2016

6th International Symposium

DeepSeaCorals

SEPTEMBER 11 - 16, MARRIOTT LONG WHARF, BOSTON, MA, USA

Greetings to the Participants of the 6th International Symposium on Deep-Sea Corals

We are very excited to welcome all of you to this year's symposium in historic Boston, Massachusetts. While you are in Boston, we hope that you have a chance to take some time to see this wonderful city. There is a lot to offer right nearby, from the New England Aquarium right here on Long Wharf to Faneuil Hall, which is just across the street. A further exploration might take you to the restaurants and wonderful Italian culture of the North End, the gardens and swan boats of Boston Common, the restaurants of Beacon Hill, the shops of Newbury Street, the campus of Harvard University (across the river in Cambridge) and the eclectic square just beyond its walls, or the multitude of art and science museums that the city has to offer.

We have a great program lined up for you. We will start off Sunday evening with a welcome celebration at the New England Aquarium. On Monday, the conference will commence with a survey of the multitude of deep-sea coral habitats around the world and cutting edge techniques for finding and studying them. We will conclude the first day with a look at how these diverse and fragile ecosystems are managed. On Monday evening, we will have the first poster session followed by the debut of the latest "*State of the Deep-Sea Coral and Sponge Ecosystems of the U.S.*" report. On the second day, we are thrilled to kick things off with a session dedicated to Dr. Steve Cairns and his contributions to deep-sea coral taxonomy and systematics. We will follow this with a series of sessions on the latest genetic techniques in systematics, aspects of coral life history, and a look at the relationship between corals and other close associates. Tuesday evening will conclude with the conference dinner in the beautiful Harborview room. Wednesday will be a free day so we can catch our breath, with an optional excursion to Woods Hole Oceanographic Institution. We will reconvene on Thursday with a look at anthropogenic threats to corals: oil spills, fishing, mining, and climate change; hopefully ending the day on a brighter note. On Friday, we will take a closer look at a variety of *Lophelia* and other cold-water coral habitats, examining how they get their food and how they build large reef and mound structures, with a look into the future.

This will be a very exciting step forward in deep-sea coral science, led by an outstanding group of established and emerging scientists. We eagerly anticipate the stimulating conversations and collaborations that this meeting will surely inspire. On behalf of the organizers and steering committee, welcome once again to Boston and the 6th International Symposium on Deep-Sea Corals!

Sincerely,

Timothy Shank
Biology Department
Woods Hole Oceanographic Institution

Erik Cordes
Department of Biology
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Program

11 September - Sunday

12:00 pm	Registration Opens in Hotel Lobby	
3:00 pm	Meeting of Steering Committee and Student Volunteers	Harborview Room
5:00 – 9:00 pm	Opening reception	New England Aquarium Long Wharf, Boston

12 September - Monday

7:30 am	Registration Opens	Palm Garden Room
8:00 am	Symposium begins; breakfast	
8:30 am	Erik Cordes	Opening remarks
Session B1: Habitat and Environmental Settings: Habitat Characterization, Mapping, and GIS Applications **Session Chair: Furu Mienis, NIOZ**		
8:45 am	***Keynote: Veerle Huvenne***	*From pixel to polyp: using novel robotic technology to achieve an integrated multi-resolution 3D characterisation of cold-water coral habitats in submarine canyons*
9:15 am	Andy Wheeler	*Coral mounds on the Irish margin revisited: a critical assessment of critical habitat*
9:30 am	Steinunn Ólafsdóttir	*Deep water corals and sea pens in the cold North Atlantic waters around Iceland*
9:45 am	Peter Etnoyer	*Where are the coral gardens? Mapping densities and condition of gorgonian octocorals in the mesophotic depth zone of the Channel Islands National Marine Sanctuary in Southern California*
10:00 – 10:30 am	Break	Palm Garden Room

Session B2: Habitat and Environmental Settings: Environment Habitat Conditions and Coral Distribution

Session Chair: Scott France, University of Louisiana

10:30 am	Christopher Kelley	*Rift zone ridge crests can provide topography and substrate conducive for the development of high-density deep-sea coral and sponge communities*
10:45 am	Rachel Wilborn	*Distribution, abundance, diversity and size of cold-water corals and sponges in the Aleutian Islands, Alaska*
11:00 am	Helle Jørgensbye	*Cup coral gardens (*Flabellum alabastrum*) a deep water, low relief ecosystem in Greenland*
11:15 am	Lara Miles	*Scale-dependent surficial geology influence on cold-water coral distribution, Flemish Cap, Northwest Atlantic*
11:30 am	Peter Auster	*Identifying spatially rare deep sea coral communities in the Gulf of Maine (NW Atlantic)*
11:45 am	J. Murray Roberts	*The ATLAS project: a trans-Atlantic assessment and deep-water ecosystem-based spatial management plan for Europe*
12:00 – 1:30 pm	Lunch: Grand Ballroom and the Galway Declaration in the Harborview Room	

Session A1: Biology, Demography, and Ecology: Biodiversity, Community Structure, and Functional Role

Session Chair: Steve Cairns, Smithsonian Institute

1:30 pm	Martha Nizinski	*A Tale of Two Canyons: ROV Surveys Highlight Differences in Species Composition and Abundances of Deep-Sea Corals in Nygren and Heezen Canyons, Western North Atlantic*
1:45 pm	Amanda Demopoulos	*Food-web structure and isotopic niches of deep-sea corals and other consumers residing within Baltimore and Norfolk Canyons, U.S. Atlantic margin*
2:00 pm	Lissette Vicotero	*The Biodiversity and Spatial Distribution of Cold-Water Corals on Equatorial-Atlantic Seamounts*
3:45 pm	Chang-Feng Dai	*Deep-sea scleractinian corals in the South China Sea*
2:30 pm	Amy Baco-Taylor	*Recovery of Seamount Precious Coral Beds From Heavy Trawling Disturbance*
2:45 pm	Michael Parke	*Deep-sea coral and sponge research in the Pacific Islands 2015-2017*
3:00 – 3:30 pm	Break	Palm Garden Room

Session D1: Anthropogenic Threats and Management Strategies: Management and Conservation Strategies **Session Chair: Murray Roberts, Heriot Watt University**		
3:30 pm	Thomas Hourigan	*U.S. Fisheries and Deep-Sea Coral Habitats: Policy, Science and Conservation*
3:45 pm	Michelle Bachman	*Applying deep-sea coral science to fishery management in New England, U.S.A.*
4:00 pm	Kiley Dancy	*Collaborative Development of Deep-Sea Coral Protected Areas in the US Mid-Atlantic*
4:15 pm	Morgan Kilgour	*Ongoing Efforts and Challenges for Managing Deep-sea Corals in the Gulf of Mexico*
4:30 pm	Greg Boland	*Recent and Ongoing Research on Deep-water Coral Resources in the Gulf of Mexico*
4:45 pm	Harriet Harden-Davies	*Conserving deep-sea biodiversity in marine areas beyond national jurisdiction?*
5:00 pm	Poster Session I	Palm Garden Room, Marriott Long Wharf
6:30 – 8 pm	State of the Deep Sea Corals Reception	Harborview Room, Marriott Long Wharf

13 September - Tuesday

7:30 am	Registration Opens	Palm Garden Room
Session A2: Biology, Demography, and Ecology: Coral Taxonomy, Systematics, and Phylogenetics **Session Chair: Martha Nizinski's, NOAA NMFS**		
8:30 am	Keynote: Scott France	*Further observations on branching in bamboo coral colonies, with implications for taxonomy and in situ identifications*
9:00 am	Les Watling	*The Global Distributions of Bathyal Octocorals are Determined by Intermediate Water Masses*
9:15 am	Esprit Heestand Saucier	*Phylogenetic analysis of the keratoisidin bamboo corals with a proposal to erect three subfamilies based on morphological characters and mitochondrial genome arrangement*
9:30 am	Gary Williams	*Recent discoveries in deep-sea pennatulacean diversity and systematics (Anthozoa, Octocorallia)*

9:45 am	Andrea Quattrini	*Phylogenomics of Anthozoa (Cnidaria): New approaches to long-standing problems*
10:00 – 10:30 am	Break	Palm Garden Room
Session A3: Biology, Demography, and Ecology: Genetics, Connectivity, and Evolution **Session Chair: Andrea Quattrini, USGS**		
10:30 am	Jonathan Gardner	*Connectivity of deep sea coral Vulnerable Marine Ecosystem indicator taxa: genetic data to inform environmental management in the New Zealand region*
10:45 am	D. Katharine Coykendall	*Contrasting patterns of population genetic connectivity in octocorals from the northern Atlantic Ocean*
11:00 am	Meredith Everett	*From population structure to eDNA: Next-generation sequencing technology opens a window into the biology of deep-sea corals*
11:15 am	Santiago Herrera	*The genomics of adaptation potential of deep-sea corals to environmental changes*
11:30 am	Anna M. Addamo	*A cosmopolitan species as model for genetic connectivity of deep-sea coral populations, key in addressing evolutionary and ecological questions in larval dispersal.*
11:45 am	Cheryl Morrison	*Genetic Connectivity among Offshore and Emergent Southeastern Alaskan Fjord Populations of a Foundation Species, the Red Tree Coral (*Primnoa pacifica*)*
12:00 – 1:30 pm	Lunch in the Grand Ballroom	
Session A4: Biology, Demography, and Ecology: Life History Characteristics and Reproduction **Session Chair: Santiago Herrera, Lehigh University**		
1:30 pm	***Keynote: Sandra Brooke***	*Can deep sea coral spawning periods be predicted using environmental data?*
2:00 pm	Bárbara de Moura Neves	*Growth in deep-water sea pens (Octocorallia: Pennatulacea): rates, patterns, and future directions*
2:15 pm	Swaantje Bennecke	*In situ growth rates of deep-water octocorals determined from 3D photogrammetric reconstructions*
2:30 pm	Meagan Putts	*Community structure and development of Hawaiian deep-water precious coral on Mauna Loa lava flows*
2:45 pm	Carlos Gomez	*Community assembly, environmental filtering and functional diversity in deep-sea octocoral communities in the Gulf of Mexico*

3:00 – 3:30 pm	Break	Palm Garden Room
Session A5: Biology, Demography, and Ecology: Community Associations and Interactions **Session Chair: Peter Auster, Univ. of Connecticut**		
3:30 pm	Tina Kutti	*Echinoid bioerosion of* Lophelia pertusa *coral reefs in Norway*
4:15 pm	Brennan Phillips	*Soft robotic grippers: a new technology for delicate sampling of deep-sea coral reefs*
4:00 pm	Christina Kellogg	*Comparison of the Microbiomes of Seven Species of Deep-Sea Corals*
4:15 pm	Inge van den Beld	*The diversity of species associating with coral habitats in submarine canyons of the Bay of Biscay*
4:30 pm	Ian Rocha	*Development of a recirculating aquaria system for cold-water corals maintenance using natural and artificial seawater in Brazil*
4:45 pm	Juliana Gadelha	*New species of the genus Corynactis (Hexacorallia, Corallimorpharia) associated to* Lophelia pertusa *from Santos Basin, Brazil*
6:45 – 10 pm	Symposium dinner	Harborview Room, Marriott Long Wharf

14 September - Wednesday

Free day / Excursion to Woods Hole

15 September - Thursday

7:30 am	Registration Opens	Palm Garden Room
Session D2: Anthropogenic Threats and Management Strategies: Anthropogenic Threats I **Session Chair: Amanda Demopoulos, USGS**		
8:30 am	***Keynote: Fanny Girard***	*Using image-based long-term monitoring to understand the biology and recovery of deep-sea coral communities after the Deepwater Horizon oil spill*
9:00 am	Danielle DeLeo	*Elucidating Oil Spill Impacts on Deep-Sea Corals Using RNAseq*
9:15 am	Samuel Vohsen	*High-throughput metabolomics identifies species- and cold seep-specific metabolites in corals*
9:30 am	Janessy Frometa	*Effects of oil and dispersants on* Swiftia exserta, *a structure-forming deep-water gorgonian octocoral from mesophotic reefs in the Gulf of Mexico*
9:45 am	Inês Martins	*Effects of Deep Sea Mining on the Antioxidant Defense System of the Cold-water Coral Dentomuricea meteor*
10:00 – 10:30 am	Break	Palm Garden Room
Session C1: Oceans Past and Future: Modeling Applications **Session Chair: Evan Edinger, Memorial Univ. of Canada**		
10:30 am	Di Tracey	*Protecting deep-sea coral communities: recent research and lessons from down-under*
10:45 am	Enrique Salgado	*RAFi: a new conservation priority index for deep-sea corals and sponges in Southern California, using parameters for richness, abundance, and fishing intensity*
11:00 am	Emma Smith	*Organic matters: Studying energy flow and trophic status of contrasting cold water coral ecosystems in the N.E. Atlantic using stable isotopes and lipid biomarkers*
11:15 am	Daan Gerla	*The energy budget dynamics of the cold-water coral* Lophelia pertusa
11:30 am	Danielle Glynn	*Major shifts in nutrient and phytoplankton dynamics seen in the North Pacific Subtropical Gyre over the last 5000 years using records of δ13C and δ15N values from proteinaceous deep-sea corals*
11:45 am	Alan Fox	*The sensitivity of modelled* Lophelia pertusa *larval dispersal and population connectivity to climate variability*

