-water (<120 meters) octocoral fauna.

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Habitat and Fish Assemblages of Three Deep-Sea Corals in Hawaii

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The submersibles *Pisces IV* and *Pisces V* were used to survey the subphotic contours between 350 and 500 m at six sites known to have deep-sea corals. The surveys recorded habitat variables (substrate, bottom relief, and temperature) and fish data (taxa, number, and body length) in relation to coral density and colony height for the hexacoral *Gerardia* sp and the octocorals *Corallium secundum* and *C. lauuense*. *C. secundum* colonies grew in high density (129/Ha; mean ht 20 cm) mono-specific patches on uniform carbonate pavement bottom. Colonies of *C. lauuense* were less dense (58/Ha; mean ht 14.6 cm) and found encrusting uneven carbonate and basalt/manganese bottom often intermixed with colonies of *Gerardia*. Mono-specific patches of *Gerardia* occurred in the lowest densities (33/Ha; mean ht 66.5cm) encrusting the edges of cliff tops and along the ridge line of walls. Although density of each taxa differed among sites the mean size of the coral colonies did not vary despite some notable temperature differences between sites. The fish surveys identified 42 fish taxa all of which were found both in and out of the coral patches. Only 4% of the total fish surveyed (>13,000) were seen in the coral trees and more than 70% of these were seen in tall coral colonies such as *Gerardia* sp. Benthic and midwater hovering fish that feed on the passing drift were the most common fish types found in the corals patches. The fish and corals likely co-occur to exploit the improved feeding associated with high flow environments.

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Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities

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The objectives of this multi-year study were to characterize deepwater hard-bottom communities at selected study sites within the Northern Gulf of Mexico, and to correlate the distribution and development of these communities with observed environmental conditions. Six study sites were selected and categorized according to their relative abundance of the scleractinian coral *Lophelia pertusa* and other non-chemosynthetic hard bottom epibiota such as sponges and cnidarians. The project was designed with three primary components: physical oceanography, which provides information on deepwater currents for incorporation into a hydrographic and larval dispersal model; geological characterization, which provides information on the geology and geomorphology of each site; and biological characterization and studies. Biological characterization provides qualitative and quantitative descriptions of the hard-bottom assemblages at each study site. Manipulative field and laboratory experiments were designed to investigate several components of *Lophelia* biology and ecology. Field work was performed in July 2004 (Cruise 1) and September 2005 (Cruise 2) using the Johnson Sea-Link submersible. Cruise 1 objectives included the collections of video transects and photo-mosaics for habitat description and coral distribution, quantitative collections of coral associated fauna, water samples for petroleum hydrocarbon analyses, live *Lophelia* fragments for laboratory experiments, and sediment cores for grain size analyses. In addition, sediment traps and *Lophelia* transplants were deployed, and two *Lophelia* colonies were stained *in situ* to calibrate growth rings and thus provide estimates of growth rate. Cruise 2 will involve the completion of project objectives and recovery of equipment deployed during Cruise 1.

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Fishes Associated with *Lophelia pertusa* Habitats in the Gulf of Mexico

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Lophelia pertusa reefs in the northern Gulf of Mexico occur atop autogenic carbonate mounds between 350-500 m depth. They present a contrast to Lophelia reefs known on Blake Plateau off North Carolina. In the Gulf, Lophelia displays a predominantly open growth form with long, thin, widely-spaced branches and limited anastomosing, suggestive of rapid growth. The low, dense growth form found off North Carolina, and characterized by extensive branching, anastomosing, and high polyp density, is absent. Also absent are the extensive fields of Lophelia rubble surrounding live reefs. In the Gulf, the coral grows directly upon unsedimented rock substrate. The shallowest reefs occur at 350 m depth, where many sessile sponges, black corals, and soft corals are important constituents of the overall sessile fauna. These shallow Lophelia habitats are populated by large numbers of hemi-benthic snowy grouper (a fishery resource species) and schooling black ruff (a potential resource species), in addition to a small suited of demersal fishes typical of structured deep-water habitats. At 500 m depth, the reef landscape is dominated by Lophelia with few other large sessile invertebrates. At this depth the grouper and ruff have dropped out of the fauna. The fish fauna here includes fishes highly associated with Lophelia reef habitat, prominently including the berycoid fishes Grammicolepis, Beryx, and Hoplostethus. Dominant species include some also found on North Carolina Lophelia reefs.

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Linking Deepwater Corals and Fish Populations

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Understanding the functional relationships between seafloor fauna and associated fishes (as habitat, competitors, and prey) is central to managing for the conservation and sustainable use of marine biological diversity. Deepwater corals have been a central focus of such work during the past decade due to their sensitivity to human disturbance, slow recovery rates, and limited distribution. Some studies have indicated corals are important for mediating population processes during particular life history stages of fishes while other work has demonstrated minimal association with corals. This leaves significant uncertainties in our understanding of the functional role that corals play. Expanded observational studies that include corals as well as non-coral features that produce enhanced flows for similar levels of prey delivery, provide complex structures for similarity in shelter value, and support diverse benthic prey populations are required to better understand the role that deepwater corals play in supporting fish communities. Adaptive management strategies can aid in developing a mechanistic understanding of the ecological role of coral habitats when responses must be measured at the scale of fish populations or communities. Studies are best designed to test a series of alternatives (or predictions) rather than simply testing for cases of no response (i.e., to a null hypothesis). The use of spatial replicates across regions and sampling over seasonal time frames will provide geographic boundaries to our knowledge.

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Oral Abstracts

Theme 8 – Conservation and Protection of Deep-Sea Corals

Listed in order of presentation.
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Conservation and Protection of Cold-water Coral Reefs: What do Policy and Decision Makers Need to Know?

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The widespread existence of large, complex coral reef ecosystems in the colder and deeper parts of the world's oceans was one of the most remarkable discovery in marine science in the last decade. Emerging results show magnificent reefs surprisingly similar to their warm-water counterparts, but also evidence that these cold-water reefs are impacted and threatened by increased human activities, particularly bottom fisheries, on continental shelves and seamounts.

Images of devastated reefs and corals entangled in lost fishing gear attracted media attention and created considerable international momentum. Reports have been written, statements requesting action been made and governments started to establish measures to conserve vulnerable reef ecosystems in their waters. The UN General Assembly called for integrating and improving the management of risks to the marine biodiversity of cold water corals. International conventions included cold-water coral reefs in their work programmes to implement the commitments and targets agreed at the World Summit of Sustainable Development.

However, policy and decision makers are facing numerous challenges: Research is geographically biased with few studies in the deeper waters off developing countries, leading to the misperception that cold-water coral reef conservation is a "developed country" concern. The unique role and functions of cold-water coral reefs in the marine deep-water ecosystem, including their value for fisheries and other sectors, are poorly understood. Scientific data on these and other issues is urgently needed before effective and comprehensive action can be taken to conserve and protect cold-water coral reefs.

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MPAs to Protect Deep Sea Corals and Seamounts off Alaska

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The North Pacific Fishery Management Council established new marine protected areas (MPAs) to protect cold water corals and seamounts off Alaska in 2005. This action was taken to minimize the effects of fishing on essential fish habitat and to provide additional protection of fragile and vulnerable benthic habitats.

The Alaska Seamount Habitat Protection Areas protects sixteen seamounts within the EEZ off Alaska. Several of these seamounts have had scientific observations of deep-sea coral communities. All bottom contact fishing by Council-managed fisheries is prohibited on these seamounts.

Within the Gulf of Alaska two separate areas for habitat protection have been identified. The Primnoa Coral Habitat Protection Areas protect sites containing large aggregations long-lived Primnoa coral, no bottom tending fishing are allowed in these areas. Additionally, the Gulf of Alaska Slope Habitat Conservation Area prohibits bottom trawling for all groundfish species in ten areas along the continental shelf. These areas are thought to contain high relief bottom and coral communities.

Within the Aleutian Islands three separate areas for habitat protection have been identified. The Aleutian Islands Coral Garden Habitat Protection Areas, protect high density coral and sponge communities. These 'coral garden' areas are closed to all bottom contact fishing gear. The Aleutian Islands Habitat Conservation Area addresses concerns about the impacts of bottom trawling on coral communities. The concept for this MPA prohibits all bottom trawling, except in small discrete 'open' areas. Additionally, the Bowers Ridge Habitat Conservation Zone prohibits mobile fishing gear that contacts the bottom.

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Protection of Deep Water Corals with the Development of Oil and Gas Resources in the U.S. Gulf of Mexico

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U.S. Dept. of the Interior, Minerals Management Service

The development of oil and gas resources has been identified as a potential threat to deep water coral habitats. The Minerals Management Service (MMS), an agency of the United States Department of the Interior, is responsible for permitting and regulating oil and natural gas activities in the U.S. offshore waters within its Exclusive Economic Zone. An element of the MMS mission is "to manage the mineral resources of the Outer Continental Shelf (OCS) in an environmentally sound and safe manner". To assure that offshore development occurs under these guidelines, MMS inspects offshore facilities, reviews plans of exploration and development, performs environmental analyses, and funds environmental and engineering research related to OCS oil and gas development. The deep water coral *Lophelia pertusa* has been found in the Gulf of Mexico in areas with increasing oil and gas exploration and development activities. Little is known about the processes controlling the distribution, growth, and life habitats of this cold water coral.

The best known and largest accumulation of *Lophelia* observed to date in the northern Gulf of Mexico lies on the upper slope of the DeSoto Canyon at a depth of around 440 meters. The MMS recently initiated a three-year study to characterize the types of non-chemosynthetic megafaunal communities that live on deepwater hard substrate outcrops and to describe the environmental conditions that result in the observed distribution and development of high density communities, particularly extensive areas of *Lophelia* coral. This paper discusses the future application of results from this study and the types of measures that may be considered by MMS for protection of *Lophelia* as oil and gas development continues to expand in the deep Gulf of Mexico. Protective measures already implemented by MMS for chemosynthetic communities will serve as a model for protection of deep water corals.

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The Occurrence of the cold-Water Coral *Lophelia pertusa* (Scleractinia) on Oil and gas Platforms in the North Sea

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This study reports a newly established sub-population of *Lophelia pertusa* the dominant reef-framework forming coral species in the north-east Atlantic on oil and gas platforms in the northern North Sea. Fourteen oil platforms were examined using existing oil and gas industry visual inspections for the presence of *L. pertusa* and it was identified on thirteen of these. Two platforms were inspected in more detail to examine depth and colony size distributions. Hundreds of colonies were recorded and occurred between 59 to 132 m depth coinciding with cold Atlantic water at depths below the summer thermocline in the northern North Sea. We suggest that these colonies provide evidence for a planktonic larval stage of *L. pertusa* with recruits initially originating from populations in the north-east Atlantic and now self-recruiting to the platforms. The size class distribution showed a continuous range of size classes with a few outlying large colonies. The break between the largest colonies and the rest of the population is discussed as the point when colonies began self recruiting to the platforms resulting in greater colonization success. We present the first documented *in situ* colony growth rate estimate (26 ± 5 mm yr^{-1}) for *L. pertusa* based on 15 colonies from the Tern Alpha platform with evidence for yearly recruitment events starting the year the platform was installed. Evidence of contamination from drill muds and cuttings was observed on the Heather platform but appeared limited to regions close to drilling discharge points where in some cases half the colony was smothered by drill cuttings while the other half remained living. Further, the potential for *L. pertusa* to act an environmental recorder will be examined by analyzing coral skeletons for trace elements commonly used in drilling fluids.

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Isolation and Characterization of Novel Tri- and Tetra-Nucleotide Microsatellite DNA Markers for the Delineation of Reproductive, Population, and Phylogeographic Structures in the Deep-Water Reef-Forming Coral *Lophelia pertusa*

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Cold-water reef-forming corals like *Lophelia pertusa* form an infrastructure that serves as refuge for a diverse and often endemic vertebrate and invertebrate community. The absence of information on the evolutionary relatedness among and within reefs is a significant hindrance to management of the species (and perhaps the associated communities), particularly in light of documented declines associated with expanding deep-sea trawl fisheries. To allow development of long-term conservation strategies in *L. pertusa*, an accurate delineation of the appropriate unit of management within and among reefs is essential. Since genetic markers offer the only true measure of effective migration (i.e., gene flow) among populations, we have developed a suite of polymorphic tri- and tetra-nucleotide microsatellite DNA markers in *L. pertusa*. Four enriched microsatellite DNA libraries have been created, tested for enrichment, and subjected to marker development. The motifs used for the libraries and the enrichment rates were: AAC (63%), AAAT, (67%), TAGA (75%), TGAC (89%). To date, 12 polymorphic loci have been developed and tested in collections of *L. pertusa* from the southeastern Atlantic and Gulf of Mexico coasts of the U.S. These markers have proven to reliably produce multilocus genotypes that will facilitate the detection of clonal and sexual reproduction and allow the delineation of fine-scale population structure. Moreover, we believe the markers will provide insights into the phylogeographic structure that exists among geographic collections of this globally-distributed species. Marker development and sample acquisition from throughout the species' range continues.

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Developing Ecological Quality Objectives for the Management of Cold-Water Coral Protected Areas

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While a number of countries have established, or are in the process of establishing, cold-water coral protected areas, little attention has been given to their management. The EC 6th Framework Project 'Marine Protected Areas as a Tool for Ecosystem Conservation and Fisheries Management (PROTECT)' involving a consortium of scientists from 10 countries will address this issue. The overall objective of PROTECT is to improve the science basis for the design, selection, implementation, monitoring and management of marine protected areas. PROTECT will then provide policy advice to the European Commission and OSPAR to facilitate a more ecologically based management of the seas based on the appropriate application of MPA regimes in support of the ecosystem approach. Cold-water coral protected areas have been chosen as one of three PROTECT case studies.

This paper describes the development of Ecological Quality Objectives (EcoQOs) and considers the applicability of this approach to the management of specific human activities in cold-water coral protected areas.

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The Darwin Mounds – From Undiscovered Coral to the Emergence of an Offshore Marine Protected Area Regime: A History of Interactions and Consequences

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The first Offshore Marine Protected Area (OMPA) in the UK will be the Darwin Mounds, an area of *Lophelia pertusa* discovered only in 1998, lying 185 km to the northwest of Scotland at a depth of 1000 meters and covering 545 km^2. This is considered to be an exceptional example of *Lophelia*, growing on a sand base, rather than hard substratum, and exhibiting a distinctive "tail" structure not yet seen elsewhere. Damage to the area caused by deep-water trawling has been observed and in 2003, at the UK's request, the EC imposed a ban on trawling in a 1380 km^2 area surrounding the Mounds, which became permanent in 2004. This move was made possible by the revised Common Fisheries Policy (CFP) and represents the first instance of a closure for nature conservation (rather than fish stocks). Eventually a network of OMPAs throughout the EU's marine waters will need to be designated, including around the UK.

Through a detailed legal and policy analysis and a program of semi-structured interviews with stakeholders, regulators and specialists in the field, this project is determining the sequence of events that led to the protection of the Darwin Mounds, the history, motives and issues underlying these events and their consequences (intended and otherwise). This analysis will contribute to the literature on offshore conservation and is also exploring (i) the rights and use of space in the offshore marine environment; (ii) tensions between different policy initiatives; and (iii) challenges and prospects for the effective enforcement of OMPAs.

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The Aleutian Islands Model for Deep-Sea Coral Ecosystem Conservation

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The Aleutian Islands, Alaska contain the highest known taxonomic diversity of deep-sea coral species and are an evolutionary center of origin for many taxa of coldwater corals (Heifetz *et al*. 2005). Bottom trawling is the primary threat to seafloor habitat posed by commercial fishing (NRC 2002) and the adverse impacts of bottom trawling on deep-sea coral ecosystems in this region are well documented by both fishery observer data and *in situ* studies. To satisfy the requirements of the Sustainable Fisheries Act to mitigate adverse fishing impacts on Essential Fish Habitat, the North Pacific Fishery Management Council recently adopted the conservation approach proposed by Shester & Ayers (2005) to protect deep-sea coral ecosystems in the Aleutian Islands. The approach differs from conventional Marine Protected Areas because it closes the entire management area to bottom trawling except for specific designated open areas, resulting in a closure of 279,114 nm^2 (957,334 km^2), or 60% of the fishable area.

While area closures offer the most effective way to protect deep-sea coral ecosystems, the extent of protection in the designated open areas remains to be seen. Here, we discuss further incentives, monitoring, research, and seafloor mapping that will improve the success of this approach and provide a foundation for future adaptive management. We also analyze the expected conservation effectiveness of the approach and the social, economic, and political considerations that led to its adoption. Overall, the implementation of the Aleutian Islands Model represents a significant step toward ecosystem-based fishery management and lays a framework for a new era of ocean conservation.

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Tools and Options for the Protection of Deep-Sea Coral Ecosystems

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As the United Nations General Assembly has recognized, urgent action is required to protect deep-sea coral ecosystems from threats posed by destructive fishing practices such as bottom trawling on the high seas. But to ensure long-term conservation, all human activities that can impact deep-sea coral ecosystems in areas beyond national jurisdiction must be effectively managed.

This paper describes the legal regime currently governing the conservation of deep-sea corals located in areas beyond national jurisdiction. It identifies the legal tools and approaches that can be used now to enhance their protection under, for example, the UN Convention on the Law of the Sea (UNCLOS), the Fish Stocks Agreement and the Convention on Biological Diversity and as well as through regional agreements.

It also explores options for the conservation of corals located along the outer continental margin, or the "legal continental shelf". Under UNCLOS, coastal States have explicit rights to explore and exploit the sedentary living resources (e.g. corals, sponges, crabs) of their legal continental shelf where this extends beyond the 200 n.m. exclusive economic zone. What a coastal State may do to protect and conserve these resources when they are threatened by activities conducted by States exercising their "high seas freedoms" such as fishing or placing installations above the shelf or laying cables on the shelf is a neglected but important issue for States to consider.

The paper concludes with recommendations to enhance the conservation and management of deep-sea corals on the legal continental shelf and beyond national jurisdiction.

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Science Priority Areas on the High Seas – Scientists' Views

Hjalmar Thiel
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Marine Science Research (MSR) is one of the high seas freedoms according to article 87 of the United Nations Convention on the Law of the Sea (UNCLOS) and does not necessarily need any permission from States or international organizations. An exception was issued by UNCLOS for The Area, i. e. the deep seabed, where the International Seabed Authority has the competence to deal i. a. with MSR in relation to ore mining.

This freedom of MSR on the high seas has led the majority of the MSR community to regard this privilege as an unlimited right. Consequently, the community neglected to express its own basic interests in discussion with other stakeholders. Various uses of the high seas summarized as resource mining, fishing, waste disposal and cable lying may be envisioned to develop in conflict with MSR interests. To avoid disadvantages for MSR already in advance, the community has to express their interests in international forum. One proposal to safeguard long-term MSR against disturbance by other human activities is the designation of SPAs (Science Priority Areas, originally termed Unique SPAs) on the high seas. In SPAs scientific research prevails as the absolute priority over any other use. Therefore, SPAs are not proposed to become part of the network of Marine Protected Areas (MPAs) or other protective measures , although – as a consequence – it offers a certain degree of protection of species and habitats. The management of SPAs will be science-based and different from that of MPAs and regulations for fisheries. It should consequently lie in the hands of the MSR community.

The presentation will recall the proposal to designate a SPA in the Northeast Atlantic Ocean and suggest that other areas on the high seas will be reserved for long-term MSR . Some legal aspects will be shortly considered.