12:00 – 1:30 pm	Lunch in the Grand Ballroom; Ocean Acidification Workshop in the Harborview Room, Fiona Murray	
Session C2: Oceans Past and Future: Corals and Climate Change **Session Chair: Erik Cordes, Temple University**		
1:30 pm	Johanna Järnegren	*The cold-water coral associated squat lobster* Munidopsis serricornis *in a future ocean, how is it affected by increasing CO2 and temperature?*
1:45 pm	Malindi Gammon	*Corals and carbon: The physiological response of a protected deep-sea coral (*Solenosmilia variabilis*) to ocean acidification*
2:00 pm	Jay Lunden	*Cold Corals in Hot Water: Responses of* Flabellum impensum *Larvae to Ocean Warming in Antarctica*
2:15 pm	Fiona Murray	*Cold-water-corals in a high CO2 ocean: behaviour, physiology and growth in* Desmophyllum dianthus
2:30 pm	Louise Cameron	*Impact of ocean acidification and warming on net calcification rate and calcifying fluid dynamics of the cold water coral* Lophelia pertusa
2:45 pm	Janina Büscher	*Interacting effects of ocean acidification and warming on the ecophysiology of* Lophelia pertusa *investigated in two long-term laboratory experiments*
3:00 – 3:30 pm	Break	Palm Garden Room
Session D3: Anthropogenic Threats and Management Strategies: Anthropogenic Threats II **Session Chair: Di Tracey, NIWA**		
3:30 pm	Steven Auscavitch	*Deep Caribbean seamounts: Insights to cold-water coral distribution and genetic relationships from the Anegada Passage*
3:45 pm	Evan Edinger	*New observations of deep-sea corals and sponges in Baffin Bay and the Northern Labrador Sea, Canada*
4:00 pm	Tina Molodtsova	*Black corals in the abyss: diversity, biogeography and adaptations. Case study of the Clarion-Clipperton Fracture Zone*
4:15 pm	Günter Försterra	*WANTED: Your opinion how to explain unresolved mass mortalities of cold-water corals in shallow waters of Chilean Patagonia*
4:30 – 5:00 pm	***Keynote: Andrea Gori***	*Ecological Restoration of Deep Coral Gardens on the Mediterranean Continental Shelf*
5:00 pm	Poster Session II	Palm Garden Room, Marriott Long Wharf

16 September - Friday

7:30 am	Registration Opens	Palm Garden Room
Session B3: Habitat and Environmental Settings: Hydrodynamics and Food Supply **Session Chair: Rhian Waller, University of Maine**		
8:30 – 9:00 am	***Keynote: Sebastian Hennige***	*How corals apply the Goldilocks Principle to engineer habitat*
9:00 am	Dick van Oevelen	*Newly-discovered recycling pathways in cold-water coral reef communities*
9:15 am	Frank Parrish	*In-situ measurements of environmental variables at three Hawaiian deep sea coral beds*
9:30 am	Sandra Maier	*Survival in a feast-famine environment: Resource utilization and storage in cold-water coral* Lophelia pertusa
9:45 am	Jill Bourque	*How do different species of deep-sea corals structure adjacent soft-sediment communities?*
10:00 – 10:30 am	Break	
Session C3: Oceans Past and Future: Reef and Mound Structures in Time and Space **Session Chair: Veerle Huvenne, National Oceanog. Centre**		
10:30 am	Furu Mienis	*How Cold-water Coral Mounds on the Rockall Bank Have Outgrown Themselves*
10:45 am	Aaron Lim	*Piddington Mound: Spatial organisation and its influences across an entire Cold-Water Coral reef*
11:00 am	Laurence De Clippele	*Using novel acoustic and visual mapping tools to predict the small-scale spatial distribution of live biogenic reef framework in cold-water coral habitats*
11:15 am	Katleen Robert	*Hanging gardens: Vertical walls from images to fine-scale 3D reconstructions*
11:30 am	Claudio Lo Iacono	*Living reefs and CWC mounds in the Alboran Sea (Western Mediterranean). Holocene evolution and present-day conditions*
11:45 am	Jürgen Titschack	*Mediterranean cold-water corals – an important regional carbonate factory?*
12:00 pm	Wrap Up & Announcements	

Symposium Side Events

MONDAY, SEPTEMBER 12, 2016

12:00-1:15 pm

The Galway Statement and opportunities for trans-Atlantic Ocean research cooperation

Harborview Room, Boston Marriott Long Wharf Hotel

In 2013 Canada, the European Union and the United States of America signed a statement in Galway, Ireland creating the Atlantic Ocean Research Alliance. During this process a number of potential areas of collaboration were identified, namely:

- Ocean health & stressors
- Ocean observation
- Marine microbial ecology
- Aquaculture
- Ocean literacy - engaging with society
- Seabed and benthic habitat mapping
- Data, data Access & information dissemination

Following this, the European Union created a series of relevant funding opportunities including a topic "Improving the preservation and sustainable exploitation of Atlantic marine ecosystems". This was released as the "Blue Growth-1" call for proposals through the EU's Horizon 2020 scheme in 2014. Among their expected impacts, projects developed to address this call were asked to contribute to the development of the Galway Statement process.

This briefing session will describe the Atlantic Ocean Research Alliance its aims and objectives. It will showcase the projects 'ATLAS' and 'SponGES' funded under the BG-1 call and open the floor for discussion over how collaborations can be developed between these projects and ongoing and new future projects created between Canada, the EU and USA to maximize the opportunities and synergies created by the Galway Statement.

The total investment in ATLAS and SponGES is over 20M euros. Both projects focus upon deep-sea ecosystems and have well-developed offshore research cruise plans. Working on a set of key ecosystems including cold-water corals, sponge grounds and hydrothermal vents ATLAS will create a trans-Atlantic assessment and deep-water ecosystem based spatial management for Europe. SponGES will examine deep-sea sponge ground ecosystems of the North Atlantic creating an integrated approach towards their preservation and sustainable exploitation.

By holding this briefing session at the start of the ISDSC we aim to maximize chances for discussion on new collaborations between delegates at the meeting. This event was arranged by the ATLAS co-ordination office and is sponsored by the European Union through the Atlantic Ocean Research Alliance support action (AORAC-SA).

6:30-8:00 pm

Reception and NOAA Town Hall

Harborview Room, Boston Marriott Long Wharf Hotel

Reception with light refreshments and a cash bar and a debut of a NOAA report on the State of the Deep-Sea Coral and Sponge Ecosystems of the U.S.

This event will feature chapter highlight presentations and group discussion covering new research findings, spotlight issues, and new management actions. The new volume is a nearly 10-year retrospective of U.S. research efforts, with 12 full-color chapters hosted online by NOAA at no cost, with updated maps and species lists for U.S. regions. This volume represents the efforts of more than 30 authors with expertise in science and management. Six regional overview chapters describe the distribution and ecology of the deep-sea coral and sponges; six spotlight chapters explore cross-cutting topics of deep-sea coral and sponge research such as species discovery, age and growth, effects of fishing gear, habitat modeling, and population connectivity.

Speakers include:

- Stephen Cairns – Species Discovery in U.S. Waters
- Robert Stone – State of Ecosystems in the Alaska Region
- Peter Etnoyer – Effects of Fishing Gear in U.S. Waters
- Frank Parrish – State of Ecosystems in the Pacific Islands Region
- Nancy Prouty – Age, Growth Rates, and Paleoclimate Studies
- Greg Boland – State of Ecosystems in the Gulf of Mexico Region
- Cheryl Morrison – Population Connectivity of Deep-Sea Corals
- Thomas Hourigan – State of Ecosystems in the Southeast Region
- David Packer & Michelle Bachman – State of Ecosystems in the Northeast Region

The Town Hall event is hosted by NOAA's Deep-Sea Coral Research and Technology Program (DSCRTP), a federal program authorized under Magnuson-Stevens Sustainable Fisheries and Conservation Act (Sec. 408) in 2007. The purpose of the DSCRTP is to provide sound scientific information needed to conserve and manage deep-sea coral ecosystems.

For more information, please contact:
Tom Hourigan, NOAA Deep-Sea Coral Research and Technology Program (Tom.Hourigan@noaa.gov)
or Peter Etnoyer, NOAA National Centers for Coastal Ocean Science (Peter.Etnoyer@noaa.gov)

WEDNESDAY, SEPTEMBER 14, 2016

Excursion to Woods Hole (Limited to 40)

8:30 am (Bus departs Boston Marriott Long Wharf Hotel)
5:30 pm (Bus arrives back in Boston)

Our excursion to Woods Hole includes a walking tour of parts of the Woods Hole Oceanographic Institution, historical sites, and the WHOI Ocean Science Exhibit Center, a provided lunch, tours of labs and vehicles as available, and free time to explore the village shops and restaurant/pubs.

See Registration Table for more information.

THURSDAY, SEPTEMBER 15, 2016

12:00 – 1:15 pm

Monitoring the effects of ocean acidification on cold-water corals: Recommendations for GOA-ON

Harborview Room, Boston Marriott Long Wharf Hotel

At the recent GOA-ON (Global Ocean Acidification Observing Network) workshop following the Oceans in a High CO2 World conference, there was a lot of discussion around biological measurements to monitor how coral reefs fare in a changing ocean. The goal of this workshop is to feed back some cold-water coral specific metrics for the forth coming GOA-ON Implementation plan document. The aim would be to identify which of the metrics for coral reefs identified so far are inappropriate for cold-water corals and to suggest some CWC specific alternatives for monitoring the impacts of ocean acidification on coral reefs.

This event is hosted by:
Dr. Fiona Murray, Research Associate
Centre for Marine Biodiversity & Biotechnology, School of Life Sciences
Heriot-Watt University, Edinburgh, Scotland

Talk Abstracts for Monday, 9/12

8:30 AM

Veerle Huvenne, National Oceanography Centre, University of Southampton

From pixel to polyp: using novel robotic technology to achieve an integrated multi-resolution 3D characterisation of cold-water coral habitats in submarine canyons

Many submarine canyons are known to host important cold-water coral (CWC) habitats. However, these are challenging to observe: the steep and irregular terrain, large depth range and strong currents limit the use of traditional sampling and surveying techniques. In order to characterise all CWC settings and understand the canyon processes driving their distribution, a unified, 3-dimensional habitat mapping approach was developed under the CODEMAP project (ERC Starting Grant no 258482), based on the latest advances in marine robotics. In a first for the UK science community, three different deep-sea robotic systems were deployed simultaneously, during the recent CODEMAP2015 expedition in Whittard Canyon, NE Atlantic. A nested bathymetric mapping scheme used multibeam data collected by the research vessel (~50m pixel size), AUV Autosub6000 (~1m pixel) and ROV ISIS (~20cm pixel) to provide increasing detail on the terrain morphology of the CWC habitats. The AUV and ROV also carried new adaptations to enable sideways mapping of cliffs and overhangs. The acoustic data were complemented by ROV-based HD video and precision sampling, while a 21-day continuous deployment of a Seaglider provided insights into the water column structure and current regime, illustrating the presence of 80m high internal waves. The observations revealed three different types of habitat for framework-building CWCs: small mounds, near-vertical "hanging" reefs, and small coral patches. The integrated, nested approach enabled us to observe all canyon processes at the scale they occur, and detailed analysis will now determine which processes and scales are critical in driving the habitat distribution.

9:00 AM

Andy Wheeler, University College Cork, Ireland

Coral mounds on the Irish margin revisited: a critical assessment of critical habitat

The Irish margin features a variety of coral provinces at comparable latitudes containing patch reefs, coral "gardens," giant carbonate mounds (both colonised by contemporary coral and not). Each province has differing environmental conditions and correspondingly differing status of contemporary cold-water coral reef development and stature. Exploration over the last 15 years allows a characterisation of the different provinces and a re-evaluation of the critical environmental controls typifying each provinces. With many variable similar in adjacent provinces, the individual impact of substrate, current speed, sediment supply and water masses on defining critical thresholds in coral occurrence and the resultant morphologies of reef forms can be evaluated. Using recent high resolution studies, this talk explores the control of these individual variables and limiting parameters on development within a relative restricted area. We present new data from the Moira Mounds in the Porcupine Seabight that shows a transition along an environmental gradient of varying current speed and bedload transport. We present new data from the Porcupine Bank Canyon where substrate controls and nutrient flux have a more dominant control of coral build-ups and compare this to flourishing reefs on the Rockall Bank where sediment supply is limited. The influence of water mass on coral limits is also considered.

9:15AM

Steinunn Ólafsdóttir, Marine Research Institute, Reykjavík, Iceland

Deep water corals and sea pens in the cold North Atlantic waters around Iceland

The presence of cold-water corals and sea pens in Icelandic waters have been known since early in the 20th century with a total of 68 species recorded, including the reef building *Lophelia pertusa*, *Madrepora oculata* and *Solenosmilia variabilis*. The Marine Research Institute of Iceland has mapped and characterized many coral reefs. In this talk a general overview will be provided about coral habitats at broad and fine scales, and evaluate what environmental drivers can influence their distribution, species composition and morphology. Considering the relatively young age of Iceland and high incidence of volcanic activity, means that the types of geomorphs which corals can be associated to are extremely diverse, e.g. ridges, troughs, landslides and glacial landforms. The composition and distribution of the Icelandic coral fauna is strongly influenced by the cold arctic waters and the warm North Atlantic waters. Some Nearctic species have been recorded within Icelandic waters, as well as NE Atlantic species. This dynamic oceanographic régime and the diverse seascape influence the distributional patterns, species composition and morphology of cold-water corals. Sea pens and soft corals are found both in the warm waters south of Iceland and in the cold arctic waters north of Iceland. Coral reefs are mainly found on the continental shelf and slope south of Iceland. Their morphology is diverse, ranging from solitary colonies to large reefs. On the shelf, these reefs are circular and easily observed on multibeam maps, but in the slope, the coral reefs seem to form more continuous framework and are not as easily detected.

9:30 AM

Charles Messing

Halmos College of Natural Sciences and Oceanography, Nova Southeastern University, Florida

Ecology, distribution and time-series analyses of mesophotic and deep-water coral assemblages on a tropical island slope, Isla Roatán, Honduras

Shore-based submersible operations, from 2008 to 2015 so far, have allowed us to examine megabenthic assemblages along the island margin of Isla Roatán from depths of <100 to 750 m, including repeated observations of the same organisms. Sessile habitat-forming taxa are dominated by at least 15 morphological species each of octocorals (e.g., *Plexauridae, Primnoidae, Coralliidae, Isididae,* and *Ellisellidae*) and sponges (*Demospongiae* and *Hexactinellida*), with fewer taxa and numbers of Scleractinia (*Lophelia prolifera*, *Dendrophyllia alternata*, *Madracis myriaster*, and *solitaries*), *Antipatharia* and *Zoanthidea*. Other important taxa include abundant and diverse *Crinoidea*. Epifaunal assemblages associated with corals include 24 macroinvertebrate species (e.g., *Asteroschema laeve* (Ophiuroidea) and Chirostylus sp. (Decapoda:Brachyura), with the highest diversity of epifauna on Plumapathes sp. and D. alternata. Taxa exhibit vertical zonation as expected (e.g., Nicella in 100-200 m; Paramuricea in 300-700 m), but many were observed only in restricted local habitats within their depth ranges, perhaps associated with specific topographic and near-bottom hydrodynamic conditions. Repeated observations of octocoral colonies show predation, recolonization, and epibiont host fidelity, as well as a multi-year decline of a *Paramuricea octocoral* and loss of its resident ophiuroids. The shore-based submersible provides a relatively inexpensive platform from which to carry out time-series observations of otherwise rarely visited mesophotic and deep coral assemblages.