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In Sight, Still Out of mind! — Coral Banks in Chilean Fjords: Characteristics, Distribution, Threats

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Extended banks of azooxanthellate Scleractinia in fjords and channels of southern Chile were first described in 2003[1]. The few studies that have been carried out since then have revealed hitherto unknown communities and astonishing facts[2]. Although eurybathic distribution allows *in situ* studies of the shallowest populations by SCUBA diving, overall attention of public, politics and science is growing slowly. This is in strong contrast to exponentially growing threats from human activities in this region, mainly represented by fish and mussel farming.

Characteristics of coral communities composed of the species *Desmophyllum dianthus, Caryophyllia huinayensis*, *Tethocyathus endesa*, and Scleractinia sp. are described on the basis of latitudinal, longitudinal and bathymetric distribution patterns that have been studied by means of SCUBA diving and the use of ROVs. The upper distribution limit of all species is marked by the maximum extension of the Low Salinity Layer. On vertical and overhanging rock walls, *D. dianthus* can form dense and thick three-dimensional banks extending more than 1000 m². Overall structure and density of coral communities seem to vary little along a bathymetric gradient, while diversity and composition of associated species differ significantly with depth. Species composition, structure and magnitude vary significantly along longitudinal and latitudinal gradients within the fjord region.

Some characteristics of the coral communities and evidence for synchronous death of *D. dianthus* populations in large areas indicate high sensitivity against recent environmental changes. In this context, possible stress factors and the impact of human activities on these coral communities are discussed.

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[2]Försterra, G., Beuck, L., Häussermann, V. & Freiwald, A. (2005): Shallow water *Desmophyllum dianthus* (Scleractinia) from Chile: characteristics of the biocenoses, the bioeroding community, heterotrophic interactions and (palaeo)-bathymetrical implications. In: Freiwald, A., Roberts, J. M. (eds.): Cold-water corals and ecosystems. Springer-Verlag Berlin Heidelberg, pp. 937-977.

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Oral Abstracts

Theme 7 – Ecosystem Based Management

Listed in order of presentation.
Presenting authors appear in **bold**.

An Ecosystem Approach to Fisheries Management – A Primer

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What are the forcing factors that affect fisheries recruitment and production? What are the trophic interactions between the species in question? What is the association of fish species with various types of habitats? What is the fishing pressure on the species? What are the indirect effects of harvesting? What are the interactions between physical and biological components of the delineated ecosystem? Using a holistic ecosystem-based approach to assess these factors requires an understanding of multiple internal and external influences. An ecosystem-based approach to responsibly managing deep-sea fisheries requires an understanding of abiotic and biotic interactions as well as the societal demands placed upon the species. In deep-sea fisheries, gathering the needed types of abiotic, biotic, and socio-economic data may currently pose a technological and monetary challenge. We would all like to see holistic, ecosystem-based approaches to managing our living marine resources. However, marine ecosystems are highly complex and many of the dynamics and interactions poorly understood. An ecosystem approach to managing marine resources takes advantage of existing fishery management tools while relying on evolving tools to reduce uncertainty, balance diverse scientific objectives, and adapt to new information and challenges. The focus of this presentation will review some of the characteristics of existing management measures and formulation of ecosystem-based tools that promote sustainable living marine resources and reduce implementation uncertainty. An ecosystem approach, by definition, is where stakeholders, scientists, and resource managers work together to develop plausible management outcomes utilizing a full range of scientific knowledge.

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A National Assessment of Deep-Sea Coral Communities and Approaches to their Conservation and Management

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Recent research and exploration throughout the waters of the United States has documented diverse and widespread deep water coral habitats. At the same time many of these areas already have been extensively damaged prior to their discovery – especially from mobile bottom contact fishing gears. Consensus is emerging that these ecosystems need significant protection. To date approaches to coral conservation have been ad-hoc and mostly enacted through the US Fishery Management Councils. To date deep-water coral habitats have varying degrees of protection; in the Aleutians corals are protected from bottom trawling, but damage form other fishing gears such as crab pots is ongoing. In Florida, the *Oculina* Bank HAPC is a no-bottom fishing gear closure but until recently a lack of enforcement has circumvented the law. In New England, deep-sea coral areas in Lydonia and Oceanographer Canyons are closed to certain fisheries, but remain open to others.

In order to develop a nationally consistent management plan Marine Conservation Biology Institute and other non-governmental organizations have been advocating for federal legislation to protect deep water coral habitats.

To enact such legislation MCBI is undertaking a review of coral records and locations, modeling efforts to predict habitats in unexplored regions and an analysis of threats to these deep-water ecosystems. The documentation of different deep-sea coral communities, and regional threats will help provide for a comprehensive approach to management. This research will also highlight deep-sea coral areas that may be contentious due to their value as fishing grounds or to other human activities such as mining or hydrocarbon development. It will also help prioritize areas for immediate management action and further research.

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Technology to Support Ecosystem-Based Fisheries Management in the South Atlantic Region

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The South Atlantic Fishery Management Council (Council) is adopting an ecosystem-based management approach. This effort requires a greater understanding of the South Atlantic ecosystem and the complex relationships between humans, marine life and essential fish habitat. To acquire this understanding, the Council is calling upon a diverse group of experts to synthesize regional data. The most logical approach to initiate this synthesis is to utilize the recent technological advances of Internet mapping and portal solutions. With this in mind, the Council commissioned a Comprehensive Ecosystem and Habitat Homepage and Internet Map Server (IMS) application from the Florida Fish and Wildlife Research Institute (FWRI).

The Comprehensive Ecosystem and Habitat Homepage developed by FWRI is a scalable portal solution designed to facilitate development of the Fishery Ecosystem Plan and sharing of information with regional stakeholders and the general public. The portal allows users to manage content and collaborate on key regional issues including the conservation and management of deep sea corals. The portal also serves as an entry point to the Coral and Benthic Habitats IMS.

This IMS application incorporates Geographic Information System (GIS) data from a variety of federal, state, academic and private sources. Example datasets include fish and habitat distributions, environmental sensitivity indexes, proposed deepwater marine protected areas and deepwater coral Habitat Areas of Particular Concern, special management zones, and artificial reefs. The IMS allows users to make custom maps, download extractable GIS data layers, view linked imagery and access associated metadata.

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Deepwater Corals in the U.S. Southeast: Conservation and Management

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The South Atlantic Fishery Management Council (SAFMC) is adopting an ecosystem approach to the management of fisheries within its jurisdiction with the development of a Fishery Ecosystem Plan (FEP) and Comprehensive Ecosystem Amendment (Comprehensive Amendment). The former will evolve from the SAFMC's Habitat Plan (SAFMC, 1998a) and become the source document for subsequent amendments. The Comprehensive Amendment will constitute the regulatory document that will initially amend the SAFMC's Fishery Management Plans as appropriate.

Included in the FEP and Comprehensive Amendment will be the designation of Deepwater Coral Habitat Areas of Particular Concern (HAPCs) within the South Atlantic Exclusive Economic Zone from North Carolina to Florida. Federal regulations encourage regional councils to identify HAPCs as subsets of Essential Fish Habitat to focus conservation efforts on areas that may be vulnerable to degradation from fishing and non-fishing activities or that are especially important to the life cycles of managed species. We present here a snapshot of the nine proposed deepwater coral HAPCs – based on reports submitted to the SAFMC by J. Reed (2004, unpublished report) and S. Ross (2004, unpublished report) – and related management activities. A section of the FEP will be devoted to specifying research needs to fully address ecosystem management. Included will be a Habitat Assessment, Research and Monitoring Plan for Deepwater Coral Habitat Areas of Particular Concern. The latter will provide guidance on priority needs to support management of deepwater coral resources and enhance coordination among researchers in the region.

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Protecting Sensitive Deep-Sea Canyon Habitats through Fisheries Management: A Case Study in the Northeastern U.S.

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Deep-sea canyons located on the southern flank of George's Bank in the northeastern U.S. are home to a wide array of fish and coral species, which provide structured habitat and shelter for some species of demersal fish and invertebrates. Watling and Auster (in press) summarize the known records of deep-sea coral species from the northeastern United States. Essential fish habitat (EFH) means those waters and substrate necessary to fish for spawning, breeding, feeding and growth to maturity. EFH for some species in the northeast U.S. area extends into portions of some of the offshore canyons and is vulnerable to the effects of fishing for monkfish with bottom trawl gear. The directed monkfish fishery is conducted with bottom trawls and gillnets in areas including offshore waters near the heads of several deepwater canyons. The possible expansion of the directed offshore monkfish fishery increases the probability of adverse impacts to EFH, canyon habitats, and, thus, deep-sea corals. To avoid potential impacts to EFH, two canyon habitat closures in Oceanographer and Lydonia Canyons are proposed by the New England (lead) and Mid-Atlantic Fishery Management Councils. The implementation of the closures to the use of bottom trawls and bottom gillnets is expected in May 2005 through Amendment 2 to the Monkfish FMP. These closures are intended as a precautionary measure. Protection of deep-sea corals is a relatively new concept in this region and the Councils assert that there are several statutory and regulatory authorities that support the initiative to protect deep-sea coral habitats (canyons).

Reference:

Watling, L. and P.J. Auster. In press. Distribution of deepwater alcyonacea off the northeast coast of the United States. In: A. Freiwald and J.M. Roberts (eds.) Cold-water Corals and Ecosystems, Springer, NY.

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Are Deep-Sea Coral Communities Benthic Habitat for Fishes on Rocky Banks off Southern California?

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There is increasing interest by science and conservation communities in the potential impacts that fishing activities have on deep-sea corals and other benthic invertebrates occurring in continental shelf and slope ecosystems. We examined the association of fishes with black corals, gorgonians, sponges, and other structure-forming invertebrates on deep rocky banks off southern California. We made 113 dives in a 2-person mini-submersible at 32-320 m water depth, surveying a variety of habitats from high-relief rock to flat sand and mud. Using quantitative video transect methodologies, we made 12,360 observations of 15 structure-forming invertebrate taxa, and quantified their abundance, distribution, size composition, and incidence of associated animals

Individual black corals, sea pens, and sponges greater than 1 m in length represented only 0.1% of all organisms, and 90% of all individuals were <0.5 m high. Fishes comprised less than 1% of observations of organisms actually sheltering on or in invertebrates. From a spatial analysis of associations between fishes and structure-forming invertebrates, six of 108 fish species were found more often adjacent to colonies than predicted by their abundance throughout the survey. These observations suggest there may be spatial associations that do not necessarily include physical contact with the sponges and corals. Because distances between fishes and large invertebrates were small, it is likely fishes and invertebrates co-occur in similar habitats without necessarily developing functional relationships. Regardless of their associations with fishes, these structure-forming invertebrates clearly contribute to the diversity of their ecosystem and deserve the attention of future conservation efforts.

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Satellite Vessel Tracking to Protect Deep-Water Corals

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In 2000 an agreement was made between European Union member states to satellite track all fishing vessels >24m in length and this regulation was amended to include vessels >15m in January 2005. A similar vessel monitoring scheme (VMS) exists for members of the North Atlantic Fisheries Association including Canada, the Faroes, Iceland, Greenland and Norway. At present these data are collated by each member state of the EU for the control and surveillance of fisheries, but are not widely used for habitat protection. However, an ecosystem-based approach to the management of fisheries is becoming increasingly adopted in Europe with satellite tracking offering strong potential to record fishing activity in areas known to support vulnerable marine habitats. This paper presents results from fishing boats fitted with combined GPS receivers and continuous dataloggers to accurately map when and where fishing takes place, providing distinctive graphs of vessel activity that can be overlaid on marine habitat maps. Also provided are two case studies of the use of VMS data in coral-rich provinces in the NE Atlantic (Darwin Mounds and Rockall Bank), showing seasonal changes in fishing activity, as well as providing good spatial resolution on the activities of the different fleets.

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Development of a Proposal to Mitigate the Adverse Effects of Bottom Trawling on Benthic Habitat off the U.S. Pacific Coast

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In this paper we discuss the development of a comprehensive proposal to mitigate the adverse effects of bottom trawling on marine habitat off the U.S. Pacific Coast. The proposal was developed during a process to identify and protect Essential Fish Habitat, a mandate of the Sustainable Fisheries Act of 1996. At the time of this writing, the Pacific Fishery Management Council has selected the proposal (Alternative C.12) as a preliminary preferred mitigation alternative in its Draft Environmental Impact Statement.

The Alternative adapts the approach outlined in Shester & Ayers (2005) to the Pacific Coast by identifying a network of open and closed areas to bottom trawling. To identify these areas, we analyzed the spatial arrangement of complex sensitive habitat criteria in relation to the distribution of bottom trawl effort and landings using GIS. The criteria used for identifying areas of complex sensitive habitat included the presence of hard bottom substrate, records of habitat-forming invertebrates (including corals and sponges), submarine canyons, ridges, and gullies, locations of trawl hangs, seamounts, and highly suitable groundfish habitat. We used the available data to develop a reasonable solution that is as cost-effective and equitable as possible. The proposal also includes trawl gear restrictions and additional research and monitoring components. If adopted, the proposal will substantially protect known areas of sensitive seafloor habitat within the current bottom trawl footprint and prevent the expansion of bottom trawling to new areas, while having minimal economic impact on the trawl industry.

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Designing Management Measures to Protect Cold-Water Corals off Nova Scotia, Canada

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In 2002, Fisheries and Oceans Canada (DFO) implemented its first fisheries closure to protect cold-water corals. The Northeast Channel Coral Conservation Area, southwest of Nova Scotia, was put in place to protect concentrations of the gorgonian corals *Primnoa resedaeformis* and *Paragorgia arborea*. Since then, DFO has established the Gully Marine Protected Area, which includes cold-water coral habitats, and implemented another fisheries closure (the Lophelia Coral Conservation Area) to protect a small, damaged *Lophelia pertusa* reef complex. The design criteria and the management measures used in each area were different, and the activities that are permitted vary. These differences reflect the circumstances particular to each area, as well as evolving knowledge of protecting coral habitats. The lessons learned in establishing the marine protected area and coral conservation areas have been applied to the development of a coral conservation plan for the region, which will be finalized in late 2005. Experience to date suggests that protecting cold-water coral areas may require a variety of approaches, even within a single jurisdiction.

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A Methodology to Reduce Bycatch of Corals and Sponges in the Groundfish Trawl Fishery: An Example from British Columbia, Canada

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With the goal of reducing coral and sponge bycatch in the bottom trawl fishery, we present a methodology to spatially evaluate observer data. As an example, we use bycatch data from British Columbia (BC), Canada, where the identity of the corals and sponges is often poorly established. From 1996 to 2002, 295 tonnes of corals and sponges were observed as bycatch in BC's groundfish bottom trawl fishery. (These observations were likely under-reported.)

Density analysis of bycatch indicates 12 areas of high species concentration, that had they been closed, would have prevented 97% of all coral/sponge bycatch by weight. Stratification of the data indicates that the diversity of deep water corals and sponges appears to also be represented by these twelve areas, though site-specific verification is required. Economically, these 12 areas are of average economic value to the fishery. However, because this is an IVQ fishery, quotas could be caught elsewhere with little or no economic harm. Overall, these potential closures would represent 7.5% of BC's continental shelf and slope.

Year-round bottom trawling closures have been established in Australia, the European Union, New Zealand, Norway, Scotland, and the USA −including vast closures announced this year in Alaska− all with the goal of protecting corals and/or sponges. In Canada, however, we lag far behind. In BC, there are only four small closures to protect sponges, and none yet to protect corals.

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"Ecosystem-Based Fisheries Management: Food-Chain Models for a Northeast Pacific Gorgonean Forest, the Mid-Atlantic Corner Rise Seamount and the Florida *Oculina* Reefs

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Magnuson-Stevens Act emphasized the single species-management strategy in the Exclusive Economic Zones (EEZ) within 200 miles off the United States. In 2004 PEW and US Ocean Commission Reports recommended a holistic 'ecosystem-based fisheries management' (EBFM) plan under the eight U. S. Fisheries Management Councils. For the purpose of helping ecosystem managers, this paper focuses on food- chain, identifying primary producers, secondary and tertiary consumers and apex species of commercial importance. 'Northeastern Pacific Kelp Forest Ecosystem' is presented to define our scientific approach. New color-stratified food-chain based models are developed for selected cold-coral dominated ecosystems. The 'Alasakan Gorgonean Coral Garden Ecosystem' near the Aleutian island chain is located between 150 an 340 m with a high diversity (atypical of a boreal zone) of sessile and sedentary fauna associated with several octocoral species. Fisheries management involves such commercial species as Atka mackeral, several species of rockfish, Pacific halibut and golden king crab. The Corner Rise Seamount near the Mid-Atlantic Ridge supports commercial populations of several highly migratory fish species. Russian fisheries have targeted at Alfonsino (Beryx sp.) and the rattail *Coryphaenoides guntheri,* possibly originated from Bear Seamount of the Northeast Atlantic via Mid-Atlantic Ridge. Long-line fishing at the top trophic level is known to cause irreversible damage to the ecosystem. The Florida *Oculina* Experimental Closed Area (OECA/2000), dominated by the scleractinian coral *Oculina varicosa* supports sea-bass and several species of grouper-snapper species complex. Heavy rock-shrimping has caused severe damages to the ecosystem structure and function. These ecosystems are discussed in the light of currents and climate change.

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Poster Abstracts

Theme 1 – Systematics and Zoogeography

Listed alphabetically by presenting author and abstract title.
Presenting authors appear in **bold**.

How Much Do We Know about Octocorals in Colombian Caribbean Continental Margin?

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In Colombia, Octocorallia studies had been focused only to reef environments. A wide diversity of this fauna was hidden in bottoms deeper than 20 m, which have been discovered through systematic explorations carried out during the last few years, on the continental shelf and the upper slope (up to 500 m depth). After a review of around 300 museum lots, where taxonomic difficulties was a common factor as there are some groups (i.e. Ellisellids) that are not yet taxonomically defined, forty-five species were identified. Nine species and six genera had not been reported for Southern Caribbean. Overall, the specimens did not exhibit remarkable morphological differences against those descriptions made for other Caribbean regions. Most of the collected species were gathered in three localities, where they constitute a diverse community in association with scleractinians and sponges. The community rise seems to be linked to local geomorphologic and environmental features. *Diodogorgia nodulifera, Thesea sp., Trichogorgia lyra* and *Viminella sp.*, were the most frequent species in the localities mentioned; the former three occurred between 70-150 m depth, whereas the last one reached 200 m. Chrysogorgiids were common from 200 to 500 m depth, i.e. *Chrysogorgia elegans*. Moreover, it appears that the presence of octocorals contributes to enhance the diversity of other invertebrates, since it was usual to find mollusks, ophiurians, crustaceans, foraminifera, hydroids, bryozoans, polychaetes attached to the colonies. There are evidences about the important role of octocorals in tropical deep sea marine communities which must be inquired with a holistic perspective.

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Cold Water Corals of British Columbia

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The current state of knowledge of cold water corals in British Columbia is summarised. Pacific Canada has a much more diverse coral community than does Atlantic Canada, as is the case for most taxonomic groups, yet British Columbian corals have been much less studied to date. A list of Pacific Canada's both known coral species and potential species based on records from surrounding areas is presented, along with maps derived from existing records and oral history showing all currently known locations of corals. Habitat preferences by corals in British Columbia are discussed and current and future threats to these and other benthic organisms are reviewed. Future priorities for coral research in British Columbia are proposed.