9:45 AM

Peter Etnoyer, NOAA's Coastal Center for Environmental Health and Biomolecular Research, Charleston, SC

Where are the coral gardens? Mapping densities and condition of gorgonian octocorals in the mesophotic depth zone of the Channel Islands National Marine Sanctuary in Southern California

The term 'coral garden' is useful for science and management because it identifies vulnerable marine ecosystems and promotes metrics for comparison, specifically density and extent of coral aggregations. This study measured gorgonian octocoral density, extent, and condition in the Channel Islands National Marine Sanctuary (30-150 meters) and compared these to densities reported for 'coral gardens' in other regions. Remotely operated vehicles have been used to monitor changes in faunal abundance in CINMS since 2005. Study sites were Santa Rosa Island, San Miguel Pass, and Anacapa Island. Corals were enumerated from still images and video. Three transect approaches were considered, based on distance (100 meters) and duration (5 and 15 minute). The 100 m and 5 min. transects identified several aggregations where density exceeded 100 colonies/100 m2. None of the 15 min. transects achieved these densities due to the patchiness of coral coverage. The highest average densities were north of Santa Rosa (36 corals/100 m2). The most abundant taxa were Eugorgia rubens and Adelogorgia phyllosclera, with maximum densities of 55 and 70 colonies/100 m2 respectively. Leptogorgia chilensis was also present. Most octocorals appeared to be in healthy condition, but there were some notable declines in density and condition since 2005 in shallow parts of Anacapa Island, near 30 m. Aggregated densities meet the Oslo/Paris convention's (OSPAR) definition for 'coral garden' (100-700 colonies/100 m2), suggesting the criteria are applicable to this area. Further work is needed to map the full extent of the 'coral gardens' and assess the potential threats.

10:30 AM

Christopher Kelley, Hawai'i Undersea Research Laboratory

Rift zone ridge crests can provide topography and substrate conducive for the development of high-density deep-sea coral and sponge communities

Many volcanic seamounts in the Pacific have rift zones, where fissures allowed lava to erupt laterally from their flanks and not just from their summits. Rift zones created linear ridges that extend for several kilometers from these seamounts. Some seamounts have as many as six rift zone ridges, although the number is usually less than four. These ridges provide significant barriers to near bottom water flow and their crests may therefore be sites where current is accelerated. We investigated whether rift zone ridges host large scale, high-density communities of deep-water corals and sponges using high-resolution mapping data in combination with ROV observations. In 2015, eighteen Deep Discoverer ROV dives were conducted off the NOAA ship Okeanos Explorer within the Papahānaumokuākea Marine National Monument (PMNM). Nine of these dives were conducted on rift zone ridges that had been mapped in 2014 using the Schmidt Ocean Institute's R/V *Falkor*. The dives ranged in depth from 1,535 to 2,797 meters. The exceptional quality of the multibeam data allowed for accurate measurements of the lengths, widths, compass orientations, and depth ranges of the ridge crests using the Benthic Terrain Modeler Extension for ArcGIS. High-density coral and sponge communities were found on five of the nine ridges surveyed, with the other four ridges having medium to low-density communities. The depth of the ridge crest, the degree to which the substrate was consolidated, and its orientation relative to the prevailing bottom current direction appeared to influence the type of community. These findings suggests that at least some rift zone ridge crests are important sites for deep-water corals and sponges and that this type of habitat warranted further study and consideration for possible protective measures.

10:45 AM

Rachel Wilborn, Alaska Fisheries Science Center, Lynker Technology, LLC

Distribution, abundance, diversity and size of cold-water corals and sponges in the Aleutian Islands, Alaska

The Aleutian Islands Archipelago extends over 1900km west of the Alaskan Peninsula and encompasses a diverse benthic community of corals (Alcyonacea), sponges, pennatulaceans, and stylasterids. In 2012 and 2014 a comprehensive underwater camera survey (216 stations) was completed for the archipelago. Over 300,000 individuals were identified, representing eight families of octocorals, one family of hydrozoans, and three orders of sponges. More than 8,000 individual heights were measured and compared within and among groups and stations, providing an extensive baseline for several corals and sponges. Mean benthic habitat density for the entire region was 0.98 individuals m-2. Demospongiae (n=137,476), Primnoidae (n=132,487), Stylasteridae (n=27,297), and Plexauridae (n=20,289) were the four most frequently identified sessile invertebrates, accounting for 96.6% of identified individuals. Sponge and coral densities for the archipelago averaged 0.47 and 0.42 individuals m-2 respectively. Stations with high density were clustered south of Amchitka Island (4.01 individuals m-2) and north of Amukta Island (5.05 individuals m-2). Environmental parameters such as depth, temperature, and substrate type were also recorded. Demosponges, sea pens, plexaurids, and primnoids were vastly more abundant at shallow depths (<200m); whereas sea whip, hexactinellid, and bamboo coral densities increased at depths greater than 600m. Community structure between stations was compared for similarities, and environmental parameters were analyzed for correlations between similar stations. Corals, sponges and stylasterids overwhelmingly preferred consolidated substrates; whereas pennatulaceans were more abundant on unconsolidated substrates.

11:00 AM

Helle Jørgensbye, National Institute of Aquatic Resources, Technical University of Denmark.

Cup coral gardens (Flabellum alabastrum) a deep water, low relief ecosystem in Greenland

The cup coral Flabellum alabastrum Moseley in Thompson, 1873 belongs to the solitary stone corals and are restricted to fine sediments of clay or silt. They have a wide Atlantic distribution but only inhabit a relatively restricted deep sea area in West Greenland. The distribution has been modelled based on presence absence data collected in three different time periods: Historical data from 1879-1928, Museum data from 1991-1992 and recent bycatch data collected during scientific fish stock assessments. ROV video data has been used to define F. alabastrum coral gardens. The distribution of F. alabastrum is related to ongoing deep sea trawl fisheries in Greenland. Data analysis has just started and is in progress.

11:15 AM

Lara Miles, Department of Geography, Memorial University of Newfoundland, Canada

Scale-dependent surficial geology influence on cold-water coral distribution, Flemish Cap, Northwest Atlantic

Cold-water coral (CWC) distributions are influenced by both oceanographic and geological factors, but the relative importance of these two is unclear, and may vary with spatial scale. While the attachment substrate preferences for many coral species are known, bedrock and/or surficial geology are rarely used to predict CWC distributions. This study examines the influence of bedrock geology and surficial geology described at five spatial scales on CWC distribution on the Flemish Cap, Northwest Atlantic. Remotely-operated vehicle transect video was used to describe the surficial geology and CWC assemblages at four sites in three regions (S, E, NE) of the Flemish Cap. Sixteen coral species were grouped into seven functional groups (large gorgonians, small gorgonians, sea pens, soft corals, black-wire corals, cup corals, and Desmophyllum dianthus). Eight geological facies were described at five spatial scales (10m, 50m, 100m, 500m, and 1000m). The eight facies, in increasing grain size, were: fine grain, gravelly fine grain, boulder, sedimentary bedrock /fine grain sediment mix, igneous outcrop/fine grain sediment mix, sedimentary/igneous bedrock mix, sedimentary bedrock outcrop, and igneous bedrock outcrop. ANOSIM analysis showed a significant difference between substrate types at fine scales (10m, 50m, and 100m) but not at broader scales (500m, 1000m). Of the fine scales, 100m was the most significant for both CWC species and functional groups. Our results suggest that bathymetry and oceanography are dominant influences on coral distribution at broad scales, with surficial geology dominating distributions at scales finer than 1 km.

11:30 AM

Peter Auster, UConn Dept of Marine Sciences & NURTEC

Identifying spatially rare deep sea coral communities in the Gulf of Maine (NW Atlantic).

Although deep-sea octocorals were historically considered common components of hard bottom communities in the deep waters of the Gulf of Maine region, they are now spatially rare and have been difficult to detect using standard towed-gear surveys. Exploratory ROV and towed camera surveys in 2002-03 and 2013-15 located sites in deep U.S. waters (ca. 200 m depth within the Maine Deep Water oceanographic regime) in western Jordan Basin, central Jordan Basin, near Mount Desert Rock, on Outer Schoodic Ridge and on Lindenkohl Knoll. Dominant taxa were Paramuricea placomus, Primnoa resedaeformis, and Acanthogorgia cf. armata with occurrences of Paragorgia arborea and Anthothela sp. Sites were added over time and in an iterative fashion based on insights from fishermen, historical records, standard bathymetric charts, multibeam sonar, and geospatial results of predictive habitat models. In initial multivariate analyses of eight 2013 transects, temperature and depth were primary environmental factors and sediment type, rock outcrop and topographic rise were primary sedimentary factors that correlated with coral distributions (mean density of 0.89-9.07 corals m-2 across 8 transects; peak density 92.45 corals m-2). Identification of discrete sites supporting coral communities (classified as coral present or coral garden) form the foundation for developing coral management zone alternatives by the New England Fishery Management Council. Decision rules to develop boundaries include linking coral distribution to seafloor features as well as the spatial limits of existing observations.

11:45 AM

J. Murray Roberts

Heriot-Watt University, Edinburgh, Scotland

The ATLAS project: a trans-Atlantic assessment and deep-water ecosystem-based spatial management plan for Europe

ATLAS is a new 9.1M euro trans-Atlantic project funded through Europe's Horizon 2020 programme. It adopts new ways of working spanning natural through to social science with the needs of marine industries and policy makers at the heart of its objectives. ATLAS will achieve its ambitions by using a dynamic new partnership between multinational industries, SMEs, governments and academia to assess the Atlantic's deep-sea ecosystems and Marine Genetic Resources to create the integrated and adaptive planning products needed for sustainable economic development or "Blue Growth" in the Atlantic basin. ATLAS will gather diverse new information on sensitive Atlantic ecosystems (including Vulnerable Marine Ecosystems (VMEs) and Ecologically or Biologically Sensitive Areas (EBSAs)) to produce a step-change in our understanding of their connectivity, functioning and responses to future changes in human use and ocean climate. This is possible because ATLAS takes innovative approaches to its work and interweaves its objectives by placing business, policy and socioeconomic development at the forefront with science. ATLAS not only uses trans-Atlantic oceanographic arrays to understand and predict future change in living marine resources, but enhances their capacity with new sensors to make measurements directly relevant to ecosystem function. The ATLAS team has the track record needed to meet the project's ambitions and has already developed a programme of deep-sea cruises, with more pending final decision. These cruises will study a network of 12 Case Studies spanning the Atlantic, including, sponge, cold-water coral, seamount and mid-ocean ridge ecosystems. The team has an unprecedented track record in policy development at national, European and international levels. An annual ATLAS Science-Policy Panel in Brussels will take the latest results and Blue Growth opportunities identified from the project directly to policy makers. Finally, ATLAS has a strong trans-Atlantic pertnership in Canada and the USA where both government and academic partners will interact closely with ATLAS through shared cruises, staff secondments, scientific collaboration and work to inform Atlantic policy development. ATLAS has been created and designed with our north American partners to foster trans-Atlantic colaboration and the wider objectives of the Glaway Statement on Atlantic Ocean Cooperation.

12:15 PM

Galway Declaration

The Atlantic Ocean Research Alliance Coordination and Support Action (AORA-CSA)

1:30 AM

Martha Nizinski, National Marine Fisheries Service, National Systematics Laboratory, Smithsonian Institution

A Tale of Two Canyons: ROV Surveys Highlight Differences in Species Composition and Abundances of Deep-Sea Corals in Nygren and Heezen Canyons, Western North Atlantic

Numerous submarine canyons incise the continental margin of eastern North America. As part of the Northeast Regional Deep-Sea Coral Initiative (2013-2015), several under-explored canyons were selected to document occurrences of deep-sea corals and to characterize benthic ecosystems and habitats. Two canyons of particular interest, Nygren and Heezen canyons, are relatively large, shelf-incising canyons that occur furthest northeast within US waters. Prior to 2013, little was known about these canyons; virtually no contemporary coral data were available. Two expeditions, using ROVs, were conducted in these canyons to collect contemporary data relative to deep-sea coral distributions, abundances, and habitats. In 2013, during the NOAA Office of Ocean Exploration Northeast Canyons Expedition, ROV Deep Discoverer was deployed twice in each canyon. Based on findings from this survey, Nygren and Heezen canyons were investigated further in 2014 using ROV ROPOS. In total, nine ROV surveys were completed in these canyons, during which more than 60 hrs of video were taken. Based on video surveys, coral presence/absence information was collected and habitats characterized. Although similar in size, these canyons differ in their morphology, in their coral diversity and abundances of corals, and the assemblage structure of corals also differs within each canyon. Significant differences, which correlate with habitat and depth, were observed in species composition and distribution of corals. Defining the composition and distribution of fauna inhabiting vulnerable marine ecosystems is critical for effective management and conservation of these living resources. Findings suggest coral habitats in these canyons are good candidates for conservation priorities.

1:45 PM

Amanda Demopoulos

US Geological Survey, Florida Integrated Science Center

Food-web structure and isotopic niches of deep-sea corals and other consumers residing within Baltimore and Norfolk Canyons, U.S. Atlantic margin

Submarine canyons often experience dynamic flow and turbulence, where canyon morphologies, current regimes, and nutrient conditions can influence the quality and quantity of food resources. Stable isotope analysis (SIA) and Bayesian standard ellipses were used to examine food-web structure and isotopic niches in Baltimore and Norfolk Canyons along the U.S. Atlantic margin. Both canyons revealed that fish and invertebrate communities were composed of isotopically diverse feeding groups, encompassing ~ 5 trophic levels, with the baseline carbon source derived from photosynthetic material. There were no significant differences between canyons for $\delta^{13}C$ or $\delta^{15}N$ values for all feeding groups analyzed. However, paired comparisons between four coral species that co-occurred in both canyons showed significant enrichment in ^{13}C in Norfolk compared to Baltimore Canyon. Isotope niche widths also varied among coral species, potentially related to differences in feeding habits and habitat association. Suspension feeders had the most diverse SIA data, potentially because they can assimilate particulate organic matter (POM) and capture invertebrate prey. Omnivores and bottom-feeders were enriched in ^{13}C and ^{15}N relative to suspension feeders. Results indicated that different feeding groups occupied distinct trophic niches, possibly due to competition for food. Consumer $\delta^{15}N$ values from both canyons were positively correlated with depth, while $\delta^{13}C$ values significantly decreased with depth. The large spread in $\delta^{13}C$ values for consumer groups indicate that the isotopic composition of POM changes, possibly as a function of location within the canyon. Thus, food availability, substrate type, and resuspension processes influence the food-web structure in these environments.