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Biodiversity and Vertical Distribution of Azooxanthellate Scleractinia in Brazilian Waters

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The Brazilian azooxanthellate coral fauna is poorly understood, yet this area is considered important to the knowledge of this group, because is a transition area between the Caribbean (approximately 130spp) and the Antarctic and the sub-Antarctic (approximately 37spp) azooxanthellate fauna. Literature review and examination of specimens deposited in museums results 51 species, this probably an underestimate for the current biodiversity of this area.

The distribution of these species can be divided in four different zones that equate to water masses, the numbers of which are placed after the number of species of each genus below: [1] Continental Shelf Water – 1-150 m, 27-20ºC, 36.5 ppm; [2] Subtropical Water – 151-500 m, 20-11ºC, 36-35 ppm; [3] Intermediate Antarctic Water – 501-1120 m, 3.5-4ºC, 34-34.3 ppm; and [4] North Atlantic Deep Water – more than 1120m, 3.4-3.8ºC, 34.4-34.5 ppm, showing that many species reported for this area aren't limited to depth ranges or water masses.

The species recorded from Brazilian waters belong to the following family and genera: Caryophylliidae – *Anomocora* (1sp[1]), *Caryophyllia* (5sp[1,2/2/3/2/?]), *Cladocora* (1sp[1,2]) *Coenocyathus* (1sp[1]), *Dasmosmilia* (2sp[1/1]), *Deltocyathus* (4sp[1,2/2/1/2]), *Desmophyllum* (1sp[3]), *Monohedotrochus* (1sp[1,2]), *Lophelia* (1sp[1,2,3]), *Paracyathus* (1sp[2]), *Phacelocyathus* (1sp[1,2]), *Phyllangia* (1sp[1]), *Pourtalosmilia* (1sp[1,2]), *Premocyathus* (1sp[1,2,3]), *Rhizosmilia* (1sp[1]), *Solenosmilia* (1sp[3]), *Stephanocyathus* (2sp[4/2]), *Trochocyathus* (2sp[1,2/1,2,3]); Dendrophylliidae – *Balanophyllia* (1sp[1]), *Cladopsammia* (1sp[1,2]), *Dendrophyllia* (1sp[2]), *Eguchipsammia* (1sp[1,2]), *Enallopsammia* (1sp[2,3]), *Rhizopsammia* (1sp[2]), *Tubastraea* (2sp[1/1]); Flabellidae – *Flabellum* (1sp[2,3]), *Javania* (1sp[2,3]), *Placotrochides* (1sp[3]), *Polymyces* (1sp[1,2]); Fungicyathidae – *Fungiacyathus* (2sp[2/1,2]); Guyniidae – *Stenocyathus* (1sp[2]); Oculinidae – *Madrepora* (2sp[2,3/2]); Pocilloporidae – *Madracis* (2sp[?/1]); Rhizangiidae – *Astrangia* (2sp[1/1]); Turbinoliidae – *Deltocyathoides* (1sp[1,2,3]), *Sphenotrochus* (1sp[1]).

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Black Corals (Cnidaria: Antipatharia) from Brazil: an Overview

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There are few records of black corals (Cnidaria: Antipatharia) from Brazil, where presently the species reported are referred to three families: Antipathidae, Schizopathidae and Myriopathidae. Most of these records are from deep sea, specially from Southwestern Atlantic seamounts and continental shelf margins. From Antipathidae, there are three *Antipathes* species registered: *A. columnaris* (Duchassaing, 1870), *A. furcata* Gray, 1857, *A. atlantica* Gray, 1857, and two forms yet to be identified. Also from this family, there are records of *Cirrhipathes secchini* Echeverría, 2002 – new species, and another five *Cirrhipathes* forms unidentified. From Schizopathidae, only *Schizopathes affinis* Brook, 1889 is registered. The Myriopathidae are represented by one Plumapathes species, *P. fernandezi* (Pourtalès, 1874), and seven *Tanacetipathes* species: *T. barbadensis* (Brook, 1889*), T. hirta* (Gray, 1857), *T. thamnea* (Warner, 1981), *T. tanacetum* (Pourtalés, 1880) and three new species, *T. paula* Pérez, Costa & Opresko, 2005, and another two, yet to be published.

This paper reports on geographical and bathymetrical distribution of black corals species registered off Brazil, and also on the first records of the families Cladopathidae and Aphanipathidae, with descriptions of the specimens of these two families.

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Isididae (Cnidaria: Octocorallia) from Brazil

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Until the beginning of the 1990's, Brazilian deep-sea fauna was poorly known. From this period on, several periodical surveys were carried out, making available for study an increasingly number of benthic specimens. Most of the octocorals represented new records or new species, including five taxa of the family Isididae, which are characterized by an axis composed of horny nodes and non spicular calcareous internodes. This family is known from all oceans, mostly in deep waters, but had only unidentified forms reported from Brazilian waters before – with no analysis at species level. All specimens herein included belong to the Keratoisidinae, two species of which had their geographic distribution greatly extended southwards: *Acanella arbuscula* (Johnson, 1862), by more than 7,000 km (from Dominica to off Rio Grande do Sul State, i.e. approximately 32 ^{o} S), and *Isidella longiflora* (Verrill, 1883), by more than 5,000 km (from Granada to off Macaé, i.e. approximately 22^{o} S). *Acanella eburnea* (Pourtalès, 1868) is herein considered a junior synonym of *Acanella arbuscula* (Johnson, 1862), based on overlapping of characters. The other three taxa, *Acanella* sp., *Isidella* sp., and *Keratoisis* sp., are distinct from all previously described species. Such findings illustrate the relevance of the collecting efforts of the past ten years, which in time will certainly be known as a cornerstone to the knowledge of the Brazilian deep-sea fauna. They also fulfil a gap on the earlier known geographic distribution of the family in the western South Atlantic, from the Caribbean to off Rio de la Plata.

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Corals from the Brazilian Shelf and Slope: New Records and an Evaluation of Richness from Latitudes 13° to 23° S

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Corals obtained during a Brazilian program to assess offshore living resources (REVIZEE), from 13° to 23° S, comprised 105 specific taxa (57 Octocorallia, 33 Scleractinia, 12 Antipatharia, two Stylasteridae, one Milleporidae). New records included seven families, 19 other genera, 17 other species, and a new species described elsewhere. Completeness of knowledge on the richness in the studied area was evaluated using indicators/estimators. These showed that coral *sensu latu* richness has not been thoroughly sampled yet. Depth distributions of species suggested the occurrence of groups at different depth ranges (up to 100 m, 100-500 m, below 500 m). Among 51 species that occurred in the shallower range, 28 (55%) were recorded exclusively from this range. Expansion of depth ranges were observed for zooxanthellate scleractinians. Depth range between 100 and 500 m is a transition zone, with 47 species/morphotypes that mostly occur also in shallower and/or deeper areas. Stations deeper than 500 m presented 41 species/morphotypes, most exclusive to the continental slope. Analysis of the distribution of coral diversity indicated a higher diversity triangular area, including the Abrolhos Bank, the Vitória-Trindade Ridge, and the Cape of São Tomé. Octocorals showed its highest diversity close to the Abrolhos Bank. Deep-water reef builders were identified - *Lophelia pertusa* and *Madrepora* sp. (two stations), and *Solenosmilia variabilis* (seven stations). This increased the number of areas that may harbor deep-water reefs off Brazil. Specimens of *S. variabilis*, from three stations, were collected with tissue, indicating live colonies in such localities.

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Status of Knowledge of the Azooxanthellate Coral Fauna off Brazil

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The azooxanthellate coral fauna diversity and its distribution off Brazil are reviewed, with data newly collected and compiled from the literature. A historical summary of studies and expeditions/cruises is presented. The Brazilian coast is more than 7000 km long and relatively few cruises and samplings have been performed in the area. Therefore, the knowledge of the azooxanthellate coral fauna is also fragmented, despite great contributions by Cairns (1979, 2000), whose specimens from Brazil total 45 species. A large increase in sampling occurred along the Brazilian coast during the last two decades, including some governmental actions such as the project "Assessment of the Sustainable Yield of the Living Resources in the Exclusive Economic Zone (REVIZEE)". Our results show the occurrence of 59 species of azooxanthellate corals off Brazil and suggest this number will increase as studies/collections are intensified. This species richness is high when compared with the low one concerning the zooxanthelate fauna (15 species) from shallow water coral reef and coral communities occurring in Brazil. At present, the ratio of azooxanthellate to zooxanthellate species is 4:1, contrasting to the ratio from the tropical-warm temperate western Atlantic (2:1). The present study also provides data on bathymetric and geographical distribution of *Lophelia pertusa* (records from 17º to 34ºS) and *Solenosmilia variabilis* (records from 09º to 34ºS), two major deep sea coral reef builders in Brazil. New and compiled information of the occurrence of cold water coral habitats are also provided.

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Azooxanthellate Coral Biodiversity in the Southern Caribbean

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Since 1998 to date a systematic exploration along the continental shelf and upper slope (depths ranging from 20 to 520 m) in Colombian Caribbean have been carried out by the Marine and Coastal Research Institute (INVEMAR), in order to complete the national marine fauna inventories. Through this research the knowledge about the Caribbean azooxanthellate coral fauna have been increased. Seventeen species of the 62 recorded for the Colombian Caribbean were first records. Two species, *Tethocyathus prahli* Lattig & Cairns, 2000 and *Stephanocyathus* n. sp were added to the 129 azooxanthellate species recorded in the Tropical Western Atlantic (TWA); one species of the Pacific that belongs to *Heterocyathus* genus was a new record to the Atlantic. Previously two biogeographic provinces have been defined for the TWA, subtropical continental and tropical insular. The occurrence of *Oculina tenella*, *Caryophyllia barbadensis*, *Fungyacyathus crispus*, which belonged to the subtropical province, in Colombian waters suggests that the biogeographical pattern is underhanded by information gaps. In addition, most of the Colombian azooxanthellate coral diversity occurred where *Madracis myriaster*, *Anomocora fecunda*, *Coenosmilia arbuscula*, *Cladocora debilis* and *Eguchipsammia cornucopia* could build carbonate structures. Solitary coral polyps, anthipatarians and octocorals, settle on them, suggesting that the recruitment in these areas might be a function driven by the bioherm accretion process through the generation of new spaces suitable to be colonized.

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Systematics of the Bubblegum Corals (Cnidaria: Octocorallia: Paragorgiidae) with Emphasis on the New Zealand Fauna

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Bubblegum corals, Paragorgiidae, are among the largest and most ecologically important benthic sessile deep-water organisms. This study covered 17 Paragorgiidae species. There seem to be a few trans-Pacific species or Atlantic species, but it is clear that no other species is as cosmopolitan as *Paragorgia arborea*, with discontinuous but bipolar distribution. There are cases of morphological sister species that correspond to the Atlantic and Pacific respectively, but the phylogenetic relationships of the remaining species indicate that most paragorgiid diversity and speciation took place in the Indo-Pacific region, as suggested by a number of sympatric species especially in New Zealand. Surface sclerites exhibit a great deal of variation under SEM, providing characters for phylogenetic reconstruction. The three most parsimonious phylogenetic hypotheses showed *P. arborea* as basal to the rest of the *Paragorgia* species (using *Sibogagorgia* as outgroup), which were divided in two clades. One clade includes the species with asymmetrical surface sclerites with some radial ornaments larger or different than others. The other clade comprises species with symmetrical surface sclerites. New Zealand, the richest location known so far, has 6 likely endemic species of *Paragorgia* intermingled in the two main clades as well as two species of *Sibogagorgia*. Consequently, the New Zealand fauna is both numerous and morphologically/phylogenetically diverse. This trend is not entirely surprising given that other sessile deep-water colonial organisms such as bryozoans, stylasterids, and bamboo corals have a deep-water diversity "hotspot" in New Zealand.

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Expressed Homeobox Genes in *Lophelia pertusa*

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Little is known about the factors that regulate the development of corals; however, genes that are known to be present in corals and that do affect development are members of the so-called homeobox gene family. Homeobox genes belong to a phylogenetically widespread family of regulatory genes that have been shown to play important roles in pattern formation and cell-fate specification in several model systems (*Drosophilia, C. elegans, Hydrozoa, Nematostella,* and *Metridium*). These genes have been found in all metazoan phyla that have been surveyed, as well as in plants and fungi. They encode proteins which serve as transcription factors and consequently regulate other genes and gene products. Interruption of these gene functions by mutation or modulation results in dramatic changes in body plan and development. To begin to investigate the molecular aspects of *Lophelia pertusa* development, we have analyzed the structure of members of the homeobox family in this cnidarian. A newly developed methodology is being used to identify *Lophelia pertusa* homeobox gene family members and follow their differential expression patterns during development. The goal is to identify genes whose expression is up-regulated at times of sexual reproduction thus yielding tools to evaluate coral reproductive potential, as well as genes that are up-regulated during growth that can serve as monitors of general coral health.

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Poster Abstracts

Theme 2 – Habitat Mapping, Sampling, and Characterization

Listed alphabetically by presenting author and abstract title.
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Distribution of Corals on Derickson Seamount, a Deep Seamount Near the Aleutian Chain of Alaska

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Derickson Seamount, a deep seamount just south of the Aleutian Islands, was explored for deep-sea corals and benthic megafauna, using ROV transects and video analyses. This was the first survey of this seamount and the deepest *in situ* survey of deep-water corals that has been undertaken. It is also the first sampling of corals deeper than about 2000m in this region of the world. Using the ROV JASON II, one vertical transect was conducted on the eastern slope of the seamount from near the base of the seamount at about 5200m, to the summit at about 2766m. A second transect was conducted on the northern side of the seamount from 4800m to 4000m.

The minimum depth of the seamount was below the maximum known depth for most deep-sea octocoral families. Not surprisingly, most of the corals collected from the seamount were new to science, extending the known depth range for their genus or family by up to 1000m. Many corals also significantly extended the northern geographic range for their genus or family. At least 5 species of Antipatharians and 17 species of octocorals in the families Primnoidae, Isididae, Chrysogorgiidae and Paragorgiidae were collected. Of these at least 10 are new to science. Soft-sedimented areas of the seamount had an abundance of solitary scleractinians in the family Fungiidae.

There was a difference in species composition and abundance between the two transects. Suggesting that surveys of seamount corals and other benthic megafauna may be biased by sampling on only one side of a seamount.

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Distribution of Deep-Sea Corals on the Northern Chain of Seamounts in the Gulf of Alaska

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Five seamounts in the northern seamount chain in the Gulf of Alaska were surveyed for deep-sea corals using the submersible Alvin. The goal of this study was to document the corals present on these seamounts and to compare species composition, abundance and diversity between seamounts. Horizontal transects were conducted along depth contours at approximately 700 m, 1700 m, and 2700 m. CTD and oxygen profiles were also collected at each seamount.

We collected over 140 coral specimens from 5 seamounts representing at least 43 species. Overall the Primnoid, Paragorgiid, Paramuriceid, and Isidid octocorals as well as Antipatharians were the most abundant groups. Only 2 species of scleractinian were observed and collected at only 1 seamount. Corals were most abundant on the shallowest depths of each seamount, with Paragorgiids and Isidids being the dominant families at 700m. Along the 2700m transects, Primnoids were the dominant family. The 1700m depth zone had the fewest corals and lowest diversity and were dominated by Antipatharians and Primnoids. This depth range fell within the oxygen minimum zone for these seamounts.

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Distribution of Deep-Sea Corals in Relation to Geological Setting in the Northwestern Hawaiian Islands

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Deep-sea coral communities on three seamounts in the Northwestern Hawaiian Islands (NWHI) were investigated using the Pisces V submersible. These are some of the first *in situ* surveys of NWHI seamounts and among the only surveys of deep-water corals below 500m that have been undertaken in the Hawaiian Archipelago. Horizontal transects were conducted along depth contours at approximately 600m, 1200m, and 1800m.

Most of the known species of Hawaiian octocorals were collected during these surveys as well as 17 species of octocorals and Antipatharians that were new to science. Very high density and high abundance octocoral communities were observed on topographic highs in the presence of strong currents, between 1450m and 1800m depth. These communities had a diversity of corals, dominated by several species of Isidids as well as Coralliids, Paragorgiids, and Chrysogorgiids. Sponges were also very abundant in these areas, some as large as 1-2 m across. Over a large area of a ridge on Pioneer Bank, the coral and sponge community was so dense, the underlying manganese-encrusted basalt was hidden from view.

In general, corals were found wherever there were hard substrates, oriented into the prevailing water currents and crowded onto sharp ridges, walls, or promontories that were devoid of sediment. Various substrate types were encountered, but it appears topography and flow regime are more important factors in determining coral distributions.

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Sponge Reefs on the Western Canadian Continental Shelf: New Multibeam Results Provide New Opportunities for Ocean Management and Science

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Multibeam surveys have revealed the form and organization of hexactinellid sponge reef complexes on the western Canadian continental shelf. Four large (> 100 km^2) reef complexes and three small complexes (< 10 km^2) have been mapped using multibeam bathymetric and backscatter data. The reefs are built by framework skeleton sponges of the Order Hexactinosida which trap clay-rich sediments resulting in a distinctive pattern of low intensity backscatter as compared to the more reflective glacial sediments of higher backscatter intensity upon which the reefs develop. The reefs are similar in some ways to Norwegian margin *Lophelia pertusa* reefs, as they have developed on a relict, glacial foundation of iceberg scour marks in deeper shelf waters. The largest reefs are up to 21 m in height and are up to 9,000 years old, and the largest of the reef complexes discontinuously covers 700 km^2. The setting and orientation of each complex is well described by these new digital data which allows for the discrimination of individual reefs as small as 20 m in diameter. These maps provide the basis for the understanding of the developmental history of the reefs and their aerial extent. The reefs provide complex shelf habitat for many species of fish and invertebrates, including juvenile rockfish. However, groundfish trawling has extensively damaged this habitat over many areas. These new data will permit sustainable fisheries management, allow accurate planning of detailed scientific studies, and offer a way to directly compare the geomorphology of reefs from different areas on the shelf.

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Southeastern U.S. Deep-Sea Corals Initiative (SEADESC): Exploring and Characterizing Deep Coral Communities of the South Atlantic Bight

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The Southeastern U.S. Deep-Sea Corals Initiative (SEADESC) is a collaborative effort to characterize known deep-sea coral habitats in the South Atlantic Bight (SAB) with the use of data collected during cruises sponsored by NOAA Ocean Exploration and the NOAA Undersea Research Center. The effort will focus on 12 deep-sea coral related expeditions that conducted over 160 dives with the *Johnson Sea-Link* submersibles on the deep-water coral reefs of the SAB. These 12 cruises collected extensive data on deep-sea corals and their associated communities, including more than 400 h of digital video. The objectives of SEADESC are to: (1) characterize known locations of habitat-forming deep-sea corals with the use of data collected during these 12 cruises, (2) facilitate the use of this information for management, education, and outreach activities in the region, and (3) prioritize areas for on-going deep sea corals exploration and research in the SAB. To accomplish these objectives, four distinct products will be developed: (1) a dive summary form for each dive that includes a list of the metadata and data collected during the dive, a summary of the observations, a 3-D dive track containing information on representative habitats observed, and still images of the same representative habitats, (2) site characterization forms, which represent a compilation and summary of all dives conducted within a given site (e.g., Cape Lookout), (3) a supporting database, and (4) a web-based digital atlas that provides public access to this information. This presentation will provide an overview of these products and their application.