2:00 PM

Lissette Vicotero, National Oceanography Centre, University of Southampton

The Biodiversity and Spatial Distribution of Cold-Water Corals on Equatorial-Atlantic Seamounts

Seamounts are prominent, globally distributed seafloor features, which are often considered as "biodiversity hotspots" hosting abundant fish stocks and diverse benthic communities, including cold-water corals. As seamounts provide rich fishing grounds, cold-water corals are caught as by-catch or damaged by bottom trawling leading to the destruction of these vulnerable ecosystems and the associated species living within the coral structures. Currently coral biodiversity patterns on seamounts are not well understood due to lack of sampling, with pronounced gaps in the Equatorial Atlantic, making it difficult to devise coherent management plans. Here we present the cold-water coral diversity, abundance and distribution from ROV video transects in three distinct seamounts in the Equatorial-Atlantic. We compare biodiversity patterns with both bathymetric variables (slope, rugosity, aspect etc.) and water-chemistry parameters (particulate organic carbon, aragonite saturation etc.), to determine key environmental drivers. Preliminary results suggest that cold-water coral gardens are highly variable in terms of composition across seamounts, but extensive gardens occur between 1300 1700 m in all seamounts. There is a notable absence of *Lophelia pertusa* and *Madrepora oculata*, with only small thickets of Solenosmilia variabilis present making Enallopsammia sp. the most abundant colonial scleractinian across the three seamounts. We also explore ecological observations of coral-associated fauna, and investigate differences between coral gardens on vertical versus horizontal substrates.

2:15 PM

Carlos Perez, Centro Acadêmico de Vitoria, Universidade Federal de Pernambuco, Brazil

Black corals (Anthozoa: Antipatharia) of the South Mid-Atlantic ridge

Black corals (Hexacorallia: Antipatharia) are common in all the oceans, mainly at great depths, to 8900 m. The paucity of knowledge about the biodiversity in deep-sea ecosystems is also reflected on antipatharians. One of the regions that best represents this state of knowledge is the South Atlantic Ocean, with about 3,000 seamounts. Among these, the most conspicuous is the Mid-Atlantic Ridge (MAR), which extends over 14000 km from the northern hemisphere, between North Iceland up Bouvet Island in the South Atlantic, separating abyssal and bathyal provinces along the Atlantic. The southern region of the MAR was sampled for the first time between the years 2006 and 2010, during the campaigns of the project MAR-ECO SA (Standards and Processes of Ecosystems of Mid-Atlantic Ridge), carried out through partnerships between Brazil, Argentina, Uruguay and South Africa. Sampling was performed by trawls and dredges, up to 5000 m deep, between the Cross Equatorial Fracture Zone and the Rio Grande Rise – Walvis Ridge. These samples made accessible the knowledge of the richness of black corals in the region. We present herein the results of examination of 10 black coral samples deposited in the National Museum of Rio de Janeiro (MNRJ/ UFRJ), Brazil. Preliminary results show a total of four black coral species belonging to three families: Schizopathidae, Cladopathidae and Leiopathidae. The records of *Stauropathes punctata* (Roule, 1905) and *Parantipathes helicostich*a Opresko 1999 (Family Schizopathidae) may indicate the connectivity between the MAR and adjacent seamounts, since both species have been recorded in Cape Verde, Azores and Valdivia Ridge. It is likely that most of the records would be related to the family Schizopathidae since it includes species that reach the highest depths. The record of *Trissopathes tristichia* (van Pesch, 1914) (family Cladopathidae) represents the first Record of this species to the Atlantic, since it was previously known only to the Indo-Pacific. The same occurs with *Leiopathes* sp. (family Leiopathidae), formerly this family was known only in the Indo-Pacific and North MAR. Now its distribution is extended to South MAR. The research MAR-ECO SA is underway, and the results promise to reveal important pieces of deep sea puzzle.

2:30 PM

Amy Baco-Taylor, Florida State University

Recovery of Seamount Precious Coral Beds From Heavy Trawling Disturbance

Increasing anthropogenic impacts in the deep sea make studies of resilience and recovery time critical, with deep-sea hard-substrate habitats and large-scale disturbances having received little attention. Seamount hard-substrate habitats in particular are thought to have low resilience due to the slow growth rates and recruitment limitations of key structure-forming taxa. Seamounts of the far Northwestern Hawaiian Islands and Emperor Chain have had some of the heaviest trawl impacts in the world, from both fish and precious coral fisheries, and include sites that are still trawled and recovering ones that have been protected since establishment of the EEZ in 1977. To test the hypothesis of low resilience we compare these impacted seamounts to untrawled sites. We used the AUV Sentry to image nine features (three per "treatment") and analyze for substrate and visible megafauna. Sites in the "still trawled" treatment were characterized by extensive areas of bare substrate with abundant trawl scars. Sites in the "recovering" and "never trawled" locations had abundant megafauna in hard substrate areas. Initial comparisons of transects at 700m depth for three sites indicate that Yuryaku had lower diversity and abundance of megafauna compared to the "recovering" and "never trawled" locations with a dominance of sea urchins. The "recovering" and "never trawled" sites were dominated by cnidarians, fishes, and echinoderms, but differed in dominant species, diversity, abundances and occurrence of dead coral skeletons. These preliminary results suggest that the recovering sites have not returned to a pre-impact community type in the 38 years since they were trawled.

2:45 PM

Michael Parke, NOAA PIFSC

Deep-sea coral and sponge research in the Pacific Islands 2015-2017

In 2015, the Pacific Islands Fisheries Science Center began a 3-year program to improve the understanding, conservation, and management of deep- sea coral and sponge ecosystems in the U.S. Pacific Islands region. This presentation will detail the approach we have adopted to address the most pressing scientific and management issues in an area that is both geographically extensive and infrastructure poor. I will highlight our successes to date and challenges for the future.

3:30 PM

Thomas Hourigan, Office of Habitat Conservation, NOAA Fisheries Northwest Fisheries Science Center

U.S. Fisheries and Deep-Sea Coral Habitats: Policy, Science and Conservation

Over the last decade, the United States has begun to take a systematic approach to protect deep-sea coral habitats from fishing impacts. This paper reviews the coordinated steps in policy, research, and management that the U.S. National Oceanic and Atmospheric Administration (NOAA) has taken that advance conservation of vulnerable deepwater habitats. NOAA's "Strategic Plan for Deep-Sea Coral and Sponge Ecosystems" advances protection of areas with abundant, diverse or rare deep-sea coral or sponge communities, and takes a precautionary approach to "freeze the footprint" of the most damaging fishing practices in unsurveyed areas. A subsequent draft Bycatch Strategy explicitly identifies the risk to benthic habitats from bycatch of habitat-forming species, and NOAA is responding by for observers in coral identification in order to produce more quantitative and geographically specific measures of fishing impacts. In 2009, NOAA's Deep Sea Coral Research and Technology Program began a series of multiyear, regional research programs to collect information that can be directly translated into conservation action. Research priorities were developed in collaboration with the fishing and management communities. Compilation of both new and historic data, and a systematic application of species distribution modeling has allowed extrapolation from study sites to larger areas relevant to management. Examples from the northwest Atlantic and northeast Pacific illustrate how this new, finer-scale information is being applied to understand and manage fisheries impacts, and point to areas where additional progress is needed.

3:45 PM

Michelle Bachman, New England Fishery Management Council

Applying deep-sea coral science to fishery management in New England, U.S.A.

The New England Fishery Management Council has recognized the importance of protecting deep-sea coral habitats from the negative effects of fishing since 2005, when Lydonia and Oceanographer Canyons on the southern flank of Georges Bank, U.S.A. were closed to monkfish fishing. Since then, the Council has designated additional canyons and seamounts as habitat areas of particular concern to highlight their biodiverse, vulnerable deep-sea communities. Currently, the Council is developing a comprehensive plan to protect deep-sea corals off the New England coast from the impacts of fishing gear. Fishery managers are required to use the best available science in the development of their plans. The Council has consulted with experts on the forefront of deep-sea exploration and research in order to ensure that we are using the most up-to-date information. These collaborations have afforded the opportunity to guide study plans so that data are available to support management decisions. In 2011, only a few of the Georges Bank canyons were considered well studied by the Council's Habitat Plan Development Team, but the body of coral science in New England has grown significantly in recent years. Presently, direct visual sampling, high resolution terrain data, and habitat suitability modeling provide a robust foundation for the design of coral management zones. Fishery managers are key consumers of data products about deep-sea ecosystems, and it is important for the scientific community to continue to make these products accessible to a range of stakeholders involved in the fishery management process, including managers, fishermen, and environmental groups.

4:00 PM

Kiley Dancy, Mid-Atlantic Fishery Management Council

Collaborative Development of Deep-Sea Coral Protected Areas in the US Mid-Atlantic

In 2015, the Mid-Atlantic Fishery Management Council proposed measures to reduce the impacts of fishing on deep-sea corals off the U.S. mid-Atlantic coast. The proposal would prohibit the use of most types of bottom-tending gear within a 99,000 km2 area on the outer continental shelf, slope, and deep sea to the outer boundary of the EEZ. The proposed coral zones will limit interactions between fishing gear and corals in areas of known or highly likely coral presence, and prevent the deep-water expansion of commercial fishing operations using bottom-tending gears. If approved by NOAA, this action will mark the first use of the 2006 Magnuson-Stevens Fishery Conservation and Management Reauthorization Act discretionary authority authorizing regional Fishery Management Councils to designate zones where fishing may be restricted to protect deep-sea corals. The successful development of this action depended on two critical factors. First, availability of recent data products, including a regional habitat suitability model, new coral observations from recent surveys in mid-Atlantic canyons, and high-resolution bathymetry data enabled the development of targeted management options supported by the best available science. Second, management options were evaluated through a collaborative stakeholder workshop to determine an acceptable balance between coral protection and negative impacts on commercial fisheries. Workshop participants, including Council members and advisors, coral and habitat scientists, fishermen who utilize the proposed areas, and conservation organizations interested in coral protection, discussed competing proposals and boundary locations. The resulting set of boundaries, representing a consensus of workshop participants, was subsequently supported unanimously by the Council.

4:15 PM

Morgan Kilgour, Gulf of Mexico Fishery Management Council

Ongoing Efforts and Challenges for Managing Deep-sea Corals in the Gulf of Mexico

Currently, the Fishery Management Councils have two major avenues for protecting deep-sea corals, via establishment of habitat areas of particular concern (HAPCs) or through the discretionary deep-sea coral authority outlined under the Magnuson-Stevens Act. While both avenues protect corals from fishing, only the HAPC designation requires a consultation with NMFS regarding any non-fishing activity. The Gulf of Mexico (Gulf) Fishery Management Council is in the initial stages of determining if additional areas in the Gulf warrant HAPC status for deep-sea corals. Currently, the Gulf has 11 individual HAPCs, sanctuaries or reserves that have fishing regulations totaling just over 4100 square kilometers. There are an additional 10 areas that have been defined as HAPCs but do not have fishing restrictions. The Gulf Council has convened several working groups to discuss new areas for consideration of HAPC status. Additionally, the Gulf Council is developing a new data management tool on our data portal to assist managers with management decisions. This presentation discusses the process, challenges, and type of the protection needed for deep-sea corals while working collaboratively with stakeholders.

4:30 PM

Greg Boland, Bureau of Ocean Energy Management

Recent and Ongoing Research on Deep-water Coral Resources in the Gulf of Mexico

Research on deep-water corals of the Gulf of Mexico (>50 m) has intensified substantially over the last decade. Since 2007, and the publication of the first State of Deep Coral Ecosystems of the United States by NOAA, at least 49 research cruises by federal, academic and the private sector organizations have taken place in this region, both before, and as a result of the Macondo well blowout and oil spill in 2010. This presentation will highlight research efforts from both continental slope and shelf (mesophotic) studies including recent large federally-funded interdisciplinary studies prior to the Deepwater Horizon event and research associated with the spill. The use of remote sensing data and modeling has helped researchers make significant advances in predicting the locations of habitat, with particular success in detecting hard bottom habitat using seismic anomaly data. There has been significant progress on gathering of new information on distribution of deep-sea corals and habitats including exploration of habitat created by artificial substrates from shipwrecks and energy platforms. Stressors include oil and gas development, and threats from fishing and related fishery issues (invasive species). Research priorities and management updates will include new and planned management actions, new priorities for management related to both oil and gas activities, and modification or adoption of new protective measures using new research results.

4:45 PM

Harriet Harden-Davies

Australian National Centre for Ocean Resources and Security, University of Wollongong, Australia

Conserving deep-sea biodiversity in marine areas beyond national jurisdiction?

More than 65% of the ocean, including much of the deep-sea, lies beyond the limits of national jurisdiction. Deep-sea corals in this vast area are subject to numerous and growing threats from human activities such as fishing, mining and climate change. The fragmented international legal framework for biodiversity in areas beyond national jurisdiction contains numerous governance gaps. The development of a new international legally binding instrument on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction under the UN Convention on the Law of the Sea offers an opportunity to address the gaps. The establishment of area-based management measures (including marine protected areas), environmental impact assessments, capacity development and the governance of marine genetic resources are the key issues under consideration. We highlight the progress made in the development of the new international legal instrument and examine the potential significance for deep-sea coral conservation. The role of marine scientific research in informing management decisions and overcoming challenges to the negotiations, particularly with respect to capacity development, is examined.