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Preliminary Discoveries of Scleractinian Coral *Lophelia pertusa* and other Deep-sea Coral and Sponge Communities in the Olympic Coast National Marine Sanctuary

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The deep-sea hard coral *Lophelia pertusa* was discovered during remotely operated vehicle (ROV) surveys off the Washington coast, Northeastern Pacific Ocean, in June 2004. Video photographs of the area were taken and voucher specimens were collected in 271 meters of water within the boundaries of the Olympic Coast National Marine Sanctuary (OCNMS). Potential coral habitat had been selected based on prior acoustic surveys of presumed hard bottom areas with some relief features. A large proportion of these corals consisted of dead and broken skeletal remains, and a broken gorgonian was also observed nearby. The source of these disturbances is not known, although evidence of fishing gear impacts to the benthos, such as bottom trawl marks and long-line gear, were found in the same vicinity. Associated benthic communities, based on preliminary identifications of ROV video footage, consisted of sponge fields, other macro-invertebrates, and up to twenty-eight species of demersal fish, including many commercially important rockfish.

The 2004 survey was conducted under a partnership between the NOAA's National Centers for Coastal Ocean Science (NCCOS) and the National Marine Sanctuary Program, and included scientists from the OCNMS, NCCOS, and several other State, academic, private, and tribal research institutions. Plans are underway for a follow-up survey in 2006 with these partnerships and additional funding from NOAA's Office of Ocean Exploration, to map and delineate the *Lophelia* patches and to explore new target sites. It is essential to expand our knowledge of these deep-sea communities and their vulnerability to potential anthropogenic impacts in order to determine the most appropriate management strategies.

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CANCELLED -- Biomapper and KGSMapper: Two Modeling Techniques for Predicting Deep-Water Coral Habitat

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The ability to accurately map marine habitats and species distributions is essential for effective conservation and resource management. The generation of such maps, however, is particularly challenging for poorly-sampled deep-sea species. Predictive modeling is a spatial analysis technique which can be used to map poorly documented habitats. In this study, we compare two predictive modeling techniques - Biomapper and KGSMapper. Both are modeling programs that determine habitat suitability using presence-only data. Our analysis focuses on comparing the size and location of suitable habitat generated from each modeling technique as well as the overall robustness of each model. Suitable habitat is determined based on quantitative relationships between physical oceanographic factors and biological data. These oceanographic factors include slope, bottom current, productivity (chlorophyll *a*) and bottom temperature. This study examines the global distribution of several families of deep-water corals and demonstrates that these tools are useful for predicting deep-water coral habitat at both regional and global scales.

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Campos Basin Deep Sea Coral Communities (SE Brazil) - Preliminary results

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Deep-sea coral communities have wide distribution in terms of latitude and depth. However, these communities are almost unknown in the South Atlantic Ocean. The present study is part of the "Campos Basin Deep Sea Coral Assessment Project", conducted by the R&D Center of the Brazilian Oil Company, Petrobras. A preliminary survey was carried out between 800 and 1000 meters during November 2004, exclusively at Campos Basin south region. Images of benthic communities were taken with remotely operated vehicles in 8 selected areas, most of them with previous side scan sonar information. The areas presented different sizes: 200 X 400 m (N=3), 400 X 400 m (N=1) and 450 X 500 m (N=4). Parallel transects (50 m far) were designed along each area in order to evaluate the presence of coral banks. 850000 m^2 of sea floor were investigated and near 90000 m^2 were covered by coral banks (around 9%). The banks varied in shape, size and height: while the smallest had rounded shapes, the biggest ones were elongated. The mean size of the banks was 1453,0 ± 250,0 m^2 (mean ± SE) and the mean height was 2,01± 0,14 m (mean ± SE).

The macroufaunal community was composed mainly by corals (Scleractinia, Actiniaria, Gorgonacea, Alcyonacea and Pennatulacea), sponges (Hexactinellida), echinoderms (Ophiuridae, Asteroidea, Holothuroidea and Crinoidea) among other invertebrate taxa (Crustacea, Mollusca and Polychaeta). Some fishes were also registered (bony and cartilaginous taxa). Further taxonomic identification will reach the lowest level possible along the project.

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Deep Sea Coral Assessment Project - Campos Basin (SE-Brazil)

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Off Brazilian coast, few are the studies on these communities and most of them with geological focus. In order to map and evaluate the coral communities in some offshore southeast Brazilian areas, the R&D Center of the Brazilian Oil Company (Petrobras) has recently implemented the "Campos Basin Deep Sea Coral Assessment Project". The main aims of this project are to characterize the coral banks in the target areas and to assess the effectiveness of the side scan sonar (SSS) information available as a tool for mapping these banks.

Remotely operated vehicles (ROV) surveys have been carried out in previously selected areas, some of them with SSS information. All images taken during these expeditions are recorded in S-VHS tapes for further megafaunal analysis. Some features of the coral banks such as shape, size and height are also registered.

During the first survey in November 2004, discrepancies between the SSS information and the banks effectively delineated by ROV were noted (e.g. banks location through ROV surveys not matching with their respectively SSS high reflectivity areas). Other surveys are planned in the scope of the project for the next months in order to enhance our knowledge of the deep-sea coral banks at Campos Basin.

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Biotic and Abiotic Measurements across the Slope of Rockall Trough (400-1000 m, NW Atlantic) over a Cold-Water Coral Community with *Lophelia pertusa* and *Madrepora oculata*

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To enhance the knowledge about why deep-sea coral communities prefer a certain area, and to what extend they can alter their environment, the abiotic and biotic environment of a deep-sea coral community at the slope of Rockall Trough was mapped on an across slope transect. Measuring-stations were made in the following different environments on this slope: areas with a high coverage of living corals, areas with mainly dead coral debris, areas with sandy megaripples, and plains or canals below and between the main coral concentrations. At each station abiotic parameters, like currents, temperature, turbidity, fluorescence, oxygen-demand, particle flux and sediment characteristics were measured with a score of instruments, like bottomlanders, CTD, watersamplers and boxcorers. Of the same station biotic samples were collected to measure macrobenthic biodiversity, abundance and biomass. Video-mapping and near-bottom traps for scavenging amphipods and the larger mobile predators completed the overall picture of the animal community of the different environment.

The results are coming mainly from measurements and samples taken during a cruise with the RV Pelagia to the Rockall Trough in June-July 2005. This cruise and the research forms part of the EU-funded HERMES (Hotspot Ecosystem Research on the Margins of European Seas) project.

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Distribution and Abundance of Black Corals (Antipatharia) in Relation to Depth and Topography on the New England Seamounts (Northeast Atlantic)

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In May of 2004, the 'Mountains in the Sea' team deployed the ROVs *Hercules* and *Argus*, equipped with high-definition still and video cameras, on ten dives (> 110 hours of bottom time) to document deep-sea coral communities on five of the New England Seamounts (northeast Atlantic) between depths of 1329–2420 meters (and 3841–3879 m on Retriever Seamount). Voucher specimens were collected for at least 27 octocoral and 8 black coral species (species identification is ongoing). In this study we report on the distribution and abundance of antipatharians (black corals) observed in the video transects.

Antipatharians have variable growth forms, sizes, and colors, and identification of some species on video is difficult, particularly from higher altitudes (observations were made from altitudes of <5 meters above the substrate). We classified the taxa into 7 types based on comparison to voucher collections: *Bathypathes*, *Leiopathes*, *Parantipathes*, *Plumapathes*, *Stauropathes*, *Stichopathes*, and "other black coral" (which includes unidentified/uncollected specimens and poorly-seen specimens that may be one of the other types). Smaller and thinly branched antipatharians, such as bottlebrush-like *Parantipathes*, blended into the landscape and may have been missed when the ROV flew at higher altitudes. Thus our density and distribution data are minimum estimates.

Our preliminary data show the distribution of antipatharians is patchy both within and between seamounts. Species of *Bathypathes* and *Stauropathes* were most abundant, and *Plumapathes*, typically the largest colonies, were rarest. *Stichopathes* were particularly patchy, with all 41 observations coming from a single dive on Manning Seamount.

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Autonomous Underwater Vehicle Design for Sampling the Deep Ocean Floor

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A specialized deep-ocean autonomous vehicle has been developed for the specific task of episodic surveying and sampling over a wide spatial range. Exploration by such means is a recognized need in the oceanographic community, because access to the deep ocean floor using the major assets (such as *Alvin*) is highly competitive, and exploratory missions are difficult to justify. The paradigm is well-suited to the survey and monitoring of deepwater coral, since the corals are difficult to detect acoustically and have broad spatial extent.

An inexpensive vehicle thus designed for very short but deep missions offers several unusual capabilities. The vehicle is not intended for extended survey, and so dive and ascent times are minimized through substantial streamlining and drop weights. Also in the interest of keeping missions short, several levels of navigation accuracy are considered: at one extreme, the vehicle descends with no real navigation except GPS at the surface, while at the other extreme, an ultra-short or long-baseline system is used in the conventional way for absolute positioning. A natural tradeoff occurs wherein the fastest missions – on the order of one hour for 3000m depth – have to occur with minimal navigation.

We detail the potential uses of the vehicle concept, with focus on deepwater coral, and present results of engineering trials.

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How Computer-Assisted Interpretation Can Improve the Mapping and Monitoring of Potential Habitats in Cold-Water Coral Reef Settings

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Sidescan sonar is a useful tool for delineating and monitoring different potential habitats within a coral environment (e.g. live or dead coral reef, sediment covered reef framework, background sediments etc.), as it is relatively easy to deploy and highly cost-effective. Facies maps can then be created by visual interpretation of the imagery, but any consistency in this work relies with the human interpreter, and two people might interpret the same imagery differently.

By taking advantage of the fact that imagery, such as sidescan sonar, is best described by its texture, we use texture analysis techniques, e.g. Grey Level Co-occurrence Matrices (GLCMs), combined with supervised or unsupervised classification, for the interpretation. This method calculates statistical indices that quantify the distribution of grey levels and their spatial relationship within the image, and classifies each image pixel according to the combination of its resulting textural indices. This way, texture analysis can be a useful tool to make facies/habitat mapping from sidescan sonar easier and faster, revealing details possibly overlooked during visual interpretation.

In addition to these advantages, preliminary tests on repeated sidescan sonar surveys with variable frequencies or different systems indicate that similar textural results are obtained and that the major features are mapped consistently in the different surveys over the same area. However, validation of details by an experienced interpreter is still necessary, and therefore visual and computer-assisted interpretation should be used as complementary tools in habitat monitoring.

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Development of New Methods for Mound-Scale Habitat Mapping and Invertebrate and Fish Community Structure Analysis, Coupling Microbathymetry, Mosaïcking and GIS: Exemple of the Theresa Mound off Ireland

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The French-Irish-EU research mission CARACOLE (Carbonate Mound and Cold Coral Ecosystems) visited five deep-water coral locations in the Irish Porcupine Seabight and Rockall in 2001, with the ROV Victor 6000. Trials of a new "module" on Victor including the multibeam sonar Reson Seabat 8101 for microbathymetry and a vertical camera with two HMI lights were realized during one long-time dive on the 100m high Theresa Mound located at 850 m depth in the Porcupine Seabight. Very accurate bathymetric map was obtained on a 600*700m area with a metric horizontal and a decimetric vertical accuracy. This map evidenced for example ripple marks along some flanks, and at some places trawls impacts between corals. Optic mosaics from video images were obtained using the MATISSE software developed at Ifremer, along transects across the mound. The Adelie software, based on ArcGIS also developed at Ifremer for submersible data post-processing was used to numerate and map large size invertebrate species and fishes along the dive tracks. Fish densities were estimated using a new Adelie tool using standardized surface sampling unit.

Microbathymetry, mosaïcs, and post-processed data are geo-referenced in a GIS environment and subsequent spatial analyses allowed to (i) map distinct habitats defined by the coral coverage (dense, sparse, coral boulders, sand), (ii) evidence spatial patterns of megafauna at the mound scale, estimate densities of several fish species (iii) localize fishing gear impacts. Major results include a correlation between bathymetry and coverage of *Lophelia pertusa*, a zonation according to depth along the mound flanks with the anthipatarian *Leiopathes glaberrima* and the hexactinellid sponge *Aphrocalistes* sp. at the base of the mound and the gorgonian *Paramuricea placomus* at the top. Multivariate analyses did not evidence spatial structuration of fish community at the mound scale, but density of *Lepidion eques* was significantly larger compared to those estimated by ROV in the Bay of Biscay and by trawls in the Porcupine SeaBight. These new methods will be useful to follow the natural trend of community structure and re-colonisation processes of damaged areas. A such long term study on Theresa mound was initiated during a cruise in June 2005 on the Irish RV Celtic Explorer in the framework of the European Hermes program where Theresa mound was identified as a key area to study biodiversity and impact on cold coral communities.

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Observations and Comparisons of Californian Seamount Communities

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Seamount communities have been observed using remotely operated vehicles (ROVs) at the Monterey Bay Aquarium Research Institute (MBARI) and were recorded using high-resolution video equipment. In order to determine seamount community compositions, 120 hours of video representing 12 dives on Davidson, Guide, Pioneer, and Rodriguez seamounts off the coast of California, USA, were annotated in detail using the Video Annotation and Reference System (VARS). Nearly 100,000 individual observations were annotated and added to the VARS database while reviewing these dives. The majority of the observations are biological with over 100 total species collected and identified by taxonomists, including more than 20 coral species.

Queries of the VARS database for all observed taxonomic groups were spatially analyzed using ArcGIS in an effort to describe the community structure and compare patterns of abundance and diversity between the different locales. Due to the nature of the collection methods, the data must be interpreted as semi-qualitative; nevertheless results are valuable in that they reveal patterns not normally discerned with traditional sampling methods in this harsh environment. These observations will also be useful to policy makers and sanctuary managers in determining if protection and subsequent incorporation into marine protected areas is warranted based on rarity of habitat and or species found.

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Spatial and Temporal Differences in Size Structure of Hawaiian Black Corals

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Hawaii has three known areas of high black coral densities. These areas (Kauai, Maui, and south Hawaii) have been commercially harvested at different intensities. Among these areas, Maui has the largest and most diverse habitat for black coral as well as the greatest fishing pressure. In addition, a portion of the Maui black coral population (Auau Channel) suffers from an invasive soft coral. The Auau Channel population provides an opportunity to examine the impacts of fishing pressure and an invasive soft coral on the size structure as well as the differences of the size structure in different habitats.

The size structure of the Auau Channel population has been historically documented by Grigg (1976, 2001, 2004). In fall 2004, 1421 colonies were measured for individual colony height, depth, location, and species in the Auau Channel. This dataset allows the population to be analyzed for temporal changes from 1975 to 2004 as well as spatial differences in the population. In addition, colony measurements were taken on Kauai and will be compared to the Auau Channel population.

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Colonization of *Lophelia pertusa* on the Tanker *Gulfpenn* Sunk During WWII in the Northern Gulf of Mexico

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On May 13, 1942 the 146 m tanker *Gulfpenn* was struck by a torpedo from the German submarine U-506 and sank in 544 m of water 60 km south of the Mississippi Delta. In the summer of 2004 the wreck was surveyed with an ROV as part of an MMS/NOAA-OE/NOPP sponsored archaeological and biological study. *Lophelia pertusa* was observed to have colonized 10-12% of the wreck. It appears to have developed most successfully on vertically oriented (hull, bulwarks, superstructures), upright (davits, railings, masts), raised (catwalks, deck piping), or open (booms, rigging) surfaces and structures. Overall, the most extensive growth is occurring on the starboard side and on catwalks and deck piping along the port side of the aft deck and foredeck. At numerous locations colonies are coalescing into thickets. The largest development is a 6-7 m high by 3-3.5 m wide aggregate of at least 5 or 6 colonies growing from the main deck/bulwarks level to above the top of the pilot house on the forward starboard corner of the main superstructure. This vertical assemblage of colonies has formed what amounts to an upright thicket. Generally, little or no colonization has occurred on most deck areas and other horizontal surfaces. One notable exception is mid-ships aft of the superstructure where colonies are growing on a deteriorating region of the deck beneath a coral encrusted mast and boom. Colonies were also found living on the sediment adjacent to the hull and on wreckage scattered about in the adjacent debris field.

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Acoustic Facies Analysis of Late Quaternary Deep-Water Coral Mounds in the Tyrrhenian Sea

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Late Pleistocene to Recent azoxanthellate deep-water coral mounds were recently described from the continental slope of the Tuscan Archipelago (NE Tyrrhenian Sea) between 355-410 m at c. 43°13 Lat N and 09°36 Long E. These low-relief patch reefs occur as discrete mounds many tens of meters wide and up to 3–4 m in height. *Madrepora oculata* is the major frame builder, in association with *Lophelia pertusa* and *Desmophyllum dianthus*. Previous bathymetric data and sediment samples documented that these mounds are at present partially buried by hemipelagic deposits, hampering a refined mapping of these coral habitats.

To achieve a better resolution of coral mound distribution and unravel their relationship with seabed morphology, we have conducted an integrated geophysical survey of the area by means of detailed multibeam bathymetry, high-resolution seismics and side scan sonar records. These data have been used to construct reflectivity maps of the seabottom and shallow subsurface permitting to distinguish various acoustic facies. From our data it appears that coral mounds are arranged as clusters of distinct 'strings' oriented N-NW/S-SE. Their distribution is uneven being localised on the seaward shoulder bordering a major bathymetric depression where bedrock sedimentary units are exhumed, providing a suitable firm or hard substratum to coral growth. Seabed morphology documents also the existence of strong currents. We suggest that these deep water coral mounds were (latest Pleistocene) and are controlled by the interplay of geological and oceanographic causes.

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Distribution of Habitat-Forming Scleractinian Corals in the New Zealand Region

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In the deep-sea, corals are one of the most important benthic invertebrate groups found both on the hard substrates of seamounts and over areas of comparatively flat deep-sea reef. Corals can provide habitat for a variety of invertebrate species and fishes.

The New Zealand region possesses one of the world's most diverse deep-sea coral faunas. Understanding the distribution and relative abundance of the deep-sea corals in the region, particularly matrix-building scleractinian or stony corals, is essential in order to fully appreciate the ecological importance of these taxa and the likely impact of anthropogenic activities on their persistence.

Historical data and new records from seamount-related research sampling for the matrix-forming stony corals *Madrepora oculata*, *M.vitiae, Solenosmilia variabilis*, *Goniocorella dumosa*, *Enallopsammia rostrata*, and *Oculina virgosa* were analysed. Analysis revealed the distributional patterns for these species and their association with seamounts and other environmental variables for the New Zealand region.

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Distribution and Abundance of Gorgonian Octocorals on the New England Seamounts in Relation to Depth and Substrate

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As part of NOAA's Ocean Exploration program, five seamounts (Bear, Retriever, Balanus, Kelvin, and Manning) in the western half of the New England seamount chain have been investigated using the submersible *Alvin* and the ROV *Hercules*. A total of 16 dives have been conducted, with most occurring on two of the peaks in the Manning Seamount complex.

Each seamount was surveyed for from 5 to 17 hours, approximately, covering an average altitude on the seamount of 200-300 m between depths of 1329 – 2420 meters (and 3879-3841 on Retriever Seamount). Each dive is continuously recorded on videotape.

Voucher specimens of approximately 32 octocoral species in 26 genera were recovered. These include members of the Acanthogorgiidae, Anthothelidae, Paragorgiidae, Chrysogorgiidae, Primnoidae, Isididae, among others.

Octocorals were found from the deepest parts of the seamount slope sampled (3879 m) to the summits. An unknown chrysogorgiid and an unknown primnoid were the only two species found at deepest station. In general, chrysogorgiids and isidids were found on the seamount slopes and paragorgiids at or near the summits. Coralliids were especially common on slope areas where the substratum consisted of cemented basaltic debris. A complete distribution pattern for all octocoral species encountered will be presented.

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Large-scale Associations between Habitat, Fish and Corals

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Off the coasts of Washington, Oregon and California there has been an increased interest in protecting deep-sea coral communities. However little coastwide information is available to study patterns and associations. In the absence of data collected expressly to survey corals, we made use of existing historical information collected during bottom trawl surveys and by fishery observers to examine the relationships between benthic habitat and corals, and their association with demersal fishes. Fishery independent trawl data came from NMFS bottom trawl surveys conducted from 1977 - 2003. Trawls were ca. 16 m wide and 2 km in length and ranged in depth from 80 to 1300 m. Fishery dependent data came from bycatch records collected since 2001 by observers of commercial vessels fishing both mobile (e.g., bottom trawl) and fixed (e.g., longline, pot) gears. We have used these data to examine large-scale (i.e., kilometers) associations. For example, we asked (1) over what type of habitats were corals caught and (2) did the assemblage structure of fishes caught in trawls that contained corals differ from that of coral free trawls? While not specifically designed to assess fish/coral/habitat associations, these data can give us some insight into patterns in trawl-accessible areas. Implications for fisheries practices and coral conservation will be discussed.

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Poster Abstracts

Theme 3A – Geology: Palaeontology

Listed alphabetically by presenting author and abstract title.
Presenting authors appear in **bold**.

Environmental and Spatial Distribution of Mediterranean Cold-Water Corals

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This study reports on the spatial distribution and the environmental parameters of cold-water coral species in the Mediterranean Sea. The results are based on literature, fishermen information, taxonomic and physical environment studies of cold-water coral collected in a regional GIS. Late Pleistocene to recent cold-coral growth is well documented in the entire Mediterranean basin. To date 16 calcareous cold-water species have been reported in the Mediterranean Sea. Cold water coral diversity is highest in the area of the Strait of Gibraltar, at the gateway between the Atlantic Ocean and the Mediterranean Sea and decreases eastwards. Nevertheless a few rare locations are reported of concentrated living cold-water corals. Cold water coral occur in the Mediterranean between 39m - 2500m waterdepth. Living cold-corals are rarely reported and have been described in the Strait of Gibraltar (200-300m) in a canyon system off shore Catalonia (110-150m) and the Ionian Sea at about 300-700m waterdepth. Most coral occurrences are situated at positive seafloor irregularities such as seamounts, canyons heads and local steep slopes. Only at particular locations the corals have formed a thickest and inside the deepest part of the Strait of Gibraltar coral banks. The dominant living cold-water corals in the present setting are the framework builders *Lophelia pertusa* and *Madrepora occulata*. Living coral occurrences seems to be associated by peculiar oceanographic conditions such as the interaction between fresh and marine waters in canyons, seamount turbulence and inside oceanographic gateways (Strait of Sicily and Gibraltar).

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New Insights into Stable Isotope Fractionation in Deep Sea Corals: Comparison with the Fossil Record

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Stable isotope analyses on the skeletons of recent non-zooxanthellate deep-sea corals have revealed significant changes in the C and O isotopic composition across the skeletal elements, with the trabecular axes showing extremely depleted C and O compositions (Adkins et al., Geochimica Cosmochimica Acta, 67: 1129-1143). These variations have been interpreted as resulting from differences in the rate of precipitation, with higher pH values at the trabecular centers promoting more negative stable O and C compositions. Such extremes should not be present in zooxanthellate corals whose isotopic compositions are 'buffered' by algal symbionts. We have attempted to replicate this approach on modern and ancient corals (Triassic) in order to ascertain whether these ancient corals possessed zooxanthellate. In addition to C and O isotopes we have also measured the Sr/Ca, Mg/Ca, and Ba/Ca ratios in these ancient corals. Preliminary results on corals, which were previously interpreted as being zooxanthellate, suggest that the pattern of minor elements and stable isotopes is similar to that observed in deep-sea corals and that therefore these corals might be non-zooxanthellate. Current work is attempting to replicate previously observed patterns in deep-sea corals as well as shallow water zooxanthellate species.

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Last Glacial Deep Water Corals from the Red Sea

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During the last glacial epoch the hydrological exchanges between the shallow-silled Red Sea and the Indian Ocean were significantly restricted and possibly even interrupted, resulting in salinity exceeding 50 per mil. This high salinity phase is thought to have been lethal to the Red Sea stenoecious ecosystems including shallow and deep water corals. Even at present, the Red Sea basin is characterised by significantly high-salinity and warm (up to c. 23°C) deep waters exterting an important control on its deep sea benthos that appears little diverse and quantitatively scarce.

Geological dredging of the central Red Sea axial troughs and seamounts conducted by Italian research vessels in 1979 (cruise MR79 of cableship *Salernum*), 1983 (cruise MR83 of RV *Bannock*) and 2005 (cruise RS05 of RV *Urania*) sampled deep-water subfossil scleractinian corals associated with carbonate hardgrounds at depths below 350 m. The recovered coral material consisted of three different colonial and solitary taxa heavily patined by Mn-Fe oxides. Preliminary MC-ICPMS U/Th-dating of coral sample MR83-10 unveiled a glacial age of 26.590 +/- 120 yr documenting a phase of deep-coral growth in the Red Sea just before the onset of the lethal basin-wide high-salinity conditions.

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Serpulid Tube-Worms (Annelida Polychaeta) on Deep Coral Mounds from the Ionian Sea (Eastern Mediterranean)

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Presented by: ***Agostina Vertino***

Since Serpulids are a common element of deep coral banks in the Atlantic and in the Mediterranean as well, they have been only occasionally mentioned in literature. Serpulids associated with a deep-water mound with living and dead scleractinians off Apulia (Santa Maria di Leuca, Eastern Ionian Sea) have been investigated. The encrusted substrates consist of dead scleractinian branches (*Madrepora oculata*, *Lophelia pertusa*, *Desmophyllum dianthus*) and fragments of a Pleistocene near-coral hardground, both sampled at depths of 670 and 900 metres.

The associated epifauna is scant and poorly diversified, serpulids being the most representative group. Notwithstanding the high coverage values of serpulid tubes, they are subordinate in the coral mound building, scarcely contributing to the carbonate production because of the small size of dominant species.

A total of eight species have been detected, almost entirely showing empty tubes (thanatocoenosis and taphocoenosis). *Filogranula gracilis* greatly prevails, the only species possessing a few living specimens. *Metavermilia multicristata* is subordinate, followed by *Hyalopomatus variorugosus*, *Vermiliopsis monodiscus*, *Filogranula stellata*, *Semivermilia agglutinata*, *Neovermilia falcigera* and *Hyalopomatus marenzelleri*.

All taxa are typically representative of deep- and cold-water serpulid assemblages, known on recent or Plio-Pleistocene deep scleractinians from the Mediterranean. *N. falcigera* and *H. marenzelleri* are presently living in the NE Atlantic and are not colonising the recent Mediterranean where they are found as fossils. Thus, they document a prolonged history of coral growth on this area. The other recovered species are endemic Mediterranean (*V. monodiscus* and *H. variorugosus*) or posses a NE Atlantic and Mediterranean distribution.

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Poster Abstracts

Theme 3B – Geology: Climate Change

Listed alphabetically by presenting author and abstract title.
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Geochemical Ecology of a High Latitude Coral: *Plesiastrea versipora* a New Paleo-Environmental Archive

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Corals growing in high latitude waters are sensitive to changes in climate, especially seasonal fluctuations in sea surface temperature. The annual bands of *Plesiastrea versipora* were calibrated using U/Th ages derived from multi-collector ICP-MS analyses and the resulting extension rates varied from an average of 1.2 mm yr^{-1} to 7 mm yr^{-1} for different colonies. High resolution (~ fortnightly) laser-ablation ICP-MS analyses of Ba, B, Sr, U and milled $\delta^{18}O$ and $\delta^{13}C$ analyses were obtained from an 800 mm (~400 year) core *of Plesiastrea versipora* from Gulf St Vincent (34.5˚S), South Australia. There was a significant correlation between $\delta^{18}O$ and Ba/Ca (r^2= 0.82) and a significant inverse correlation was observed between $\delta^{18}O$ and $\delta^{13}C$. The trace elements and $\delta^{18}O$ were compared to *in situ* sea surface temperature (SST) and satellite (IGOSS) records, with significant correlations observed for $\delta^{18}O$ and Ba/Ca. A SST linear regression provided the calibration equation for Ba/Ca (μmmol/mol) = 7.53 (±0.49) – 0.17 (±0.022) SST (˚C). Barium may not have been recognised as a temperature proxy in previous studies due to the smaller temperature range for lower latitude environments (~5°C versus 12°C for this study) and other factors masking the Ba signal such as terrestrially-derived or upwelled sources. Hence, the evidence given in this paper suggests that *Plesiastrea versipora* may be useful as a coral paleoclimate archive in high-latitude environments, recording large seasonal variation in both temperature and productivity regimes with high fidelity.

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Radiocarbon Reservoir Age of North Atlantic Surface Water Inferred from Orphan Knoll Corals

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The $\Delta^{14}C$ value (reservoir age) of North Atlantic surface water is expected to vary according to the rate of North Atlantic Deep Water formation. Previous attempts to estimate the $\Delta^{14}C$ of North Atlantic surface waters indicate potentially large changes but these prior studies involve many unsupported assumptions. Here we present an alternative strategy to measure surface water reservoir ages via the use of corals collected from shallow seamounts or shallow ridges in the high latitude North Atlantic; sites which are rapidly ventilated by North Atlantic surface waters on an annual (e.g. deep winter mixing) or decadal time scale. These corals can be dated by paired $^{230}Th/^{234}U/^{238}U$ and ^{14}C dating techniques and the maximum reservoir age of North Atlantic surface waters supplying the coral site can be computed using our new radiocarbon calibration curve and $\Delta^{14}C$ reservoir age computation algorithm: (http://www.radiocarbon.ldeo.columbia.edu). In this demonstration study, paired $^{230}Th/^{234}U$ /^{238}U and radiocarbon dates were measured on *D. cristagalli* specimens from Orphan Knoll (50°26'N, 46°22'W; 1600 meters water depth), northwestern North Atlantic to estimate North Atlantic surface water reservoir age (maximum) during the last deglaciation. We numerically estimate the reservoir age by "back-tracking" the computed $\Delta^{14}C_{water}$ to the intersection with the $\Delta^{14}C_{atm}$ record computed from our radiocarbon calibration curve. We compute a reservoir age of 400 years for the Bolling-Allerod (samples date from 13ka to 14ka) deglacial climate interval when proxy records indicate that North Atlantic Deep Water reached its maximum strength after transitioning from sluggish glacial production rates.

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Elemental Imaging and Proxy Development in the Deep Sea Coral, *Corallium secundum*

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There is an increasing interest in developing proxy records of oceanographic conditions from intermediate and deep-water environments. Elemental and isotopic ratios incorporated in the calcite skeleton of deep-sea corals have been proposed as a method for obtaining this information. Before elemental proxies can be used, rigorous testing of elemental spatial variability and calibration is needed. Using the high-spatial resolution NanoSIMS 50 we examined the spatial variability of Mg/Ca, Sr/Ca and Ba/Ca ratios (potential temperature proxies) in 10 micron square images using a ~200nm size primary beam (O^-) in a thin-section of the deep-sea coral *Corallium secundum*. We found that the distribution of magnesium is not homogenous. There are many <1 μm features with Mg/Ca concentrations that are ~40% higher than the surrounding area. At this point we speculate that these features may be organic molecules rich in Mg, centers of calcification, or perhaps amorphous calcium carbonate. The Sr/Ca and Ba/Ca patterns are more homogenous; they do not show features related to the high Mg/Ca spots. The heterogeneity seen in the Mg/Ca ratio in this deep sea coral suggest that even if there is a temperature dependence of Mg/Ca the occurrence of these higher Mg/Ca locations may hinder the accurate reconstruction of water temperature using this proxy. The more homogenous Sr/Ca and Ba/Ca patterns will be compared to ambient temperature data from the region in order to test their viability as temperature proxies.

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Multiple Proxy "Vital Effects" in a Deep-Sea Coral

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$\delta^{18}O$, $\delta^{13}C$, Mg/Ca and U/Ca were measured in the deep-sea coral D. *cristagalli* to evaluate their use as paleoceanographic proxies. The tracers varied significantly within individual skeletons. Furthermore, they co-varied with skeletal morphology. $\delta^{18}O$ and $\delta^{13}C$ ranged widely and were linearly correlated except at the most depleted values. These most depleted values were located within the thin optically dense trabecular center. Mg/Ca was ~3 times higher within the trabecular center compared with surrounding aragonite. U/Ca was ~4 times lower in a region containing, but somewhat wider than, the trabecular center. Tracer variations in a homogenous deep-sea environment, an example of "vital effects", suggest we are measuring the biomineralization environment rather than oceanographic conditions.

Co-variation of tracers suggests a common mechanism. To understand this mechanism, a previously described isotope "vital effects" model[3] was expanded. In the open box-model biological pumping drives calcification. Originally only equilibrium isotope effects were considered. To make the model more general, the carbonate system was treated kinetically. Steady-state solutions including kinetics exhibited higher calcifying fluid pH for the same biological pumping. Similar $\delta^{13}C$ correspond to different pH in the kinetic and equilibrium models. Coupled with $\delta^{13}C$, a pH proxy might determine the extent of carbonate equilibrium during biomineralization. It is hopped that Mg/Ca and U/Ca ratios will further constrain the model.

[3]Adkins, J.F., et. al. *GCA*, 2003.

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Environmental Variability at Intermediate Water Depths Recorded by Bamboo Coral Geochemistry

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Geochemical studies of corals from the deep ocean have provided a unique view of the magnitude and rate of modern and paleoenvironmental change of the deep sea (>2500 m depth). Research has demonstrated that circulation and environmental change (e.g. temperature or salinity) at intermediate water depths (200-2000m) may also play an important role in forcing climate change as well as being a sensitive indicator of subtle changes in the ocean circulation system. Hence, it is of great interest to quantify the rate of change at intermediate water depths on short timescales, as well as to establish a baseline of natural environmental oscillations at these depths.

To address this problem, we are investigating the geochemistry of bamboo corals (Family: Isididae) that reside at intermediate water depths. A total of 19 living and dead coral specimens have been collected through collaboration with the Monterey Bay Aquarium Research Institute (MBARI), from 250-2200m water depths on the California margin. Preliminary radiocarbon dating of two coral specimens from 250m and 2000m depth suggest that bamboo corals live for decades to centuries, with growth rates of ~100 μm/year. While growth bands (annual to subannual) have been previously described in bamboo corals (Roark et al., 2005), we observe that some specimens have clear banding while others have diffuse or complex growth features. Trace elemental (Mg/Ca and Sr/Ca) and stable isotopic ($\delta^{18}O$) analyses indicate that the corals record temperature and geochemical changes on decadal-timescales and include distinct cyclical variations in Sr/Ca for the past several hundred years.

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Stable Oxygen and Carbon Isotope Composition of Extant North Atlantic *Acesta* spp. (Bivalvia:Limidae) Provide High-Resolution Environmental Archives for Cold-Water Coral Habitats

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Four *Acesta* species are known from Northeast Atlantic cold-water habitats: *Acesta excavata* between Newfoundland, the Norwegian Shelf and south to Angola, *A. angolensis* along equatorial West Africa, *A. bullisi* from the Gulf of Mexico and *A. colombiana* from the Caribbean Sea. These are the largest bivalves frequently associated with *Lophelia pertusa* communities. Their annual external banding pattern found within the shells provides wide stable isotope sampling intervals with good inter- and intra-annual resolution. Stable oxygen and carbon isotope variations across several annual growth increments obtained from a living *Acesta excavata* in Trondheimfjord (Norway) is in good agreement with recorded longterm monthly environmental timeseries of temperature and salinity - supporting its potential as paleoceanographic archive. Deviations from predicted equilibrium conditions are guided by kinetic vital effects and reach maximum depletion of up to 1.3 ‰ PDB $\delta^{18}O$ and 1.0 ‰ PDB $\delta^{13}C$. The extent of vital effects could be estimated by isochron transects, connecting contemporaneous fast-grown shell-portions to slow-grown shell portions, which are precipitated at equilibrium. Superimposed vital effects on the environmental signal are much smaller than for neighboring corals. Further isotopic sampling of *A. excavata* from the Faroes and Mauritania, in combination with investigations of *A. angolensis* from Zaïre, *A. bullisi* from the Gulf of Mexico and *A. colombiana* from the Colombian margin, exhibited clear latitudinal trends in seasonality and trophic regime. Ongoing isotopic investigation on radiocarbon-dated Last Glacial to Holocene *Acesta* from the Mediterranean basin provide high-resolution windows to paleoceanographic conditions at cold-water coral sites, monitoring temporal changes within intermediate watermasses.

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Shallow-water *Desmophyllum dianthus* from the Chilean Fjords: U-series Dating and *In-Situ* Trace Element Geochemistry

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Desmophyllum dianthus, recently discovered in surface waters of the Chilean fjords, provides a unique opportunity to study a cosmopolitan community normally found at bathyal depths. Here we report ages, growth rates, and nutrient element geochemistry in the skeletal components of *D. dianthus*.

The ^{238}U- ^{230}Th systematics of fossil and living specimens of *D. dianthus*, were determined using new, highly sensitive, MC-ICPMS techniques developed at ANU. Dating of the uppermost (living), mid-portion, and basal (oldest) sections from a 23 cm long skeleton gave ages of 7 ±3 yr, 22 ±4 yrs and 48 ±5 yrs, respectively. These samples have high [^{230}Th /^{232}Th] and hence insignificant detrital corrections. Assuming a constant +5 yr offset, determined from septa within the living coral tissue region (possibly due to ^{230}Th directly scavenged from seawater), then an age of ~42 ±5 years is obtained for the basal section. This basal age is consistent with the number of tabulae (~37 ±2) implying that they are secreted annually. Thus, within the first third of its life, this specimen grew at ~1 to 3 mm per year, similar to deep-sea rates, with growth accelerating to ~1 cm per year.

Correlated P, Mn, and Ba concentration profiles are exhibited in laser ablation ICP-MS scans of septa with P being a factor of x5 to 10 higher than in hermatypic corals. The potential therefore exists to use well-dated samples of *D. dianthus* as nutrient proxies, although the role of physiological effects remains to be constrained.

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Deep-Sea Bamboo Corals: Living Bone Implants

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Presented by: ***George Schmahl***

Deep-sea bamboo corals [Calcaxonia: Isididae] show promise in biomaterial applications. These jointed corals consist of bony calcareous structures alternated by proteinaceous nodes of gorgonin, giving the skeletal remains of the organism a unique fingerlike appearance. A comprehensive understanding of the bamboo coral internodes with respect to chemical composition, structure, and mineralization behaviour may prove to be a novel model for biomimetic synthesis of biomaterials. To test our hypothesis that bamboo coral internodes exhibit bone-like mechanical and biochemical properties, structural (SEM, TEM, AFM, LSM, XRD, FTIR, Raman) and biochemical (HPLC, PAAG-Electrophoresis) analyses of these natural biomineral composites and extracted proteinaceous components were performed.