5:00 PM - 6:15 PM

Poster Session I

Talk Abstracts for Tuesday, 9/13

8:30 AM

Scott France, University of Louisiana at Lafayette

Further observations on branching in bamboo coral colonies, with implications for taxonomy and in situ identifications

At ISDSC3, SCF presented genetic data that whip-like colony morphology was widespread across the Keratoisidinae sensu stricto and not a synapomorphy of a single genus, i.e. Lepidisis. We subsequently showed that the articulated skeleton that characterizes the bamboo corals is likewise not a homologous character, but has independently evolved multiple times across Octocorallia. These observations point to the morphological flexibility of a modular, i.e. colonial, animal. Here, based on genetic analyses of >400 bamboo coral colonies, we report that within Keratoisidinae nodal branching is the likely ancestral condition, with strictly internodal branching most derived. Some genetic clades (presumptive genera) are wholly characterized by nodal or internodal branching, but, with some interesting exceptions, there is little observable pattern to colony shape as a genus-level characteristic; one clade appears to be transitional, displaying a mixture of all branching types and even axial skeletons lacking nodes. Observations made during NOAA's Okeanos Explorer 2015 Hohonu Moana expedition of "irregular" branching of Keratoisidinae suggest that colony form is plastic and influenced by local conditions and events occurring during the lifetime of the colony. Analyses of polyp-scale and genetic characters are required to determine if there are colony-level features that may be used for in situ identifications. We conclude the genus name Lepidisis is associated with a clade of nodal-branching taxa, most of which have relatively thin axial skeletons, and the tall, coiling whips with thicker skeletons common on seamounts and ridges and traditionally called Lepidisis must be described in multiple new genera.

9:00 AM

Les Watling, University of Hawai'i at Mānoa

The Global Distributions of Bathyal Octocorals are Determined by Intermediate Water Masses

As noted by Watling et al. in their 2013 paper proposing deep-sea biogeographic provinces, the bathyal provinces are the least well known. Most of the substrate at bathyal depths exists in the form of ridges and seamounts and has a high proportion of hard, and sometimes vertical, surfaces. We have compiled a global database of gorgonian octocorals from bathyal depths (300 to 3500 m) and plotted the records in ArcGIS. For the bamboo corals (Isididae: Keratoisidinae) and a few other families information on genetic relatedness was used to determine the distributions of closely related specimens. The major distributional patterns fell into the following groups: 1) NW Atlantic; 2) NE Atlantic; 3) central Pacific (Hawaii); 4) N Pacific; 5) W Pacific; 6) SW Pacific. The N Pacific has a fauna distinct from the rest of the Pacific, and the same is true of the eastern N Atlantic. Genetic data show the same or sister taxa extending from the NW Atlantic through the central Pacific to Tasmania. We propose that bathyal octocoral distributions are strongly influenced by the distribution and movement of intermediate waters. The N Pacific is isolated by the gyre of the North Pacific Intermediate Water. In the eastern Atlantic the major intermediate water mass is Mediterranean Outflow Water, which extends from the Straits of Gibraltar north to the British Isles and south to off W Africa, and westward across the Mid-Atlantic Ridge. The one water mass that unites the NW Atlantic, Hawaii, and Tasmanian faunas is Antarctic Intermediate Water.

9:15 AM

Esprit Heestand Saucier, Dept. of Biology, University of Louisiana at Lafayette, LA

Phylogenetic analysis of the keratoisidin bamboo corals with a proposal to erect three subfamilies based on morphological characters and mitochondrial genome arrangement

Keratoisididae (=Isididae: Keratoisidinae) are a subfamily of deep-sea bamboo corals found in all major oceans basins that we previously proposed be elevated to family level. Although taxonomically diverse and relatively abundant in the deep sea, there has never been a phylogenetic analysis of the keratoisidids that included all known genera. We use genetic methods to provide the most comprehensive phylogenetic analysis of Keratoisididae to date with the goal to organize and classify the diversity seen within the group. We propose to revise the diagnosis of Keratoisididae to include both articulated and non-articulated skeletons, and to focus primarily on sclerite morphology. We delineate 3 subfamilies within the newly proposed family. The new subfamilies are defined by mitochondrial genome arrangement and morphological characteristics.

9:30 AM

Gary Williams, Department of Invertebrate Zoology & Geology, California Academy of Sciences

Recent discoveries in deep-sea pennatulacean diversity and systematics (Anthozoa, Octocorallia)

Pennatulaceans octocorals or "sea pens" are a specialized group of corals, most of which are adapted to live in soft benthic substrata by a basal muscular peduncle. Thirty-six genera of sea pens have been described between 1758 and 2015. Sea pens are known from all oceans worldwide, intertidally to over 6200 m. The depth record for the group was established in 2013 at 6260 m off the Peru-Chile Trench, southeastern Pacific Ocean (Umbellula sp. indet.). Species in sixteen of the thirty-six described genera (44% of the known genera) are known from the deep-sea (depths > 1000m). The five deepest known genera (>4000 m) are Scleroptilum, Disthichoptilum, Kophobelemnon, Porcupinella, and Umbellula. Morphological responses of some pennatulaceans at depths greater than 1000 m include reduction of number of polyps, increase in polyp size, greatly elongated stalks, and the clustering of polyps along areas of the rachis. The most recently discovered and described deep-sea species is Porcupinella profunda from the Porcupine Abyssal Plain in the northern Atlantic Ocean, and is known from 4510-5300 m in depth at three locations in the northeastern Atlantic from off of southwestern Ireland to the equatorial latitudes. At least four species of sea pens (known as "rockpens") are able to attach to hard, rocky substrata by a plunger-like adaptation of the basal end of the peduncle. Between the mid-2000s and 2016, rockpens have been recognized as attached to rocky substrata, in temperate and tropical latitudes of the Indian, Pacific, and Atlantic Oceans, between 441 and 1803 m in depth.

9:45 AM

Andrea Quattrini, Harvey Mudd College, Claremont, CA

Phylogenomics of Anthozoa (Cnidaria): New approaches to long-standing problems

Anthozoan cnidarians are arguably some of the most ecologically important metazoans inhabiting shallow waters to the deep sea. Predictions that ocean acidification and warmer ocean temperatures will impact coral skeletogenesis, even in deep waters, have generated widespread concern about the future of coral reef ecosystems. To inform predictions of future ocean change, it is necessary to resolve when particular clades and morphological characters arose and to identify any possible connections between those evolutionary events and paleoclimate conditions. Yet, the evolutionary history within the Anthozoa remains poorly understood, as several key regions in the phylogeny are unresolved. Thus, efforts to understand character evolution within the group have been hindered.

To create a robust, time-calibrated phylogeny of the Anthozoa, we are generating probes to capture ultraconserved elements (UCEs) and their flanking regions. We have sequenced (MiSeq, 40X coverage) eight new anthozoan genomes, including three hexacorals (corallimorpharian, cerianthid, zoanthid) and five octocorals (Renilla sp., Keratoisidinae n. sp., Alcyonium digitatum, Cornularia pabloi, Parasphaerasclera valdiviae). Combining these new resources with existing genomic data, we have successfully designed probes to target 624 UCE loci. We have also incorporated existing transcriptomic data into the pipeline, designing probes for 1157 loci. By aligning these probes back to existing anthozoan genomes, we show, in silico, that these loci accurately reconstruct phylogenetic relationships. Library preparation is currently underway for 192 anthozoan species, including several deep-sea coral species (e.g., Chrysogorgia tricaulis, Paramuricea sp. Desmophyllum dianthus, Flabellum aotearoa). Genomic enrichment for loci will be conducted and libraries will be multiplexed on two lanes of an Illumina HiSeq, followed by species-tree and time calibration analyses. All probes (120 bp tiled probes) will be made freely available to the public, providing a much-needed resource for understanding the evolutionary history of corals and their relatives.

10:30 AM

Jonathan Gardner, School of Biological Sciences, Victoria University of Wellington, New Zealand

Connectivity of deep sea coral Vulnerable Marine Ecosystem indicator taxa: genetic data to inform environmental management in the New Zealand region

The New Zealand Exclusive Economic Zone (EEZ) and is both topographically rich, including the world's longest undersea volcanic arc and the second deepest trench, and highly biodiverse. The region includes deep-sea fauna that are considered indicators of vulnerable marine ecosystems (VMEs), including deep sea corals that form structurally complex and fragile habitats. In the New Zealand EEZ some VMEs have been damaged by commercial deep-water fisheries and are now threatened by prospective seabed mining. However, the population genetic structure and connectivity of deep sea corals from these habitats are poorly understood. We used DNA sequence data and microsatellite genotyping to assess genetic connectivity of five coral taxa within and beyond the New Zealand EEZ. Levels of genetic diversity and patterns of regional genetic structure tended to be species-specific, but some generalities were apparent. Populations within the Kermadec (northern) region tended to show low or zero levels of differentiation, but showed evidence of regional differentiation at a scale of 100s to 1000s of kilometres. The identification of regional differences and barriers to gene flow should aid management decisions about which sites or populations are in need of protection. We discuss our results in the context of life-history characteristics, physical oceanography and the potential for larval dispersal between sites and amongst regions. This multi-species approach provides new insights into the genetic structure and connectivity of New Zealand's VME indicator taxa, and highlights important species-specific differences in patterns of connectivity that will need to be considered in future management (protection) plans.

10:45 AM

D. Katharine Coykendall, United States Geological Society

Contrasting patterns of population genetic connectivity in octocorals from the northern Atlantic Ocean

Connectivity regulates community structure by influencing genetic composition, diversity and demographic stability. Thus, connectivity is fundamental to short-term and long-term resilience. Measuring larval dispersal is logistically difficult (realized connectivity). However, population genetic analyses can provide insights into connectivity integrated over several generations. We compare patterns of genetic connectivity between two habitat-forming gorgonian coral species, Primnoa resedaeformis and Paragorgia arborea. Both species have discontinuous distributions in the North Atlantic Ocean, yet often co-occur in continental slope habitats along the northeastern coast of North America and off western Europe. Microsatellite markers reveal starkly contrasting connectivity patterns. When populations in Norfolk and Baltimore canyons off the mid-Atlantic U.S. coast were compared, Primnoa resedaeformis, but not Paragorgia arborea, were differentiated. Similarly, estimates of connectivity were low between Primnoa resedaeformis populations in the mid-Atlantic Canyons versus the Gulf of Maine (FST estimates = 0.241 to 0.312), and a stepping-stone model of gene flow adequately described the relationship between geographic and genetic distances, suggesting that gene flow is limited by dispersal. In contrast, our genetic estimates of connectivity suggest that gene flow in Paragorgia arborea is adequate to maintain cohesiveness among U.S. East Coast populations. Trans-latitudinal and trans-oceanic gene flow was estimated for the first time for these species through comparisons with populations off the Canadian provinces of Nova Scotia, Newfoundland and Labrador, and the Whittard Canyon off Ireland. The contrasting patterns of connectivity between these two species will be discussed in relation to their reproductive strategies, colony morphology, and post-recruitment survival. We will also highlight the relevance of these findings to inform conservation and management measures.

11:00 AM

Meredith Everett , Northwest Fisheries Science Center, NOAA

From population structure to eDNA: Next-generation sequencing technology opens a window into the biology of deep-sea corals

One of the primary challenges in the study of deep-sea corals remains the ability to collect samples. Emerging sequencing technologies are enabling additional understanding of deep sea corals by overcoming the analysis concerns associated with small sample sizes and providing opportunities for increased non-destructive sampling. RAD-sequencing enables the development of thousands of novel SNP markers in organisms with few existing genetic resources. In Swiftia simplex, we successfully used RAD-sequencing to identify and genotype 1,145 SNPs from 23 individuals spanning the U.S. west coast and assessed population structure across the region. In collaboration with USGS and NOAA Alaska Fisheries Science Center, we are applying this technique to determine levels of connectivity among populations Primnoa pacifica from across southeast Alaska. Thus far we have discovered more than 700 SNPs. These P. pacifica SNPs will allow for direct comparisons of connectivity patterns assessed from SNP versus microsatellites (USGS). Next-generation sequencing also has the potential to increase our opportunities for sampling by enabling us to look at environmental DNA (eDNA). Environmental DNA methods require only a sample of water from close proximity to the specimen in question, and thus may be easier to obtain on a greater number of expeditions. In collaboration with the Seattle Aquarium, we successfully performed a pilot study sampling eDNA from deep-sea corals and confirming species identification in this controlled setting. Subsequently, coral eDNA samples from the Cascadia margin were collected in collaboration with the Ocean Exploration Trust to test this method on field collections.

11:15 AM

Santiago Herrera, Lehigh University

The genomics of adaptation potential of deep-sea corals to environmental changes

Species inhabiting a wide range of environmental conditions constitute natural systems of biological adaptations, which can promote our understanding of the ecological consequences of environmental changes on ecosystems. Some populations of deep-sea coral species can be found in shallow (< 45 m) high-latitude fjord environments, where they experience significantly different environmental conditions than their deep relatives. Therefore, both deep and shallow-water populations are believed to inhabit the extremes of the species' ranges and physiological tolerances. These species likely have developed adaptations that enable them to colonize these shallow-water environments. Our aim is to identify genomic regions that may have enabled the successful adaptation to shallow-water in the deep-sea octocoral species *Paragorgia stephencairnsi*. To characterize the genome-wide genetic diversity of populations of *P. stephencairnsi* found in shallow-water populations and compare it to the genetic diversity from deep-water populations, we performed high-resolution genome-wide scans of single nucleotide polymorphisms as well as whole genome sequencing. We found patterns of significant population genetic differentiation among the examined populations of *P. stephencairnsi*, which are consistent with the hypothesis that larvae from outer deep populations seeded shallow-water inner fjord populations. Furthermore, we find candidate positive-selection markers shared between parallel comparisons of two shallow populations and a deep population, and thus identify them as likely candidate makers for genomic regions involved in adaptation to the shallow-water fjord environment. This work lays groundwork for describing the impacts of natural selection on deep-sea coral species under the influence of oceanographic environmental change.

11:30 AM

Anna M. Addamo, National Museum of Natural Sciences, Madrid, Spain

A cosmopolitan species as model for genetic connectivity of deep-sea coral populations, key in addressing evolutionary and ecological questions in larval dispersal.