The following results were obtained: Due to its high potential for colonisation with both human osteoblasts and osteoclasts, the organic matrix, composed of an acidic fibrillar protein framework, showed itself to be a very successful model for possible applications in tissue engineering. The resorption of the calcite-containing fragment of the coral implant was faster than that of bioceramics. The material properties of the coral axial internode measured, namely Young's modulus (160 ± 35 GPa, n=20), density (2.7 ± 0.02 g/cm^3) and flexural strength (107 N/mm^2) correlate well with the material property charts for materials used in orthopaedic surgery. On the basis of the high biomimetic potential of the results obtained, we propose that biotechnological processes for the aquacultural cultivation of *Isididae* corals as "living bone implants" should be developed in the near future.

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In-Situ High Resolution Minor and Trace Element Compositions in *Desmophyllum dianthus* from the Mediterranean Sea and the Pacific Ocean

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Azooxanthellate bearing deep-water corals may potentially preserve climatic signals and records of the intermediate and deep waters compositions unconfounded by the influence of symbiotic zooxanthellae. In order to recover unambiguous paleo-climatic signals an understanding of the fine-scale geochemical composition and influence exerted by different coral architectural elements is required.

Here we report on the minor and trace element systematics of three living specimens of *Desmophyllum dianthus* collected at different depth range in the Mediterranean Basin, in the Western and Eastern Pacific Ocean. U-series dating of the basal (oldest) parts gave ages of 49 ±14 yrs, 30 ±4 yrs and 48 ±5 yrs, respectively, indicating very large differences in growth rate (0.36 mm/yr, 1.46 mm/yr and ~ 3-4 mm/yr, respectively). The mid-plane and the outer faces of S1 septa in all the samples have been tracked using the high resolution (20 μm) pulsed laser ablation ICP-MS system at the Research School of Earth Sciences, ANU.

For all samples Sr/Ca in the outer face is positively correlated with U/Ca and negatively with Mg/Ca and B/Ca, which display strong positive correlation. On the other hand, the mid-plane exhibits a strong positive correlation between P, Mn and Ba. These different correlations between the two septal portions are interpreted as the result of analysing different coralline microstructures (i.e. fibrous aragonite versus centres of calcifications) controlled by different biomineralization processes. This demonstrates that in order to extract reproducible results that have environment significance, requires a thorough understanding of the physiological controls upon different architectural elements

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U-Series Dating of Submerged Sites Documents Continuous Growth of Extant Deep-Water Coral Mounds in the Mediterranean since 500 ky at Least

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The scleractinian corals *Lophelia pertusa*, *Madrepora oculata*, and *Desmophyllum dianthus* are major frame builders of modern deep-coral mounds in the Northern Atlantic Ocean and Mediterranean Sea. These taxa have been also reported from many Early Pleistocene outcrops in southern Italy and Rhodes (Greece) as well as from last glacial submerged assemblages in the entire Mediterranean basin.

We have analysed a large set of deep water corals of from Mediterranean submerged sites from the Alboran Sea eastward to the Ionian Sea. TIMS U/Th-dating documents deep-coral growth since c. 480 ky in the Strait of Sicily. Most ages, however, are clustered at around 13-11 kr (Strait of Sicily, northern Tyrrhenian Sea, Alboran Sea) and concern coral mounds at present buried by a thin veneer of muddy sediment at depths between 300-400 m.

We suggest that the abrupt decline of deep coral mounds inhabiting various sectors of the Mediterranean continental shelves was due to a sudden and dramatic silting pulse dlinked to the Younger Dryas climate change.

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Paleobiodiversity of the Plio-Pleistocene Deep-Water Corals from the Messina Strait (Southern Italy): NE Atlantic Affinity

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Exceptionally well preserved and rich Plio-Pleistocene coral assemblages crop out along the margins of the Messina Strait (southern Italy). Their affinity with the Recent NE Atlantic communities has been noticed since the 19th century (e.g Seguenza, 1864; Zibrowius, 1991), but detailed comparative studies are still missing.

As a result of the comparison of macro and micro-skeletal parts of the fossil specimens with the Recent species from the Mediterranean and the NE Atlantic, we present an overview of the deep-water coral paleobiodiversity from the Messina Strait. To date, over 30 species belonging to the order Scleractinia and the subclass Octocorallia have been recognised. Most of them are still living in the Bathyal Zone of the NE Atlantic Ocean, but less than 1/3 populate the "warmer" depths of the Recent Mediterranean Basin.

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Fossil Scleractinians from the New England Seamounts – Ancient DNA Techniques Give New Insights Into Past Climate Change – Preliminary Data

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Fossil scleractinians corals from NW Atlantic seamounts have been used to define major changes in intermediate and deep ocean circulation that coincide with large swings in atmospheric climate since the Last Glacial Maximum. However, the biological consequence of ocean climate change directly on ancient population phylogeography has not yet been investigated. The relatively recent development of stable techniques to extract ancient DNA (aDNA) from fossil and sub-fossil material has opened this avenue of research, with scleractinians that leave behind a hard aragonitic skeleton, being an obvious candidate for such techniques.

In 2003, fossil *Desmophyllum dianthus* and *Lophelia pertusa* were collected using DSV Alvin from two New England Seamounts and Muir Seamount (north of Bermuda) for paleoclimate data analyses (^{14}C , U-series data). Methods have been developed at WHOI to extract aDNA from these specific scleractinians skeletons, allowing us to elucidate historical patterns of gene flow and migration across these seamounts at times of climatic change.

This poster presents our preliminary data for aDNA extraction and amplification of the ITS1 and ITS2 gene regions and its context in the climate history of the New England Seamounts.

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Poster Abstracts

Theme 4 – Coral Biology: Feeding, Growth and Reproduction Characterization

Listed alphabetically by presenting author and abstract title.
Presenting authors appear in **bold**.

Responses of *Lophelia pertusa* to Environmental Factors

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Lophelia pertusa is a major structure-forming deepwater coral that colonizes a wide range of habitats including fjords, continental shelf edges and mid ocean seamounts. These reefs are composed of variable proportions of live and dead *L. pertusa*, with dead coral often more prevalent than live colonies. The reasons for the observed widespread mortality are unknown; however, low frequency extreme environmental events such as temperature anomalies, benthic storms or strong currents may cause stress or death in these fragile corals. This study examines the sensitivity of *L. pertusa* to a range of temperatures, suspended sediment concentrations, current speeds and food level. Fragments of *L. pertusa* collected from the Gulf of Mexico were exposed to experimental temperatures between 5^{o}C and 25^{o}C. After 24 hours, coral mortality was observed at temperatures $\geq$ 20^{o}C, and after 1 week, mortality was observed at temperatures $\geq$ 15^{o}C. To investigate the effect of food on growth and survival of *L. pertusa*, coral fragments were fed *Artemia* nauplii on different schedules for one month. Results from this experiment are currently being analyzed. Exposure to sediment and high currents produced behavioral responses of increased mucus production and extension of mesenterial filaments respectively. Understanding the coral responses to these potential environmental stressors will provide insight into the factors that constrain *L. pertusa* distribution or may cause the high mortality observed in the field.

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Laboratory Study of *Lophelia pertusa* Polyp Behaviour in Different Current Regimes

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The deep-water hermatypic scleractinian coral *Lophelia pertusa* (Linné 1758) is known to grow in places with medium to high current velocities. Common habitats are consequently continental slopes, seamounts and fjords, all places with accelerated current velocities. The rapid currents are supposedly both supplying food and keeping the coral polyps clean from sediment. In Western Sweden and Southern Norway *L. pertusa* reefs are typically situated on sills and along deep troughs on places where they are exposed to accelerated semi-diurnal tidal currents. In these reef areas current velocities have been measured in the interval 0–0.64 $m \cdot s^{-1}$.

The aims of this study were to find out at which current velocities *L. pertusa* expands their polyps in order to feed, and if they have an internal rhythm for expansion and retraction based on local tidal currents.

With a ROV small pieces of *L. pertusa* colonies were collected from the Swedish and Norwegian reefs. The coral fragments were then put in aquariums which were placed in a constant temperature room with conditions suitable for *L. pertusa*. The aquariums were long and narrow in order to generate a current without eddies. The coral fragments were exposed to different current velocity in different aquariums. In some of the aquariums the flow was kept constant all time. In others the semi-diurnal flow was copied with short periods of no flow and then a reverse of flow direction. The number of coral polyps expanded or retracted in each aquarium were counted on regular basis.

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Sizes and Distributions of Octocorals *Keratoisis* sp. and *Paragorgia* sp. on the New England Seamount Chain: Implications for Colonization Dynamics

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The New England Seamounts, a chain of seamounts extending SE from Georges Bank in the N. Atlantic, host diverse communities of deep-water corals comprising octocorals, antipatharians and scleractinians. It has been hypothesized that these corals are long-lived (decades to centuries, Andrews et al., 2002) and recruit only rarely. Our objective is to test this hypothesis by investigating colonization dynamics of two octocoral species, the whip coral *Keratoisis* sp. and the bubblegum coral *Paragorgia* sp. We measured colony size-distributions from seafloor images taken during ROV transects to look for evidence of recruitment pulses or missing size classes. *Keratoisis* colonies ranged from 0.14 to 4.03 m in length; *Paragorgia* ranged from 0.34 to 1.36 m in maximum linear dimension. The absence of small (< 0.3 m) *Paragorgia* in the transects suggests a lengthy interval since the last successful recruitment event. However a few tiny colonies (0.01 to 0.1 m) were discovered during specimen collections, highlighting the limitations of transect measurements. Neither of the species colonized basalt settlement blocks placed in adult habitats for 10 months. Longer-term deployments of settlement blocks are in progress, and ^{210}Pb dating studies of the coral skeleton are being attempted, in order to get a better estimate of the frequency of colonization for each species and to ascertain ages for existing colonies. In areas so far sampled, *Keratoisis* was more widely distributed across seamounts and among habitat types than *Paragorgia*, which may indicate differences in dispersal potential and/or habitat tolerances.

Reference:

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Observations of the Solitary Scleractinian, *Flabellum alabastrum* Moseley, 1876 in Lab and Field

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The cup coral, *Flabellum alabastrum* is common and abundant off Nova Scotia. It was often encountered during video surveys, in clusters of individuals close enough for tentacles to interact. The average abundance, when present was, 107 individuals ·100 m^{-2}. Fragmentation was common and may represent an asexual reproduction mode. Live specimens were collected with remotely operated vehicle and videograb, and studied in laboratory for 21 months. *Flabellum* was easy to maintain in aquaria and observations were made on patterns of body extension/contraction, feeding behavior, and survival and regeneration of coral fragments. Large food particles (< ca 1.5 cm) were handled with a relatively rapid withdrawal of the tentacles, whereas smaller particles were transferred to the mouth by "licking" upper and lower sets of tentacles separately at a slower pace. The coral has the ability to rapidly expand its body size more than ten times normal size. This behavior may be related to food uptake and physiology, but may also represent a way to facilitate movement along the bottom by means of increased buoyancy and drag. Expanded individuals were also observed in the field. In aquarium, *Flabellum* was observed moving slowly, leaving tracks in the sediment, but the mechanism for this is not understood. Respiration of *Flabellum* was measured as oxygen consumption in closed chambers, and rates varied between 0.71 and 1.41 µl $O_2 \cdot g^{-1} \cdot h^{-1}$ for individual corals. The turnover time was estimated to 2.7 years with a production of 0.19 g $C \cdot m^{-2} \cdot yr^{-1}$ in areas with an average abundance of the coral.

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Reproductive Morphology of Two Deep-water Octocorals, *Paramuricea placomus* (Plexauridae) and *Metallogorgia melanotrichos* (Chrysogorgiidae)

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Gorgonian-type octocorals are widely distributed in deep-water environments but basic reproductive biology and reproductive processes are not well known in most species. We compared the reproductive morphology of two gorgonian-type octocorals, *Paramuricea placomus* (Plexauridae) and *Metallogorgia melanotrichos* (Chrysogorgiidae) and use morphological data to infer sexual reproductive strategy. *P. placomus* is a member of the Family Plexauridae which includes both deep and shallow-water species. It's range extends from the eastern to the western North Atlantic (150m -1600m). The material we examined was collected in the Gulf of Maine in June 2002 and August 2003. *M. melanotrichos* belongs to the exclusively deep-water octocoral family Chrysogorgiidae. This species occurs both in the Atlantic and Pacific Oceans (183m - 2078m). We collected and examined *M. melanotrichos* colonies from the New England Seamount Chain in July 2003 and May 2004. Our study shows that both species are gonochoristic, a trait which is common in shallow-water octocorals. Basic reproductive anatomy in *P. placomus* and *M. melanotrichos* is typical of anthozoans, with gonads developing along the mesenteries in the basal region of the polyps (Achituv and Benayahu 1990; Tyler et al. 1995). In male colonies of both species, germ cells appear to undergo synchronous development. In female *M. melanotrichos* colonies oocytes in various stages of development are present in a single polyp.

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Dendrochronology in Bamboo? Geochemical Profiles and Reproducibility in a Specimen of the Deep-Water Bamboo Coral, *Keratoisis spp*.

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The deep-water bamboo coral *Keratoisis spp.* is a promising candidate for a new paleoenvironmental archive of oceanic information. Specimens can live for many centuries, and the calcareous segments of skeleton are relatively pure calcite with fine banding that suggests a simple radial growth form.

Reproducibility is an essential first criteria for establishing whether a natural archive contains useful paleoenvironmental information. If data cannot be reproduced within a specimen, then they contain little useful information. We have used laser-ablation ICP-MS to obtain multiple trace-element profiles from a basal cross-section of a Keratoisis sample recovered from 580 m off the coast of Florida in 2004. We use statistical time-series and frequency analysis to quantify the reproducibility of these profiles.

Preliminary results demonstrate a high degree of reproducibility between closely spaced tracks for most elements. Tracks spaced along different radii in general show less reproducibility, but profiles of Mn, S, Pb and Ba clearly contain features which are common to all profiles, suggesting radial bands of compositional variation.

Using published growth rates, we estimate the sample to be between 150 and 300 years old. Lead shows a broad trend in increasing concentration from older to younger coral, and may represent a record of atmospheric Pb input from gasoline additives over the last 150 years. The profiles of Ba show an extraordinary degree of reproducibility. Although at present it is not known what causes the Ba variations seen in the *Keratoisis*, it is concluded that this element has excellent potential as an environmental proxy.

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Some Findings on the Reproduction of Hawaiian Precious Corals

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Three species of Hawaiian octocorals were collected throughout the Hawaiian Archipelago. These corals have been called 'precious corals' because of their use in the jewelry industry. *Corallium lauuense* (Red Coral), *Corallium secundum* (Pink coral) and a *Gerardia* sp. (Gold Coral) collected between August and November 1998 – 2004, were all histologically analysed for reproductive tissues.

All three species of precious corals are gonochoric (both males and females of all species being identified), with the two *Corallium* spp. having reproductive material contained in siphonozoids and *Gerardia's* gametes being present in the mesenteries. Maximum oocyte sizes are - *Gerardia* sp. - ~290υm; *Corallium lauuense* - ~660υm and *Corallium secundum* - ~600υm.
All three species are hypothesized to spawn during the collection period, *Gerardia* was observed spawning during collection and the two *Corallium* spp. show areas where gametes appear to be missing. *Gerardia* sp. has a single cohort of gametes developing, suggesting seasonal reproduction and the two *Corallium* spp. show multiple sizes present in single individuals, suggesting a quasi-continuous reproductive periodicity.

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Poster Abstracts

Theme 5 – Biodiversity: Microbial and Invertebrate Association

Listed alphabetically by presenting author and abstract title.
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DNA Extraction and Genetic Fingerprinting of Prokaryotes on Deep Water Corals and Associated Invertebrates

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Recently, an increased research interest has focused on prokaryotes associated with invertebrates, however, deep water coral bioherms and invertebrates have hardly been studied. We developed a rapid, inexpensive and non-toxic method to extract DNA for genetic fingerprinting of prokaryotes from water samples, which can also be used onboard a research vessel. Testing for rRNA preservation and extraction from corals and sponges by this method is currently being performed. Tests with a more simplified extraction method than the usual phenol extraction showed similar results also for corals and sponges. Extracted DNA can be stored without the need of liquid nitrogen or a -80° C freezer. Preliminary data suggest that the domains *Bacteria* and *Archaea* as assessed by 16S rRNA gene denaturing gradient gel electrophoresis (DGGE) inhabit invertebrates. Also, diversity of *Bacteria* and *Archaea* was different on invertebrates than in surrounding water suggesting that invertebrates harbor specific prokaryotic communities.

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Habitat Association of Macroinvertebrates with Deep-Sea Corals in Hawaii

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Deep-sea corals and coral-associated invertebrates were collected from three Hawaiian precious coral beds. The goals of this study were to assess the preference of invertebrates for given coral species, and to compare the invertebrates associated with the same species of corals at different sites.

These sites are dominated by the precious corals *Corallium lauuense*, *Corallium secundum*, and *Gerardia* sp., but include a diversity of octocorals and Antipatharians. The most common of the commensal invertebrates on these corals included galathaeoid crabs, barnacles, sponges, anemones, zoanthids, polychaetes, crinoids, ophiuroids, and basket stars. Preliminary observations suggest some of these commensals may be specific to their host while others are more generalized. One of the more notable commensal relationships is the association of polynoid polychaetes with species in the genus *Corallium*. Each *Corallium* species appears to have its own species of polychaete, which can reach high densities within individual colonies. A more generalized commensal is the unbranched basket star, *Asteroschema* sp., which has been observed in a number of different species of octocorals at each site. Dead coral skeletons also appear to provide good recruitment habitat for many invertebrate species, with many types of sessile attached fauna observed as well as numerous young corals. At the Makapu'u coral bed, a crinoid species was observed in very high densities, but was absent at other sites. Past studies of this site suggest that this species has been steadily increasing in abundance at Makapu'u. It now covers many octocoral colonies, leaving little surface area for other commensal species.

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Population Genetics of North Atlantic Seamount Fauna: Investigating Pathways, Dispersal and Evolution

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The mechanisms of faunal dispersal across ocean basins is one of the key unknowns in our understanding of present-day biodiversity of deep-sea fauna. Seamounts are proposed to play several important roles in faunal evolution, acting as regional centers of speciation, stepping-stones for dispersal across ocean basins and boundary currents and being areas of high production that support abundant faunal assemblages, including many commercially-important species of fish. With the decrease in pelagic fisheries, many fishermen are exploiting deep-sea species commonly found on seamounts resulting in the destruction of deep-sea corals and loss of habitat for associated invertebrates, placing a premium on the maintenance of these species through dispersal and gene flow.

Over 150 invertebrate species have been collected from North Atlantic seamounts (New England Seamounts and Muir Seamount, north of Bermuda). Ophiuroids and goose barnacles, invertebrates often associated with deep-sea corals, collected from these seamounts were genetically analyzed to investigate the population connectivity between seamounts. Comparisons of 16S and 28S mitochondrial gene regions revealed that most of the above species are shared among these seamounts. Molecular systematic identification of these species permits genetic comparisons at the population level across seamounts. Initial results from the comparison of mitochondrial cytochrome b sequences show a high degree of genetic variability between conspecifics of the various ophiuroid species and is a good candidate molecular marker for population level studies. Similar rapidly-evolving gene regions will be used on additional invertebrate species to assess congruent patterns of dispersal and gene flow.