A wide interest for cold-water coral reefs has been expressed in the last decade; several expeditions and projects have been realized, increasing the scientific knowledge and giving an important baseline for a potential and efficient conservation plan. Nevertheless, reproductive strategy and larval dispersal capability of deep-sea corals are still largely unknown biological processes. In this study, larval dispersal and marine connectivity among deep-sea coral reefs has been indirectly inferred from genetic markers. Several individuals of Desmophyllum dianthus were collected from 13 localities in the Mediterranean Sea, Atlantic and Pacific oceans, and were analysed using 30 microsatellites isolated for this species. Beside significant genetic differentiation between populations inhabiting northern and southern hemispheres, a peculiar phylogeographic structure has been found in the South Pacific and Atlantic oceans. The results suggest a genetic pattern of isolation-by-distance in the former case, and a discrete larval dispersal (strongly depth-current-dependent) among individuals from Chile, New Zealand, Australia and Argentina.

11:45 AM

Cheryl Morrison, Leetown Science Center, US Geological Survey

Genetic Connectivity among Offshore and Emergent Southeastern Alaskan Fjord Populations of a Foundation Species, the Red Tree Coral (Primnoa pacifica)

Red tree corals, Primnoa pacifica, are large gorgonians that are the dominant structure-forming coral species in the Gulf of Alaska (GOA). Red tree corals serve as important habitat to fishes and invertebrates, yet this long-lived species are highly susceptible to disturbance from fisheries, and as such, some protection has been afforded to several offshore populations in the GOA. Red tree corals are often a dominant component of emergent fjord communities in southeastern Alaska, occurring as shallow as six meters. The variable combination of tides, storms, freshwater discharge, plus complex passageways to the sea may restrict larval exchange between offshore and fjord P. pacifica populations, or conversely, fjord populations could become important larval sources should offshore populations become depleted. Microsatellite markers were used to characterize the spatial scale and pattern of genetic connectivity across a large portion of the range of P. pacifica in the North Pacific Ocean. Over 300 discreet, geo-referenced samples of P. pacifica were collected via remotely operated vehicles or SCUBA divers on NOAA-sponsored research cruises in 2013-2016 from three offshore GOA populations (Dixon Entrance, Cape Ommaney, the Fairweather Grounds) and three fjords (Tracy Arm, Endicott Arm and White Thunder Ridge in Glacier Bay National Park). A complex pattern of connectivity was recovered, with offshore populations being more highly connected than fjord populations. This study provides important insights regarding the most appropriate tools available to resource managers to protect sensitive coral habitats and the ecosystem services they provide.

1:30 PM

Sandra Brooke, Florida State University

Can deep sea coral spawning periods be predicted using environmental data?

Like their shallow-water counterparts, deep-sea corals can exhibit one of several different reproductive strategies; however, all of the reef-building stony coral species studied to date are gonochoristic broadcast spawners. *Lophelia pertusa* is possibly the most widespread and well-studied of the reef-building stony corals. The reproductive biology of this species shows location-specific differences in timing of the gametogenic cycle across the North Atlantic. In the western Atlantic canyons, several species of broadcast-spawning deep-sea corals (e.g. L. pertusa, Solenosmilia variabilis, Dasmosmilia lymani) show synchrony in their reproductive cycles, with more advanced maturity in the fall than the spring. Off New Zealand, gametogenesis of three species of stony corals (S. variabilis, Enallopsammia rostrata, Goniocorella dumosa) was highly synchronized among species, with spawning occurring in April-May; however, S. variabilis from the western Atlantic were immature in May. Synchrony in the timing of reproductive cycles within a location is evidence that common factors are influencing multiple species; location-specific differences in spawning of con-specifics allows identification of those drivers. Such information can be used to predict spawning periods in areas where sampling is logistically or economically unfeasible. Understanding reproductive strategy and timing of spawning in deep sea corals can inform studies of connectivity and community resilience, and also has management implications in areas where human activities may negatively affect coral early life history stages. This presentation uses data on coral reproduction and regional environmental variables to explore whether coral spawning periods can be predicted using environmental data.

2:00 PM

Bárbara de Moura Neves, Memorial University of Newfoundland

Growth in deep-water sea pens (Octocorallia: Pennatulacea): rates, patterns, and future directions

Deep-water sea pens can provide habitat for other species and are vulnerable to anthropogenic activities (e.g. bottom fisheries), but little is known about their longevity and growth rates. In this study we present data on longevity and growth rates of the sea pens Halipteris finmarchica, Umbellula encrinus, and Pennatula grandis from the Northwest Atlantic. The internal skeletons (i.e. axis) of the sea pens were cross sectioned, polished and photographed under UV light in stereomicroscope. Growth rings were visually counted, and Radiocarbon and trace element analyses were performed to assess frequency of ring formation. Average diametric growth rates were similar among the three species (0.13-0.14 mm.yr-1), but linear growth rates in H. finmarchica and U. encrinus were more similar to each other (4.5 and 4.9 cm.yr-1 respectively) than to P. grandis (1.8 cm.yr-1). Maximum average number of rings for the analyzed colonies ranged from 22 in H. finmarchica to 68 in U. encrinus. Trace element analysis of Sr/Ca, Mg/Ca, Ba/Ca, and Na/Ca ratios yielded a number of trace element peaks comparable to the number of growth rings visually determined. The radiocarbon signature of both U. encrinus and P. grandis was comparable to that from the calcite of other deep-water octocorals that lay down rings annually. Growth rates were statistically related to bottom temperature (U. encrinus) and surface chlorophyll a (P. grandis), but no clear trends were identified. Sea pens can have decadal longevities and similar diametric growth rates among species, and environmental factors might partially influence growth rates in these octocorals.

2:15 PM

Swaantje Bennecke, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

In situ growth rates of deep-water octocorals determined from 3D photogrammetric reconstructions

Growth rates of deep-water corals provide important information on the recovery potential of these ecosystems, for example from fisheries induced impacts. Here we present in situ growth dynamics that are currently largely unknown for deep-water octocorals, calculated by applying a non-destructive method. Videos of a boulder harbouring multiple colonies of Paragorgia arborea and Primnoa resedaeformis in the Northeast Channel Coral Conservation Area at the entrance to the Gulf of Maine at 863 m depth were collected in 2006, 2010 and 2014. Photogrammetric reconstructions of the boulder and the fauna yielded georeferenced 3D models for all sampling years. Repeated measurements of total length and cross-sectional area of the same colonies allowed the observation of growth dynamics. Growth rates of total length of Paragorgia arborea decreased over time with higher rates between 2006 and 2010 than between 2010 and 2014, while growth rates of cross-sectional area were slightly increasing. A general trend of decreasing growth rates of total length with size of the coral colony was documented. While no growth was observed for the largest colony (165 cm in length) between 2010 and 2014, a colony 50 - 65 cm in length was growing 3.7 cm yr-1 between 2006 and 2010. Minimum growth rates of 1.6 2.7 cm yr-1 were estimated for two recruits (<23 cm in 2014) of Primnoa resedaeformis. We successfully extracted biologically meaningful data from photogrammetric models and present the first in situ growth rates for these coral species in the Northwest Atlantic.

2:30 PM

Meagan Putts, Hawaii Pacific University, Waimanalo, Hawaii

Community structure and development of Hawaiian deep-water precious coral on Mauna Loa lava flows

Adjacent deep-water coral communities on submarine lava flows of different ages were compared to examine species succession and community structure across time. On the leeward flank of Hawaii Island, a total area of 93,840 m2 was surveyed across six coral communities that ranged in age from 61 2,330 years as well as a much older coral community (~15,000 years) on a sunken carbonate escarpment. Taxa abundance, community composition, and colony size structure progressed with time. Coralliidae dominated the early successional stage establishing a mature community within 150 years. Antipatharia and Isididae were slower to colonize and proliferate, while gold coral, Kulamanamana haumeaae, was the slowest, suggesting that millennia are required for a precious coral community to form with full diversity, high evenness, and mature size structure. Analyses of quantitative geophysical parameters of the benthic terrain (i.e. hardness, slope, aspect, curvature, and Bathymetric Position Index) on the presence/absence and abundance of corals demonstrated significant associations on a localized scale (e.g. single survey site) but not across survey sites. These results have important implications for predictive modeling of the distribution and abundance of deep-water coral across large spatial scales.

2:45 PM

Carlos Gomez, Temple University, Philadelphia

Community assembly, environmental filtering and functional diversity in deep-sea octocoral communities in the Gulf of Mexico

Unraveling patterns of community assembly and functional trait diversity will help clarify some of the mechanisms that control species distributions and the potential effects of perturbations in deep-sea ecosystems. Our aim is to better understand processes such as environmental filtering and its influence in the community composition by analyzing species' traits and environmental information. For this purpose, coral collections were conducted at 27 sites spanning a depth range from 2502500m using ROV. Octocorals from 54 different species were sampled, from which 11 morphological traits were measured. In general, 79.8% of the variation in species' traits was well explained by two principal components that aggregate six main morphological traits. Traits of octocorals in shallow water communities differed from those found in the deepest communities (pseudoF=4.94 $p<0.05$). Specifically, octocorals with calcified axes and non-retractable polyps predominated at deeper depths, while octocorals with retractable and dense polyps arranged in whorls were characteristic of shallower assemblages. Moreover, significant relationships with depth were evident for polyp size, polyp density, and inter-polyp distance for some specific groups suggesting environmental filtering related to food availability. Functional richness, evenness, and dispersion did not vary among depths and were independent of species richness suggesting a similar level of ecosystem functioning despite the observed variability in morphological traits. Furthermore, these indices were independent of species richness suggesting a similar level of ecosystem functioning at the different depths. These results highlight the importance of including functional traits when attempting to make predictions of assembly mechanisms of this significant taxonomic group.

3:30 PM

Tina Kutti, Institute of Marine Research, Norway

Echinoid bioerosion of Lophelia pertusa coral reefs in Norway

In shallow-water tropical coral reefs, echinoids are important bioeroders of coral framework, limiting reef growth and stability. Yet in deep-sea habitats the role of echinoid bioerosion in controlling reef development is less understood. Recent reports of the presence of live and dead coral fragments in the stomach of four species of deep-sea echinoids suggest that they are able to feed on and erode both live and dead coral reef framework, although no quantitative data on bioerosion was presented. Here we report the results of a laboratory study that aimed at quantifying the preference and amount of live and dead coral *Lophelia pertusa* consumed by the sea-urchin Echinus esculentus, and their bioerosion rates. We offered the sea-urchins live and/or dead coral fragments for two weeks, after which we measured weight loss of the fragments, as well as weights of organic matter and calcium carbonate (CaCO3) in the feces and stomach of the sea-urchins. Based on our results, the sea-urchins clearly preferred feeding on dead coral framework (119±25 mg.individual-1.day-1), with consumption rates nine times higher than that of live coral fragments (13±7 mg.individual-1.day-1). The amount of CaCO3 removed by E. esculentus during feeding was combined with field data on sea-urchin sizes and abundances on the Nakken Reef, Norway, and bioerosion rates of the sea-urchins were estimated to be 20 ± 8 g CaCO3.m-2.year-1. Implications of these results for the carbonate budget and coral reef development are discussed.

3:45 PM

Chang-Feng Dai, Institute of Oceanography, National Taiwan University

Deep-sea scleractinian corals in the South China Sea

Yu-Rong Cheng Institute of Oceanography, National Taiwan University

The South China Sea (SCS) encompasses vast deep-sea basins and numerous coral reef islands. However, the biodiversity of deep-sea corals in the SCS is largely unknown. Field surveys of deep-sea corals surrounding Dongsha Atoll, Macclesfield Islands and the Spratly Islands in the SCS was conducted in 2013-15 and 46 species in 21 genera and 9 families of scleractinians were obtained. A review of more than 1500 coral specimens collected from the SCS and deposited in various museums revealed 73 species and 46 species (63%) were different from our survey data. Analysis of community structure of deep-sea corals showed large variations of species composition among stations in the SCS. These results indicate that the SCS may have high diversity of deep-sea corals. Furthermore, 15 individuals of Hyrrokkin sarcophaga, a large parasitic foraminifer, were discovered on three deep-sea corals (Madrepora oculata, Flabellum japonicum, Caryophyllia diomedeae) collected at 339-552 m depth in the SCS. This is the first report on the occurrence of H. sarcophaga in the Pacific. It extends our knowledge on the global distribution of H. sarcophaga as well as its ecological affinity and host preference.

4:00 PM

Christina Kellogg, U.S. Geological Survey

Comparison of the Microbiomes of Seven Species of Deep-Sea Corals

While studies of the bacterial associates of shallow-water corals have occurred for over 40 years, deep-sea corals have only been the topic of microbial studies for the last decade. In that time, the main focus has been the scleractinian *Lophelia pertusa*. However, it is difficult to compare studies as different methodologies (e.g., cultivation, clone libraries, T-RFLP, 454) were used. Even when confined to the same methodology (e.g., 454 pyrosequencing), different extraction techniques and primers confound direct comparisons. DNA samples from 51 individual colonies of seven species of deep-sea corals have been extracted and sequenced using identical methodologies such that they can be directly compared. The species are L. pertusa, and ocotocorals Anthothela grandiflora, Anthothela sp., Alcyonium grandiflorum, Paramuricea placomus, Primnoa pacifica, and Primnoa resedaeformis. These corals were pyrosequenced targeting the V4V5 variable region of the 16S rRNA gene. Comparison shows deep-sea coral microbiomes cluster based on host genus rather than host species. The only bacterial phylum shared by all corals was Protobacteria, however, 92% of samples contained Planctomycetes, 84% of samples contained Firmicutes, 76% of samples contained Bacterioidetes and 71% of samples contained Actinobacteria. There were no bacterial operational taxonomic units or genera shared across all coral species nor shared by all the octocorals. The actinobacterial family Pseudonocardiaceae was present in all 12 L. pertusa samples and none of the other corals. This in-depth look across multiple cold-water coral species creates a critical baseline for future comparisons to determine impacts of climate change or anthropogenic influence.