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Bryozoan Fauna Associated with the Azoxanthellate Coral Cladocora Debilis (Colombian Caribbean)

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Bryozoan research in Colombian waters have been scarce, not previous records of them being associated with corals were known. Since the most representative study about the Phylum in the country was carried out in 1947 by Osburn, during the last five years the soft bottoms on the continental shelf and the upper slope have been explored with aims to increase the biodiversity information in the colombian Caribbean. The most important locality for the bryozoan biodiversity was an azooxanthellate Cladocora debilis coral bank (70 m depth) off La Guajira peninsula with sponges. Some living branched colonies C.debilis were substrate for 23 bryozoan species. All of them were cheilostomes which Hippothoa flagellum, Microporella ciliata, Cleidochama contractum, Stylopoma spongites and Escharina pesanseris were the most common species. They are all typical tropical coral reef species. Although sponges were also abundant in this station, bryozoans only settled on the coralline substrate, where it was common to find up to five species attached at the same coral colony. Most species were characterized because of being laminar encrusting, some of them colonizing wide surfaces of the coral branches. Geographical distribution known for eight species were extended, for example the encrusting Membraniporella aragoi, that had been observed on corals in the Red Sea. A total of 18 species were first records for colombian Caribbean and six were observed for the first time living on corals. These outcomes contribute to the understanding of the diverse and complex relationships between the different groups that cohabit in deep sea ecosystems.

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Fish and Crustacea Associated with *Lophelia* Reefs in the Agassiz Coral Hills (Blake Plateau) and in the 'OSPAR' region of Northeast Atlantic

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Habitat destruction with bottom fish and shrimp trawling has led to significant spatial reduction and decline in niche diversity in the living coral seascapes in the OSPAR region of the Northeast Atlantic. Likewise, commercial fishing at the top of the trophic food-web by long-line or purse-seine fishing removed predators such as Portuguese dogfish (sharks), swordfish and tuna in the seamounts of the so-called ICES areas within EEZs of several European nations in the Northeast Atlantic. However, in the Blake Plateau in the Northwestern Atlantic, several identified *Lophelia* bioherms, lithoherms and chemoherms are still not adversely impacted by commercial fishing industry. The only major targeted fishery, thus far, revolved around wreckfish *Polyprion americanus.*

Nevertheless, wise management strategies imposed by South Atlantic Fisheries Management Council (SAFMC) reduced fishing fleet size and annual catch. This paper deals with commercial fish and important crustacean species associated with cold coral reefs. Commercially important red and golden crab *Chaceon quinquedens* and *C. fenneri* respectively, occur on and around *Agassiz Coral Hills* over Blake Plateau. Commercially important fish species include *Alfonsino* (*Beryx* sp.), *Hoplostethus* sp., rattail *Coryphaenoides rupestris* and *C. armatus*. The deep-sea eel *Synophobranchus kaupi* is abundant around *Lophelia* reefs off Cape Lookout, North Carolina and also in the Darwin Mounds located north of Scotland. On the Blake Plateau four out of twenty four fish species are commercially important (George, 2002) but in the *Lophelia* reefs in the Northeast Atlantic seventeen out of twenty five fish species are commercially caught in tons (Costello et al., 2005 and ICES Report, 2003). What *Lophelia* corals and economically important fish species eat is poorly known. Many diet species are not even described yet. For example, this author found the following four new species of benthopelagic isopod crustaceans (Munnopsididae) closely associated with *Lophelia* reefs off North Carolina: 1.*Torbenocope hulti* n. gen., n.sp., 2. *Acanthocope ahlfeldi* n. sp. 3. *Munnopsis herrimgi* n. sp., and 4. *Ilyarachna raderi* n. sp. (George, 2005). This paper appeals to SAFMC and ICES to take appropriate actions to create a net work of HAPCs (marine reserves) of *Lophelia* reefs on Agassiz Coral Hills from Cape Canaveral (Florida) to Cape Lookout (North Carolina). Immediate banning of commercial trawling (not scientific), long-line fishing and trapping must be imposed while NMFS (NOAA) initiates the so-called Ecosystem Based Fisheries Management (EBFM) over the Blake Plateau.

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Petrarca (Crustacea: Ascothoracida) Infesting *Fungiacyathus marenzelleri* off Southern California, with a Retrospective Review of Petrarcid Galls in Deep-Sea Corals

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The ascothoracidan crustacean family Petrarcidae includes three genera of endoparasites of scleractinian corals, predominantly azooxanthellate corals from deep water. The PULSE cruises conducted off Southern California by the Scripps Institution of Oceanography in the mid-1990s resulted in the collection of many disc-shaped corals from depths of around 4000 m. They were preserved in ethanol and later identified as *Fungiacyathus marenzelleri*. Large galls induced by *Petrarca* sp. were present on several of the corals from different stations. The parasites (hermaphrodites, but occurring in pairs) were removed from some galls, and those corals were then bleached and photographed. One parasite was dissected and drawn in detail. Although galls on *Fungiacyathus* spp. have been noted before, the parasites themselves have only been recovered twice, both times from *F. marenzelleri*. These were the type lot of *P. bathyactidis,* from off Japan (Fowler, 1889) [supplementary descriptions by Okada (1938) and Grygier (1985)], and specimens referred to *P. azorica,* from off Morocco (Zibrowius & Grygier, 1985). Despite the conspecific host, the present material appears to differ in some respects from both *P. bathyactidis* and *P. azorica*, but more specimens should be examined to check for variability.

In order to increase awareness of ascothoracidan parasites, published illustrations of petrarcid galls in various scleractinian corals are reproduced from several of the first two authors' earlier papers. Also, SEM photographs of some details of two shallow-water petrarcid species from southern Japan, *Petrarca morula* and *Zibrowia* (?)*auriculata*, are presented.

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Deep Coral Reefs along the Angola Margin and Hypothetical Relation to Cold Seeps

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Deep benthic communities dominated by the coral *Lophelia pertusa* were observed by the french ROV Victor during the BIOZAIRE 1 cruise along the Angola margin between 380 m and 350 m depth. Video record analysis and mapping with the SIG software Arcview are presented showing the spatial distribution and extent of coral dominated communities. The corals were observed on circular mounds aligned over 200 to 600 m long where *Lophelia pertusa* form patches from 10 to 25 cm in diameter. The mounds are 20 m to 45 m high with living corals on the highest part on about 15 m high whereas dead corals and debris are at the lower part of their flanks and at the base. According to these observations, the mounds could be formed by coral accumulation. An abundant and diversified fauna (fishes, crustaceans, echinoids, sponges and octocorallians) was observed on the mounds, in particular in association with living corals. Lucinid shells of large size were observed and sampled in the soft sediment areas around the mounds, and inside a depression between mounds. Density of shells is high at some sites, nevertheless no living individual were sampled by the ROV. As these species are known to be associated with reduced sediment and seep areas, their presence may be indicative of either present or past fluid emissions. Observation of grey-dark sediment at these places also suggest reduced environment may be due to diffusion of methane and sulfide-rich fluids, as cold seeps are a widely process along this margin (Sibuet et al. 2002, Gay et al.2003). These observations may suggest several hypotheses : (i) either as suggested by Hovland (1990) and Henriet et al. (1998), there is a direct link between the formation of mounds and corals and methane fluid emissions, (ii) either we suggest only a indirect relation implying carbonate crust formation known to be formed by methane oxidation at seeps (Aloisi et al. 2000), that may favour or have favoured coral settlement. Indeed, at least at present, nutritional link is unlikely, as stable isotope analyses of the polyps did not evidenced the use of chemosynthesis- originated carbon by *Lophelia*.

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Poster Abstracts

Theme 6 – Fish Ecology

Listed alphabetically by presenting author and abstract title.
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A Description of the Fish Assemblages in the Black Coral Beds off Lahaina, Maui, Hawaii

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A series of scuba dives were made to survey patches of black corals and their associated deep reef fish community in the channel waters (50-73 m) of Maui, Hawaii. Most of the colonies were identified as *Antipathes dichotoma*, and they averaged 76 cm (± 0.37 cm) in height. Forty fish taxa were surveyed in and around the corals. Only *Oxycirrhites typus* was found exclusively with these coral trees. Sixty percent of the fish surveyed were observed to frequent and pass through the coral branches; however, only four fish species were documented to reliably take shelter in the coral branches when evading the approaching diver. An archival video was used to monitor movement patterns of fish around a cluster of black coral trees for a 60-hour period. During daylight hours *Dascyllus albisella*, *Centropyge potteri*, *Forcipiger flavissimus*, *Aulostomus chinensis*, and *Canthigaster jactator* were observed to be the routine users of the coral patch, but only *Dascyllus albisella* and *Centropyge potteri* appeared to be residents to specific trees. At night Neoniphon sp. were observed using the trees as a base from which to forage and *Heniochus diphreutes* dropped from their daytime position high in the water column to hide in the tree branches throughout the evening hours. These observations indicate that black corals trees are used by many fish as a general form of habitat and if the coral trees are the largest relief feature at a site, their removal will likely impact the fish assemblages.

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Sublethal Injury Rate in a Deepwater Ophiuroid, *Ophiacantha bidentata*, an Important Component of Western Atlantic *Lophelia* Reef Communities

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The presence/absence, and relative abundance of tissue (arm) regeneration in the ophiuroid, *Ophiacantha bidentata*, was examined in individuals collected among colonies of the deep-water coral *Lophelia pertusa* occurring in the South Atlantic Bight. Seven deep-water coral sites (405-756 m), located between Cape Lookout, NC, and Cape Canaveral, FL, were sampled in June 2004 using a manned submersible. The presence of regenerative tissue was evaluated by visual inspection and the proportion of regenerating arms per individual was examined relative to size of individual, geographic location, and depth of collection. *Ophiacantha bidentata,* which constituted 90% of the brittle stars collected, commonly displayed signs of sublethal injury with over 60% of individuals displaying some evidence of regeneration. These rates of regeneration rival those reported for shallow-water ophiuroids. Larger individuals (> 6.5 mm, disc diameter) had a higher incidence of regeneration than smaller individuals. Size of individual and percent of regeneration were negatively correlated with depth. Although *O. bidentata* was significantly less abundant in southern versus northern sites, ophiuroid abundance did not appear to be influenced by either limitations of coral substratum or oceanographic features (e.g., currents, ˚C, $^{0}/_{00}$, DO). Presence of dense aggregations of *O. bidentata* indicates that they are an important component of the invertebrate assemblage associated with deep-water coral habitat in the northern reaches of the South Atlantic Bight. Assuming that observed injury/regeneration rates represent predation events, then presence of dense ophiuroid aggregations in these deep-water coral habitats represents an important trophic link and a possible renewable resource within these communities.

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Deepwater Emergence of Red Tree Coral (*Primnoa* sp.) in Glacier Bay, Alaska

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Red tree coral (*Primnoa*) thickets are important structural components of eastern Gulf of Alaska continental shelf ecosystems. Several deepwater (>150 m) areas supporting dense thickets of *Primnoa* were recently designated as Habitat Areas of Particular Concern and the use of all bottom-contact fishing gear will be prohibited in an effort to protect these sensitive habitats. In 2004 and 2005, *Primnoa* was found thriving in shallowwater areas of Muir Inlet, Glacier Bay, Alaska. Glacier Bay is a large, y-shaped fjord with multiple tidewater glaciers and was formed by rapid glacial retreat during the past 220 years. *Primnoa* appears to be an important pioneer species in the primary succession of recently deglaciated habitats. Colonies were found at depths ranging between 11 and 35 m (the maximum depth sampled). These observations represent a shallowwater depth range extension for the genus. Deepwater emergence of *Primnoa* likely occurs in shallowwater areas of the glacial fjords because the oceanographic conditions there (low temperature, high salinity, and low ambient light levels) are similar to those in the typical depth range of *Primnoa* in Alaska (>150 m). In situ access to shallowwater populations of *Primnoa* and a meticulously recorded deglaciation record during the past 130 years provide an invaluable opportunity to examine recruitment processes and to validate indirect methods previously used to age *Primnoa*. Information on recruitment and growth will provide insights into the ability of this species to recover from disturbance and its ability to colonize protected areas established to mitigate the effects of fishing activities.

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Poster Abstracts

Theme 7 – Ecosystem Based Management

Listed alphabetically by presenting author and abstract title.
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An Economic Model of Pink Coral (Corallium secundum) Harvest at the Makapu'u Bed in the Main Hawaiian Islands, USA

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We present an economic model analysis of the deep-water precious coral harvest industry in Hawai'i, with a focus on pink coral (*Corallium secundum*). A generalized natural resource extraction model proposed by Sweeney[1] was augmented to represent the characteristics of selective harvest for slow-growing, high-value deep-sea corals using manned submersibles at the Makapu'u precious coral bed east of Oahu. The objective is to explore the bio-economic dynamics that characterize this precious coral fishery and suggest explanations for its current dormancy. The model incorporates the effects of pink coral growth rates, variable costs of currently allowable harvesting techniques, stock size effects on marginal harvest cost, and variable discounting on harvest profitability. Model parameters were determined through interviews and a review of relevant literature. The sensitivity of each of these factors was analyzed in determining an optimal extraction rate for maximum long-term profitability.

Our model suggests that the effect of stock size on catch-per-unit-effort and world market prices for precious corals are the dominant factors governing profitability. Consequently, maintaining lower harvest rates and higher stable stocks relative to current maximum sustainable yield practices would most likely result in greatest long-term profitability of the Hawaiian precious coral harvest if the fishery resumes. However, our analysis is limited by exclusion of alternate harvest areas, complementary precious coral species, and the imprecise current understanding of coral growth rates. The model shows significant potential for application to optimal harvest of other long-lived species.

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Poster Abstracts

Theme 8 – Conservation and Protection of Deep-Sea Corals

Listed alphabetically by presenting author and abstract title.
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Measurement of Exposure and Effect of Chemical and Particle Discharges from Oil and Gas Activities in Deep-Sea Corals for the Purpose of Integrating Biomarker Response Data into a Risk Assessment Model

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Biological markers or biomarkers have been developed and used in relation to E&P activities for environmental monitoring in shallow waters. The potential to transfer the same tool to the deep-sea environment is now evaluated on deep-sea organisms. In that context, a preliminary study has been carried on the cold and deep water coral species *Lophelia pertusa*.

Biomarkers for oxidative stress, Gluthathione-*S*-transferase, catalase and TOSC have been measured in tissues of the cold water coral *Lophelia pertusa* to the Atlantic margin off West Africa. Activity levels were found to be very low, as also reflected by the very low protein concentration in cytosol compared to other deep-sea invertebrate species in the area. This finding is discussed with regard to the possible specific strategy of corals for handling exposure to anthropogenic compounds in the environment.

In order to achieve a better knowledge for the potential use of biomarkers to monitor the effect and to estimate the risk of anthropogenic discharges to cold water corals, a new study with *Lophelia* will be considered. Controlled laboratory experiments will focus on the exposure and effects of hydrocarbons and to chemicals linked to drilling muds and several types of biomarkers will be considered. The outcome of this work will contribute to the development of deep-sea risk and monitoring tools.

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Warm and Cold Water Coral Reefs – Same Roles? Same threats?

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Coral reefs: a marine ecosystem that inspires, intrigues, provides and protects. They exist in the deep cold oceans and in the warm shallows of the tropics. They are under threat.

Many comparisons have been made looking at the similarities and differences of cold-water coral reefs and their tropical cousins. Whilst the breadth of services provided by warm water corals are well documented from shoreline protection to supporting the livelihoods of millions of people living in the coastal zone, the full range of services provided by cold-water coral reefs have yet to be fully understood.

The three dimensional structure created by coral reefs, both warm and cold provide ideal nursery habitats, food and shelter for a huge diversity of fish and support significant fisheries. For warm water reefs these tend to be small scale, artisanal multi species fisheries, critical to supporting the livelihoods of poor and vulnerable communities; cold-water coral reefs support industrially exploited fisheries. Perversely it is the fishing activities that constitute one of the biggest threats to sustainability of coral reefs across the world. Fishing activities have contributed to the degradation of 60% of the world's warm water coral reefs and worryingly have been observed to have impacted all cold-water coral reef sites surveyed to date.

The world's coral reefs and the services they provide are it seems all at risk, no matter how hidden they may be.

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Deep-sea Conservation for the UK – A Project to Develop Our Ability to Predict the Occurrence of Cold-Water Coral Reefs and Raise Public Awareness of Vulnerable Deep-Water Habitats

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Surveys of the territorial waters of the United Kingdom have uncovered reefs of the cold-water coral *Lophelia pertusa*. In several regions of the world it is now clear that cold-water coral reefs have been damaged by bottom trawl fishing. The Deep-sea Conservation for the UK project (DC-UK) is developing a series of educational resources raising awareness of *Lophelia* reefs and other deep-water habitats, analysing fishing vessel activity using data from satellite tags ('VMS' data), archiving and restoring historic video surveys from submersible dives during the 1970s and developing predictive models of the distribution of *Lophelia*.

DC-UK is creating a series of websites to summarise this information in a readily accessible form. The National Oceanographic Centre, Southampton is developing an extensive image archive of the deep-sea environment, collating many pictorial and video resources and making them available on-line. The website *Lophelia*.org has been developed by SAMS to centralise information on *Lophelia* reefs, and encompasses large amounts of information on this reef framework-forming coral, as well as tools for academics and games for children. The University of Plymouth is analysing VMS fishing data and located areas of high fishing activity. At SAMS we are exploring a predictive model of *Lophelia* distribution based on a series of environmental parameters. Predictive modelling may be an ideal tool for managers and conservationists, especially for deep-water habitats where our understanding of their distribution is constrained by the expense and logistical challenges of any basic survey work.

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Protecting Deep-Sea Corals by Including Davidson Seamount in the Monterey Bay National Marine Sanctuary

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There are 20 documented deep-sea coral taxa on the Davidson Seamount. The distribution of these corals was characterized during a cruise in 2002, and public interest in the seamount has been growing since then. Interesting science and high quality images from the cruise generated an award-winning interactive CD, extensive print and television media coverage, two web sites, an agency promotional poster, numerous public presentations, as well as peer-reviewed publications. As a result, the potential for protecting Davidson Seamount through sanctuary designation arose in the management plan review process for the Monterey Bay National Marine Sanctuary (MBNMS). After receiving input from a focus group of stakeholders and experts, the MBNMS Advisory Council voted to pursue inclusion of the Davidson Seamount in the MBNMS. Sanctuary status would increase national opportunities for education on deep-sea corals and limit extraction of corals from the Davidson Seamount. The potential regulations to achieve this have been presented to other public agencies for consultation, and NOAA's Pacific Fishery Management Council supported protection of the seamount habitats though inclusion in the MBNMS. There continue to be discussions on which branch of NOAA would best be suited for regulating fisheries that might impact these corals. The draft MBNMS Management Plan and supporting Environmental Impact Statement is due for public comment in the fall of 2005 with a final determination scheduled for spring 2006. Consultation by scientists has been critical throughout this process, and will be described with an update on the sanctuary designation status for Davidson Seamount.

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Assisting Management Initiatives through Development of a National Deep Sea Coral Database

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Deep Sea Corals (DSC) have received global attention in the past few years and are increasingly threatened by anthropogenic activities. NOAA is responding to these threats by developing a DSC management strategy and by publishing a U.S. Status of Deep Coral Communities report that will point out gaps in research and general knowledge. As DSC research efforts increase and the scientific community responds to gaps in knowledge, the need for data management becomes increasingly necessary. Many researchers have established DSC databases containing various data types but they are often limited to particular regions or specific functions. The development of a National Deep Sea Coral Database by NOAA could organize many of the existing databases and scientific research into a central portal that can better serve DSC managers/researchers. NOAA has recently partnered with USGS to develop a GIS database of DSC locations for the Eastern and Southern U.S. regions.