4:15 PM

Inge van den Beld, IFREMER (Brest, France)

The diversity of species associating with coral habitats in submarine canyons of the Bay of Biscay

The scleractinians *Lophelia pertusa* and *Madrepora oculata* form reefs that function as shelter, nursery grounds and feeding areas for many organisms, including commercially important fish. Reefs are also biodiversity hotspots. Therefore, these reefs are important subjects for conservation and are listed in several international initiatives, such as the OSPAR convention. Habitats formed by gorgonians, black corals and seapens, may have similar functions as scleractinian reefs and are also targets for conservation management. In the Bay of Biscay, submarine canyons incising the continental margin, are known to host many cold-water coral (CWC) habitats. Since the discovery of CWCs in this area in the early 19th century, only a few studies have investigated coral habitats and associated species. This study investigates the species community associated to ten CWC habitats based on their dominating coral group and substrate type. The associated species have been identified on image footage acquired by a towed camera or ROV during 46 dives (7 cruises) in the submarine canyons of the Bay of Biscay. More than 30,000 associated individuals have been observed, from almost 200 morpho-types. In general, coral reefs and rubble have higher diversity than habitats on hard substrate. Higher densities were observed in coral reefs and habitats on hard substrate than in habitats dominated by soft substrate and rubble. Substrate is an important factor differentiating species communities. Other forcing factors, e.g. the coral species forming the habitat, latitude and depth, will also be investigated.

4:30 PM

Ian Rocha, LABTOX- Laboratório de Análise Ambiental LTDA

Development of a recirculating aquaria system for cold-water corals maintenance using natural and artificial seawater in Brazil

In a partnership between PETROBRAS and LABTOX, it was set up the first recirculating aquaria system in Brazil to maintain *Lophelia pertusa*, in order to perform ecotoxicological studies to evaluate the effects of oil and gas industry activities. The corals sampling was performed in 2014 and 2015. The specimens were obtained from three different *Lophelia* reefs located in Santos Basin (SE Brazil) at 208-252 meters depth, by ROV. In the laboratory, three aquaria systems, containing 700, 300 and 300 L, were set up in refrigerated room (10-12 °C) in the dark and maintained in recirculating filtered natural marine water and in synthetic seawater. Each system consisted of a water reservoir connected to a chiller and two aquaria with biological, chemical and mechanical filtration. Three sentinels coral branches were chosen in each aquarium and they were monitored for health and survival. The monitoring of temperature, salinity, conductivity, pH, dissolved oxygen and nutrients was performed weekly along with water renewal (10%) to replace minerals and trace elements. Over two years, it was not verified significant differences on physicochemical parameters (coefficient of variation <0.1 or 0.15). Mortality events were punctual and were not related to the measured physicochemical parameters of water quality. The polyps' behavior suggests that the colonies were adapted to the reproduced artificial conditions and the colony longevity has been satisfactory. The recirculating aquaria system with natural and artificial seawater proved to be suitable for *Lophelia pertusa*.

4:45 PM

Juliana Gadelha, Centre for Environmental and Marine Studies, University of Aveiro, Portugal

New species of the genus Corynactis (Hexacorallia, Corallimorpharia) associated to Lophelia pertusa from Santos Basin, Brazil

Cold-water corals as *Lophelia pertusa* play a significant role as habitat builder for many deep-sea species. We describe a new species of Corynactis (Corallimorpharia) in association with *L. pertusa*. Samplings were made on February 2014/2015 during surveys performed for PETROBRAS research project "SENSIMAR Marine Sensitive Environments". Fragments of L. pertusa were collected from three different *Lophelia* reefs, by ROV (Remotely Operated Vehicle), in Santos Basin (Brazil) at 208-252 meters depth. Colonies were maintained in a closed system with natural and artificial seawater, powered by a generator, in dark chambers with temperatures between 10-12º C. Associated fauna was removed and traditional protocols of study were used. The diagnostic features of the analyzed material are in accordance with Genus Corynactis which has 17 valid species, but only five are registered at depths greater than 100m. Because of differences in cnidom, arrangement of the tentacles, and musculature, our material has not matched any of the species already described. This is the first record of a member from Corynactis living in L. pertusa. The present work extends the bathymetric record for Corallimorpharia in Brazil (from 36m to 250m) and the bathymetry for the genus Corynactis (201m to 250m). It constitutes the first record of association between L. pertusa and Corallimorpharia in South Atlantic. Finally, it registers a new species of genus Corynactis to science. This study confirms the importance of deep-sea coral reefs formed by *L. pertusa* as habitat to a rich and still unknown associated community.

6:45 – 10:00 PM

Symposium Dinner, Grand Ballroom, Marriott Long Wharf

Talk Abstracts for Thursday, 9/15

8:30 AM

Fanny Girard, Pennsylvania State University

Using image-based long-term monitoring to understand the biology and recovery of deep-sea coral communities after the Deepwater Horizon oil spill

In April 2010, the Deepwater Horizon blowout led to one of the largest oil spills in history. Within months three impacted coral communities were discovered. We developed a method to quantify the long-term impact of the spill on deep-sea coral communities in the Gulf of Mexico and assess their recovery. Paramuricea spp. colonies were imaged every year between 2011 and 2015 at four different sites, and the images digitized to quantify impact, identify hydroid overgrowth, and track recovery patterns. Observed recovery between consecutive years was negatively correlated with the level of impact apparent on corals in 2011. Significant branch loss was observed throughout the study period; most often occurring in impacted areas of the colonies but sometimes resulting in the loss of apparently healthy portions. This method not only allowed us to better understand the coral's response after impact from a spill, but also helped answer fundamental questions about the biology of these organisms. We were able to measure growth rates for both Paramuricea biscaya and Paramuricea sp. B3, as well as characterize the relationship between corals and their associate ophiuroids. On average, P. biscaya had slow growth rates compared to P. sp. B3, and growth was negatively affected by colony size and level of total visible impact. Impacted branches were also less likely to form new branches. The presence of ophiuroid associates was found to have strong positive effects on these corals. Ophiuroids mitigated the effects of the initial impact and enhanced recovery of the colonies hosting them.

8:45 AM

Danielle DeLeo, Temple University

Elucidating Oil Spill Impacts on Deep-Sea Corals Using RNAseq

The 2010 Deepwater Horizon (DWH) disaster and subsequent cleanup efforts released an unprecedented amount of oil and chemical dispersants in the deep waters of the Gulf of Mexico (GoM). Detrimental effects have since been documented including impacts to deep-water corals. Understanding how corals respond to these environmental pollutants, including the effects of exposure at the cellular level, is essential to determining long-term consequences to deep-sea coral populations. RNA was extracted from unexposed and in situ spill-impacted (DWH) Paramuricea biscaya for RNAseq analysis. A de novo reference transcriptome was produced and used to explore the stress-induced variations in gene expression. Live exposure experiments were also conducted on two octocoral species, Callogorgia delta and Paramuricea type B3, to investigate the genome-wide influence of different oil and dispersant treatments on coral gene expression and for comparison to in situ expression signatures. The RNAseq analyses on DWH spill-impacted corals revealed a large suite of differentially expressed genes including over-expression of Cytochrome p450 (CYP1A1), Tumor necrosis factor receptor-associated factors (TRAFs) and additional genes involved in toxin processing, innate immunity and wound repair. A subset of the genes differentially expressed by corals during the spill were also found among corals experimentally exposed to oil and dispersants. Together, our results provide insight into the stress responses of deep-sea corals and the implications of using dispersants. The genes revealed in our expression data may serve as useful biomarker candidates for assessing and monitoring future spill impacts as resource extraction continues in the deep waters of the GoM.

9:00 AM

Samuel Vohsen, Pennsylvania State University

High-throughput metabolomics identifies species- and cold seep-specific metabolites in corals

Untargeted metabolomics such as Liquid Chromatography-Mass Spectrometry (LC-MS) has the potential to rapidly and quantitatively fingerprint biological states and identify key metabolites in biological processes yet it has rarely been applied to corals. Here, we first quantify variation from multiple experimental sources such as extraction procedures and within colony variation demonstrating the reproducibility of LC-MS coral metabolomics using Leiopathes glaberrima (Antipatharia). LC-MS was then used to compare the metabolomes of the shallow-water coral Acropora palmata (Scleractinia) and 4 species of deepwater coral including *Lophelia pertus*a (Scleractinia), Callogorgia delta (Alcyonacea), Stichopathes sp. (Antipatharia) and L. glaberrima. Metabolome-wide differences between all coral species were detected including many species-specific metabolites. The shallow water coral, A. palmata, differed most strongly from the deepwater taxa likely due to the presence of Symbiodinium sp. To evaluate the potential of LC-MS to detect ecologically relevant, within-species differences, colonies of Callogorgia delta were collected near and far from areas of natural hydrocarbon seepage in the deep Gulf of Mexico. Colonies growing near seeps had d13C and d15N stable isotope values reflecting input of seep derived organics. Assignment based on stable isotope values revealed that seep-influenced colonies differed from those that were not seep-influenced metabolome-wide. Characterization of metabolites driving species and habitat differences is underway. These experiments lay the groundwork for joint analyses of metabolomic, proteomic and transcriptomic data that may yield unprecedented insights into the molecular stress response of corals.

9:15 AM

Janessy Frometa, NOAA

Effects of oil and dispersants on Swiftia exserta, a structure-forming deep-water gorgonian octocoral from mesophotic reefs in the Gulf of Mexico

One outcome of the Deepwater Horizon oil spill was the realization that no well-established toxicity thresholds exist for benthic taxa in deep water (>50 m). Surveys of mesophotic reefs along the Gulf of Mexico Pinnacle Trend in 2011 showed that large octocoral colonies below the oil slick exhibited significantly more injury than in years before the spill. Swiftia exserta, an octocoral species found throughout the West Atlantic at depths of 20-200 meters, was among the injured taxa. In the Gulf of Mexico Swiftia has white polyps, as opposed to the typical red polyps in East Florida, but haplotype frequencies of mitochondrial gene mutS suggest no difference between the two localities. Live fragments of S. exserta from East Florida were exposed to varying concentrations of water-accommodated oil fractions (WAFs), Corexit® 9500 dispersant, and chemically-enhanced WAFs (20:1 oil-dispersant mixtures, aka CEWAFs) to determine the vulnerability of Swiftia octocorals to oil and dispersants. Following 96-hour toxicological assays, dispersant-alone and oil-dispersant mixtures were substantially more detrimental to coral health than any of the WAF concentrations tested. Complete mortality was observed within 48 hours for some fragments in the dispersant-alone (96h LC50=51.17 mg/L) and oil-dispersant (96h LC50=46% CEWAF) treatments, while the WAF and control groups remained relatively uneffected. This is the first toxicity threshold established for a mesophotic octocoral species subject to the DWH spill, and provides evidence of octocoral sensitivity to oil and dispersants, which should inform scientists and managers in the event of a future oil spill.

9:30 AM

Inês Martins, IMAR/MARE-Azores

Effects of Deep Sea Mining on the Antioxidant Defense System of the Cold-water Coral Dentomuricea meteor

Benthic suspension feeders, such as corals, are likely to be greatly impacted by sediment plumes generated during mining activities for deep-sea mineral resource extraction. Exposure to suspended sediments can mechanically damage corals by smothering and clogging their tissues, and can also contain toxic substances that affect coral physiological processes. In an aquaria-based experiment we simulated the effects of polymetallic sulfide (PMS) plumes, generated during mining activities in a hydrothermal vent field, on the physiology of the cold-water octocoral Dentomuricea meteor. Corals were collected from the summit of Condor Seamount at depths between 185-210 m. Coral fragments were maintained in 10-L aquaria and exposed to three experimental treatments for a period of 27 days: (1) a control treatment with filtered seawater; (2) exposure to suspended PMS particles (25 mg/L; 0.5-70 µm); (3) exposure to suspended inert quartz particles (25 mg/L; 0.5-70 µm). The two particle treatments were designed to distinguish between potential mechanical and toxicological effects of mining sediments. PMS particles were obtained by grinding sedimentary rocks collected at the hydrothermal vent field Lucky Strike, and particle size matched the range expected by Seafloor Mining Tools excavation and by dewatering processes, according to the IHC Mining B.V Company. During the experiment period, diffusive gradients in thin films (DGT's) were used to monitoring the bioavailable labile metal fraction in the different exposure treatments. The antioxidant enzymatic activities of superoxide dismutase (SOD), catalase (CAT), glutathione S-transferase (GST), heat-shock protein HSP70 and lipid peroxidation (MDA built-up) were examined in coral fragment tissue to evaluate tissue metabolic specificities under PMS exposure. Here we describe the implications of PMS exposure to Dentomuricea meteor antioxidant defense system and discuss the potential consequences of mining activities in cold-water communities.

9:45 AM

Thierry Baussant, International Research Institute of Stavange, Norway

Evaluating the Impact of Drilling Wastes on the Cold-water Coral Lophelia pertusa: Laboratory Experiments

This talk will provide some highlights of the research done at IRIS (Stavanger, Norway) on the *Lophelia pertusa* coral using examples from Norwegian Research Council and industry projects. The main research focus is on the assessment of impact from offshore drilling wastes from a series of laboratory experiments performed with L. pertusa. In Norway, the oil and gas industry is present in a number of areas along the continental slope where deep-sea corals thrive and have existed for generations ago. The scleractinian coral L. pertusa forms major reef framework, in fact some of the largest known on earth today. While they provide important services for the deep-sea, offshore exploration represents a potential hazard recognized by the environmental authority requiring a number of mitigations to prevent harm to corals. The focus is on regular discharges of drilling wastes that need to be documented and the effects to corals monitored. Basic knowledge of L. pertusa biology/physiology is still scarce, and understanding of their sensitivity and resilience to exposure from drilling discharge is necessary for establishment of effect threshold values as basis for environmental risk, impact assessment, and management of discharges from drilling operations. A series of experiments were performed using methodologies encompassing molecular to physiological measurements, varying food concentration and scenarios with actual drilling wastes (mud and cuttings) in the range 2 to 40 mg/l. Our general conclusion is that L. pertusa coral is a tolerant species with high resilience. Perspective for new deep-sea coral research on that issue will be provided.

10:30 AM

Di Tracey, National Institute of Water and Atmospheric Research (NIWA)

Protecting deep-sea coral communities: recent research and lessons from down-under

Deep-sea corals are diverse and widespread in the New Zealand region and the retaining of most species is prohibited. They remain however, vulnerable to damage from various human activities, and recent research has addressed questions about the nature and extent of these threats. There has been a substantial increase over the last few years in the collection of distributional and verified identification data on benthic invertebrates, from commercial fisheries and research surveys. These data have supported several Species Distribution Modelling exercises to improve our knowledge of species diversity and spatial variability in coral distribution in the region, and help inform our understanding of how deep-sea ecosystems might be impacted by fishing as well as future changes in ocean chemistry. In this talk, we will discuss management implications when predicting distributions for taxa that are indicators of Vulnerable Marine Ecosystems, and likely changes in species distributions due to changing marine environmental conditions in the next 100 years. Based on this research, the role of the Kermadec region as a possible 'sanctuary' for particular corals will be described.