An overview of existing databases and their functions will be presented. Results from a survey regarding the types of information to include and the most user-friendly format for a national database will also be presented. The overall goal of this initiative is to respond to the management needs of DSCs and to improve future collaborations among DSC researchers.

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Fishing in Troubled Waters – Evidence for higher Diversity and high Abundance of Cold Water Corals along the Chilean Coast

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While status and threats of coral communities in other parts of the world are comparably well studied, even basic data on composition, size and distribution of coral communities are extremely scarce for the South East Pacific. With just 18 known species of azooxanthellate Scleractinia and only few registers of gorgonians and antipatharians, the cold water coral fauna of continental Chile is considered depauperate[1]. In contrast to this assumption, recent SCUBA diving surveys recorded extended and hitherto unknown coral communities in shallow water of the Chilean fjord region[2]. Long line fisheries on demersal fish species regularly deliver cold water corals from greater depth as a by-catch entangled in the gear. We present a list of Scleractinia, Gorgoniaria and Antipatharia based on specimens that have been sampled by SCUBA diving and by biological observers on fishing boats. This list includes several recently added as well as new records for Chile. Considering species and specimen numbers sampled with comparably little effort, the low probability of specimens being "sampled" by long line fishery and the high number of habitats that have not yet been sampled, leads to suppose a much more abundant and diverse coral fauna from continental Chile than hitherto known. Especially sizes and numbers of specimens of Isididae and Scleractinia such as *Madrepora oculata* give evidence for important deep water coral reefs.

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The Status of Deep Coral Communities in the United States: Challenges for Conservation

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The territorial waters and Exclusive Economic Zone (EEZ) of the United States include extensive deep coral habitats. The National Oceanic and Atmospheric Administration (NOAA), working with other Federal and Academic partners, is completing the first comprehensive status report of these habitats. A variety of different coral taxa contribute to structuring habitats in deeper waters in different regions. True cold-water scleractinian or stylasterine coral bioherms in U.S. waters are found primarily in the Atlantic off the Southeast and Gulf of Mexico coasts. Elsewhere, octocorals are the primary taxa structuring deep communities, reaching perhaps their highest diversity and abundance in North Pacific waters off the Aleutian Islands. Many areas are still largely unexplored, especially deeper habitats of the U.S. Caribbean and the Central and Western Pacific aside from Hawaii.

The major current threat to deep coral communities is damage from bottom-tending fishing gear. Management of demersal fisheries in the U.S. EEZ is governed by fishery management plans developed by regional fishery management councils. This system is responsive to local fishery needs, but has resulted in significant regional differences in conservation approaches, in monitoring of fisheries and bycatch, and in timetables for action. Despite these differences, a national consensus is emerging for increased conservation of deep coral communities. In this paper, we reflect on the results of the Status Report and present recommendations for research and conservation priorities based on the observed regional trends.

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Outreach and Education Efforts in Support of Deep Water Coral Resources of the Southeast

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Deep water coral (DWC) reefs are slower to mature and may be more susceptible to damage by fishing activities than their shallow water counterparts. Since DWC coral reefs are rarely, if ever, accessible to the general public, they are difficult to promote as important habitats that need public support and conservation. In 2004, NOAA Fisheries, Southeast Fisheries Science Center (SEFSC) initiated a DWC education and outreach (O&E) program to help educate managers, stakeholders, students and local constituents about the value of these reefs and the need to protect them. Through partnership, the SEFSC, South Atlantic Fishery Management Council (SAFMC) and NOAA Undersea Research Center (NURC) developed a multi-disciplinary and multi-institutional O&E plan for DWCs of the southeast region, focusing on the relatively well-known and studied Oculina Banks DWC reserve. Scoping meetings characterized local issues and concerns and helped us identify appropriate methods to engage the community and increase stakeholder involvement and ownership of this resource. Pre-campaign surveys quantify the effects of outreach efforts. A new website and printed materials provide local, regional and national outreach. Research and monitoring cruises in 2005 and 2006 provide "event based" opportunities to educate stakeholders and the general public. Outcomes of this project are applicable to broader DWC issues, encouraging expansion of mapping, research, monitoring, and conservation activities.

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Industrial Fisheries Impact on the Deep-Sea Scleractinia in Southern Brazil

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Large concentrations of deep-sea Scleractinia, specially the occurrence of the colonies *Lophelia pertusa, Solenosmilia variabilis* and *Madrepora oculata* (listed in order of biomass), are known to be important reservoirs of deep marine biodiversity and are of great value as habitat, serving as feeding and nursering areas for several species, including fishes, crustaceans, mollusks and many others. For instance, many important commercial fishes (*Lophius gastrophisus*, *Urophisys brasiliensis* and *Genipterus brasiliensis*) and crustaceans (*Chaceon ramosae* and *Chaceon* sp.) occur near or/and on these deep-corals.

The increase of demersal fisheries (deep-trawl, bottom gill-net, bottom long-line and trap) in southern Brazilian waters is impacting the poorly understood community of deep-sea corals from the outer shelf and upper slope. This impact is related to the fact of these fisheries be more productive when the equipment is deployed exactly on or very near the coral patches. However, many authors suggest that the deep-trawlers are the worst fishery due to their negative indirect impact (e.g., sediment suspension, suffocating the polyps).

On the continental shelf and slope of Rio Grande do Sul State, due to the intense large areas of deep-sea Scleractinia and their associated assemblages have disappeared, showing the necessity for the creation of potential areas for the exclusion of these fisheries.

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Virgin Fisheries of the Tropical Western Atlantic Associated with Deep-Water Reef-Forming Corals Necessitate Protection

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Worldwide overfishing has greatly increased the pressure to explore new fisheries. It is inevitable that all regions and depths of the oceans will be exploited. Much recent attention has focused on destructive and unsustainable fishing practices on deep-water reefs. Corals that form these structures have been recorded throughout the tropical western Atlantic. The station data and reports from these occurrences record many commercially viable species and a rich diversity of associated benthos. These unexploited resources present an unparalleled opportunity to establish protection in advance of exploitation.

In the tropical western Atlantic the presence of structure-forming corals (also called cold-water corals) indicates potential regional deep-water reefs and associated exploitable fisheries. Five species of deep-water structure-forming coral have been recorded in the exclusive economic zones of many regional coastal and island nations. Distribution, inferred from available station data, appears to follow the Antillian chain and the shelf edges of South and Central America. Half of the stations that reported associated benthos include commercially viable fish, many more include commercially viable shellfish. Commercially viable species include deep-sea codfish, benthic sharks, wreck fish, hake, rattail fish, grenadiers, and deep-water shrimp, crabs, and lobsters. Other associated benthos includes many other fish, squid, crinoids, gorgonians, bamboo and black corals, sponges, echinoderms, and mollusks. This review emphasizes the potential fisheries resources of the deep-water reefs of the tropical western Atlantic and urges proactive protection.

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Protected Deep-Water Coral Reefs in Norway

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In 1999 the Norwegian fisheries authorities instituted regulations for the protection of deep-water coral reefs in accordance with the Sea Fisheries Act and the Act related to the EEZ of Norway. The regulation prohibits deliberately destruction of coral reefs and requires precaution when fishing in the vicinity of known reefs. The regulation also gives special protection to specified coral reefs by a total exclusion of bottom trawling. The criteria for choosing reef protection sites include size, uniqueness and degree of threat. This paper gives a brief description and status of each of the protected reefs. At present, five coral areas have been given special protection in Norway; the Sula Reef, Iverryggen Reef, Røst Reef, Tisler Reef and Fjellknausene Reef. In addition Selligrunnen Reef, rising up to 39 m depth below the surface is protected on an interim basis according to the Norwegian Nature Conservation Act. In a proposed system of Marine Protected Areas in Norway these reefs are included and several more reefs will probably be incorporated. The biology and ecological significance of *Lophelia* is still poorly known for example its role as habitat for commercially important fish. In lack of this knowledge the management should adopt a precautionary approach.

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Effects of Bottom Trawling on a Deep-Water Coral Reef

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The deep-water *Oculina* coral reef ecosystem occurs off eastern Florida and consists of azooxanthellate bioherms that are similar to *Lophelia* reefs in structure and biodiversity. In 1984, almost one-third (315 km^2) of the known *Oculina* reef system was protected as a Habitat Area of Particular Concern (HAPC), prohibiting trawling and dredging. Unfortunately, the northern two thirds of the reef system remained open to bottom trawling until 2000 when the HAPC was expanded. In the 1970s, the *Oculina* reefs were teeming with large populations of snapper and grouper. By the early 1990s, commercial and recreational fishing had taken their toll on fish populations, and the coral had been severely impacted by shrimp trawling. Historical photographic transects, taken in the 1970s with the *Johnson-Sea-Link* submersibles, provide crucial evidence of the status and health of the reefs prior to heavy fishing and trawling activities of the 1980s and 1990s. Nearly 20,000 35-mm photographs taken during these submersible surveys were recently restored and archived on DVD. Quantitative analyses by point counts provide percent cover of live coral in the 1970s, prior to intense trawling, compared to the same sites today. Recent submersible and ROV surveys conducted from 2001 to 2003 by the investigators and funded by NOAA/NURP and NMFS suggest that some of the *Oculina* habitat within the *Oculina* HAPC has been reduced to rubble especially in the recently protected northern portion. Management plans for this coral reef ecosystem must be based on sound scientific understanding; this work will provide the foundation for that understanding.

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Status of Deep-Water Coral Areas off Iceland and Management Actions

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Information from Icelandic fishermen indicate that a substantial number of coral areas known to exist prior to 1990 do not exist any more and that the overall coral distribution on the shelf off Iceland has reduced significantly during the last 20-30 years. When these areas were examined in relation to bottom-trawling effort, they had normally experienced a considerable pressure for a number of years.

In 2004, a research programme was started to map coral areas off Iceland and to assess their species diversity and status in relation to potential damages by fishing practices. In some of the shelf areas tilted or broken colonies of *Lophelia* and remains of trawl nets and trawl marks were observed, providing evidence of the effects of trawling activities. Intact *Lophelia* reefs were located in two places on the shelf slope off the south coast of Iceland. There was no evidence of bottom trawling activities in these areas. Based on these findings three coral areas were recommended to be closed for all fishing activities.

The present legislation for closed areas off Iceland is aimed at minimizing the impact of fishing on commercial fish species. The current management system is now being reviewed in order to facilitate protection of vulnerable habitats around Iceland, such as *Lophelia* reefs.

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Oceana's Continuing Efforts to Protect Deep-Sea Coral

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Since the last Deep-Sea Coral Symposium at Erlangen, global efforts to conserve deep-sea corals have continued to increase, with progress being made in many areas. At the last symposium, Oceana, an international non-governmental conservation organization, described its efforts focused on the conservation of deep-sea coral communities in the United States. Oceana's campaign to protect deep-sea corals in the United States has continued, and work in Europe has gotten underway. Oceana is carrying out a number of activities as part of its deep-sea coral campaign. These include:

- Working to pass legislation that would protect deep-sea corals throughout the United States (in collaboration with the Marine Conservation Biology Institute).

- Working to protect deep-sea coral habitat in New England, the US Pacific coast, and Alaska through the US regional fishery management councils (The work being done by Oceana in the Aleutians and Pacific will be discussed in detail by Jon Warrenchuk.);

- Working to protect specific closed areas in European waters;

- Working as part of the Deep Sea Conservation Coalition to protect corals on the high seas from destructive trawling;

- Developing educational materials for decision-makers, the media, and the general public.

The status of these efforts will be discussed at the symposium. Oceana's goal continues to be: By 2007, to ban bottom trawling in all U.S. and European waters containing significant amounts of deep-sea corals.

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The 'Santa Maria di Leuca' *Lophelia* Reef of the Mediterranean Basin: A Case for Total Protection

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To date, the 'Santa Maria di Leuca' deep coral mound province (SML) off the Apulian coast is the only known example of large-scale live *Lophelia* reef of the Mediterranean basin and the only example of such type living at temperatures as high as c. 13 degrees Celsius. Although the existence of deep water corals in this sector of the Ionian Sea was known for more than a century, only recently it has been realized the extent and lushness of SML that hosts *Madrepora oculata*, *Lophelia pertusa* and *Desmophyllum dianthus* as major frame builders. Based on geophysical, biological and visual observations it appears that coral frames do not form large aggregations but are instead scattered on a vast area whose surface might be in excess of 400 square km and bathymetric range comprised between 300-1200 m. SML's biodiversity is noteworthy, albeit impoverished with respect to modern Atlantic Ocean *Lophelia* reefs and Pleistocene Mediterranean counterparts.

SML is exposed to many actual or potential threats. Differently from Atlantic counterparts, SML is not particularly exposed to large-scale commercial fishery, especially to the dreadful bottom trawling. However, fishing lines entangled in or fouled by corals have been consistently documented from this area, indicating the need of protection of coral habitats from such practice. Furthermore, this area is exposed to other negatively impacting activities including cable placement or other industrial works, illegal waste dumping and uncontrolled scientific prospections.

In order to minimize the potential risks to damage this relatively fragile and unique ecosystem completely included within Italian waters, we are raising the case of SML as being in urgent need to obtain the status of total natural reserve. Long-term research on SML is carried out through ESF Eurocores 'Moundforce', Italian FIRB 'Aplabes' and EU 'Hermes' programs.

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On the Occurrence of a Shark Nursery (Family Scyliorhinidae) in a Deepwater Gorgonian Field in the Mississippi Canyon, Gulf of Mexico

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Here, we present recent evidence of fish using deepwater gorgonian corals as nursery habitat in the Gulf of Mexico. This manuscript reports specifically on the occurrence of a large field of *Callogorgia americana delta* adorned with egg cases of Scyliorhinid catsharks on a low-relief mound at 533 meters depth in the Mississippi Canyon. Observations were made during the 2003 Gulf of Mexico Deep Habitat Expedition with the remotely operated vehicle Sonsub Innovator. NOAA's Office of Ocean Exploration sponsored this mission to document the diversity, abundance, and ecology of deep-water corals and their associated communities in the western Gulf of Mexico.

Hard attachment substrate is uncommon in the Gulf, so *C. americana delta* may provide essential fish habitat for catsharks in the Gulf of Mexico. Catsharks may also exhibit a preference for certain coral species over others, as a large field of *Acanella sp.* at a similar depth did not contain egg cases. Management of catsharks in the Gulf must consider the status of deepwater gorgonian fields since they appear to play an important role in the shark's life history. The relationship between catsharks and gorgonian corals is not unique to the Gulf, however. Corals with egg cases have been collected off the coasts of Nova Scotia and California. The affinity of catsharks for gorgonian corals was documented as early as 1896 in a woodcut print from Royal Museum of Natural History (Lydekker, 1896).

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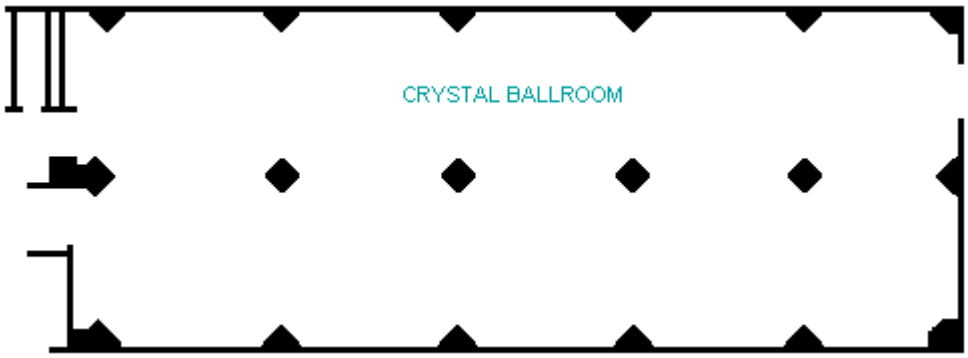
Author Index

Bold numbers indicate presenting authors.

Doubletree Hotel Coconut Grove Floor Plans

Main Level



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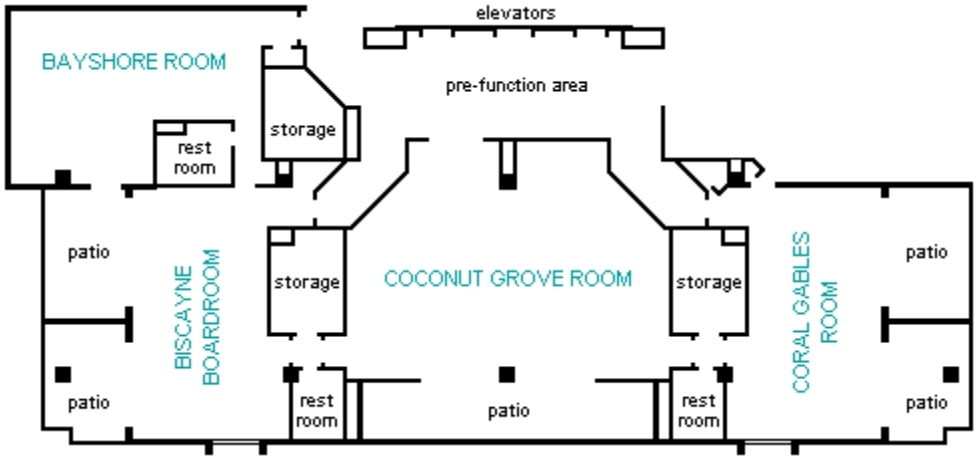

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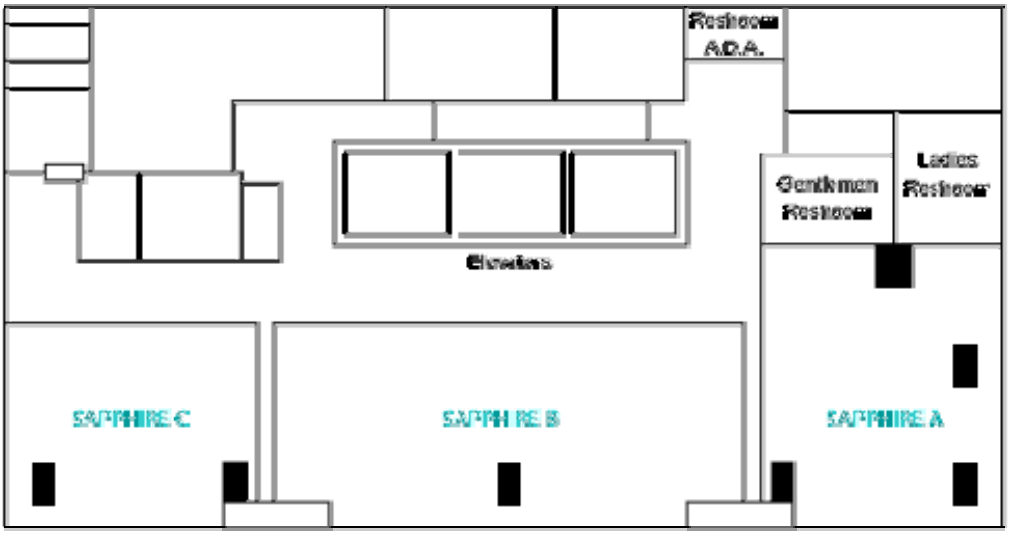

University of Miami RSMAS Map