10:45 AM

Enrique Salgado, NOAA

RAFi: a new conservation priority index for deep-sea corals and sponges in Southern California, using parameters for richness, abundance, and fishing intensity

Deep-sea corals and sponges in Southern California are diverse, abundant, and subject to multiple stressors, including bottom contact fisheries. There is a need to identify priority areas for conservation and special protections. The region is suited to development of a priority index because of the long history of benthic surveys, fisheries monitoring, and conservation action. Remotely operated vehicles have been used by NOAA to survey deep-water habitats since 2003. Fisheries landings are tracked by the state since 1972. These data were combined in a novel priority-setting algorithm to identify where corals are most diverse and abundant, and demersal fishing effort (2007-2011) was most intense. In order to identify where future conservation efforts might be most effective. 26 genera of corals and sponges were identified at 25 sites. The most diverse localities contained 22 genera, with a Simpson's index of 9.2. The most abundant genera in the mesophotic depth zone were Eugorgia, Adelogorgia, and Leptogorgia. Most abundant in the deep-sea were Desmophyllum, Plumarella, and *Lophelia*. 467 observations of derelict fishing gear were made, 33% with corals. Lines were most common. Fixed gear fisheries accounted for 67% of landings, and were widespread throughout the study area. Trawls had a smaller geographic extent and fewer landings. Results of the RAFi algorithm indicate that most diverse and abundant aggregations with high intensity fishing are currently protected by MPAs, with some exceptions. San Clemente Island, Mission Beach, and Channel Islands National Marine Sanctuary should be prioritized for enhanced protections from bottom contact fishing.

11:00 AM

Emma Smith, Liverpool John Moores University

Organic matters: Studying energy flow and trophic status of contrasting cold water coral ecosystems in the N.E. Atlantic using stable isotopes and lipid biomarkers

Cold-water corals (CWC) are now realised as abundant, cosmopolitan and biodiverse hotspots of the global ocean with over 65% of known corals living at over 50m depth. Studies suggest that the quality of suspended particulate organic matter (sPOM), typically the sole energy source of CWC, is of vital importance to the structuring and functioning of CWC ecosystems. Fresh marine sPOM undergoes a variety of complex transformation processes during transport to the ocean interior, thus altering its nutritional quality; characterising sPOM can clarify its importance to the functioning and biogeochemical cycling in CWC ecosystems. This study investigates the nutritional quality of sPOM that reaches CWC ecosystems from two contrasting oceanographic settings of the N. E. Atlantic. sPOM ~10 m above CWC communities was collected using an in situ large volume filtration system. Elemental (C/N ratio), molecular (lipids) and stable isotopic analyses (δ13C and δ15N) were used to investigate nutritional quality, trophic dynamics, and carbon sources of sPOM respectively. Study sites are the shallow (~150m) Mingulay Reef on the NW Scotland shelf vs the deeper (~700m) Logachev Province on the SW slope of the Rockall Trough. Results show significant ($p < 0.05$) differences in the isotopic values of sPOM between locations, indicating differences in trophic dynamics and sPOM re-working (δ15N), which is supported by significant ($p < 0.05$) differences in zooplankton lipids. Differences in δ13C values may be due to differences in planktonic community composition and/or potential chemosynthetic contributions to sPOM in the Logachev Province.

11:15 AM

Daan Gerla, NIOZ Royal Netherlands Institute for Sea Research

The energy budget dynamics of the cold-water coral Lophelia pertusa

Cold-water corals are the reef builders of the deep but they are under threat from climate change, ocean acidification and disturbances of the sea floor. These threats likely occur simultaneously and assessing their impact requires an integration of the impacted physiological processes which determine growth, survival and reproduction. Here we present the first Dynamic Energy Budget (DEB) model of a cold-water coral, namely of *Lophelia pertusa*. DEB theory provides a mechanistic model predicting growth and survival of organisms as function of their size and environmental factors such as food availability and temperature. We optimize parameter values of this model to make simulations fit experimental data on feeding, growth and respiration of *Lophelia* under different food availabilities and temperatures. Having found good agreement between model simulation and data, we proceed by making predictions under simultaneously varying environmental conditions. Specifically, we simulate the effect of starvation, which is a likely result of certain anthropogenic disturbances, on survival and growth of the coral. The model predicts that the coral survives without feeding for long periods of time and that growth is only moderately affected by a 30 day period of starvation, as would be expected for a species with a feast-and-famine lifestyle. However, maximum survival times are reduced by a 1 degree Celsius temperature increase, to a similar extent by an increase in energy demands as expected from ocean acidification of 0.1 pH units and even more by the combination of the two.

11:30 AM

Danielle Glynn, University of California, Santa Cruz

Major shifts in nutrient and phytoplankton dynamics seen in the North Pacific Subtropical Gyre over the last 5000 years using records of δ13C and δ15N values from proteinaceous deep-sea corals

The North Pacific Subtropical Gyre (NPSG) is the largest continuous ecosystem on this planet, and currently expanding in a warming global climate. This study represents the first decadal-scale resolution record of nutrient and ecosystem dynamics in the NPSG over the past five millennia, and offers a historical baseline to better analyze the effects of current and future anthropogenic climate forcing. We reconstructed a 5,000 year record of past changes in stable bulk nitrogen (δ15N) and carbon isotopes (δ13C) from multiple deep-sea corals from the Hawaiian archipelago. Previous studies have indicated a substantial decrease in both δ15N and δ13C (1 to 1.5‰) since the onset of the Industrial Revolution (~1850s) to 1,000 year lows of 8‰ and -17‰ respectively (Sherwood et al. 2014, McMahon et al. 2015). Our new data reveals that shifts of this magnitude are not unprecedented in the Mid- to Late Holocene. Our extended records indicate that over multi-millennial time scales there is a large range of natural variability, with δ15N values ranging from 8.5‰ to 12‰ and δ13C values ranging from -17‰ to -15‰. However, rates of change in these older corals were approximately an order of magnitude slower. Comparisons with climate records suggest that these shifts may be directly linked to past changes in temperature (ocean stratification). Based on simple models linking phytoplankton 13C to major known drivers, we propose that these signals most likely reflect shifts in phytoplankton species dynamics, and are less likely to be driven by atmospheric 13CO2 baseline dissolved inorganic carbon changes.

11:45 AM

Alan Fox, Heriot-Watt University

The sensitivity of modelled Lophelia pertusa larval dispersal and population connectivity to climate variability

Is the existing *Lophelia pertusa* network in the North Atlantic robust to climate change? Dispersal of larvae from sub-populations of L. pertusa and connectivity between sub-populations are crucially dependent on the atmospheric state. Laboratory observations have revealed that L. pertusa larvae have sufficient vertical swimming ability to reach near-surface waters, exposing the larvae to stronger and more variable currents than at depth. When this behaviour is introduced into a larval particle tracking model, the resulting dispersal of larvae from sub-populations in the NE Atlantic shows strong correlation with the North Atlantic Oscillation, the dominant mode of inter-annual atmospheric variability in the region. Positive NAO state is correlated with a more connected, though directional west to east, network. Negative NAO results in a less connected network, though with more larvae transported from east to west. A long-term shift towards either more positive or more negative NAO state would result in loss of connections, potentially isolating sub-populations. The L. pertusa network connectivity is also threatened by reduced larval lifespan through rising ocean temperatures, and the impact of ocean acidification shallowing the aragonite saturation horizon exposing reefs to potentially corrosive waters. The larval dispersal and network connections are modelled under these scenarios, demonstrating increasing fragmentation of the network. These results pose challenges for management of vulnerable deep sea coral populations. Increasing fragmentation of the networks, and with it decreasing resilience, may be inevitable without significant intervention.

1:30 PM

Johanna Järnegren, Norwegian Institute for Nature Research

The cold-water coral associated squat lobster Munidopsis serricornis in a future ocean, how is it affected by increasing CO2 and temperature?

Rising atmospheric CO2 and global warming is causing concern regarding the consequences of multiple-stressor interactions on marine organisms and ecosystems. The squat lobster Munidopsis serricornis is associated with deep-water gorgonian corals and cold-water coral reefs and is one of the few species found in the live coral part of the reefs. Here we present results from a six-month longitudinal study on the response of adult M. serricornis to realistic levels of increased fCO2 (400 or 1000 µatm) and temperature (8 or 11°C), both separately and combined. Examined endpoints, including metabolism, nitrogen excretion, growth and molting frequency, revealed no significant interaction between fCO2 and temperature, and no effect was observed in response to isolated warming or ocean acidification conditions. Our findings indicate that the adult stage of M. serricornis is able to acclimate physiologically to the increased temperature and fCO2 conditions expected in the future ocean. This is positive news for the future vitality of this species and its vulnerable ecosystems. However, further examination of the sensitivity of the early and putatively more vulnerable life stages of this species are necessary before negative effects of future conditions on this species can be fully dismissed.

1:45 PM

Malindi Gammon, Victoria University of Wellington, NZ

Corals and carbon: The physiological response of a protected deep-sea coral (Solenosmilia variabilis) to ocean acidification

Little is understood about how deep-sea corals may respond to predicted scenarios of ocean acidification (OA), but any changes will have wider impacts on the ecosystem. Over 12-months, colonies of the deep-sea coral, Solenosmilia variabilis, were maintained in temperature controlled (~3.5°C) continuous flow-through tanks. Colonies were held in seawater with pH 7.88 or 7.65, designed to reflect current pH conditions and end-of-century conditions, respectively. In addition to investigating changes in growth, measurements of respiration and intracellular pH (pHi) were taken after a mid-term (6 months) and long-term (12 months) exposure period. pHi and respiration rate was not influenced by the reduced seawater pH tested here. Respiration rates were highly variable, ranging from 0.065 to 1.756 μg O2 g -1 protein h -1 and pHi ranged from 7.67 8.30. Yearly growth rates were also variable, ranging from 0.53 to 3.068 mm year-1, and again showed no detectable difference between the treatment and control colonies. However, a loss in the colouration of coral skeletons was observed in the treatment group and was attributed to a loss of tissue. This could indicate a reallocation of energy, allowing for the maintenance of those other physiological parameters measured here (e.g. growth and respiration rates). This research is an important first step towards understanding the sensitivity of deep-sea corals to OA. While it suggests in many respects that S. variabilis might not be susceptible to end-of-century projections of OA, the observed tissue loss is interesting and warrants further investigation to assess its long-term implications.

2:00 PM

Jay Lunden, University of Maine

Cold Corals in Hot Water: Responses of Flabellum impensum Larvae to Ocean Warming in Antarctica

Recent studies have reported that the deep ocean is not insulated from global changes such as warming and acidification. The Western Antarctic Peninsula (WAP) is currently experiencing the most dramatic temperature increases in the entire Southern Hemisphere, with increases of up to 4˚C expected by the end of this century. Within this context, cold-adapted corals inhabiting the deep polar ocean may face imminent threats to their long-term persistence. To explore the potential effects of ocean warming on a locally relevant species, we exposed larvae of the solitary coral Flabellum impensum to experimental increases in temperature over 44 days at Palmer Station, Antarctica. Using a combined approach of whole-organism (e.g. conventional morphometrics), cellular (e.g. flow cytometry, electron microscopy), and skeletal-level (e.g. X-ray diffraction) metrics, we assessed the viability of F. impensum larvae under four warming scenarios: ambient (-0.5˚C), +1.5˚C, +2.5˚C, and +4˚C. Over the course of this study, larval size ranged from 2-4 mm and did not appear to be affected by elevations in temperature. Furthermore, larval settlement did not differ among temperature treatments, and 8-15% of larvae across all treatments began secreting calcium carbonate within 44 days. While there was no significant mortality documented in this study, some sub-lethal effects were observed, including an increase in cellular necrosis by up to 30%. These results suggest that while F. impensum may not exhibit obvious deleterious effects at the whole-organism level, sub-lethal effects may potentially challenge this species' long-term survival in a warming ocean.

2:15 PM

Fiona Murray, Heriot-Watt University, Scotland

Cold-water-corals in a high CO2 ocean: behaviour, physiology and growth in Desmophyllum dianthus

Increased ocean acidity with accompanying shifts in temperature and aragonite and calcite saturations are expected to be detrimental to marine calcifiers and research to date has painted a bleak outlook for coral species. Colder waters, including polar and deep water are acidifying faster than other water masses, in part because CO2 dissolves more readily in colder waters, and deep sea corals will need to adapt to ocean acidification faster than shallow species to survive into the future. Here we present results from a 15 month incubation study of the responses of the cosmopolitan deep sea coral Desmophyllum dianthus to increased carbon dioxide (750 ppm) and temperature. Skeletal growth was determined using a 136Ba isotope tracer introduced at the start of the incubation. Feeding behaviour was recorded using time-lapse photography after 12 months. An additional 8 month incubation under the same CO2 treatments at 12 and 15 ˚C temperature treatments was conducted to examine calcification, respiration and ammonia secretion. Our results show that D. dianthus has the ability to withstand elevated pCO2 (750 ppm) under ambient temperature, however under combined temperature and pCO2 stress respiration, calcification and metabolic pathways are impacted. Our work highlights the importance of multi stressor experiments to examine the impacts of ocean acidification and suggests that the degree of ocean warming will be a key determinant in the ability of D. dianthus to persist in a high CO2 ocean.

2:30 PM

Louise Cameron, Northeastern University

***Impact of ocean acidification and warming on net calcification rate and calcifying fluid dynamics of the cold water coral* Lophelia pertusa**

Since pre-industrial times, atmospheric pCO2 has increased by 120 ppm. This trend is set to continue, causing a decline in global ocean pH and aragonite saturation state, and warming of surface ocean waters. Cold water regions will be particularly susceptible to ocean acidification's effects, as many already experience seasonal aragonite undersaturation. Cold water corals may be particularly vulnerable to dissolution under future acidification scenarios. We report on experiments investigating the impact of acidification and thermal stress on the calcification rates of the cold water coral species *Lophelia pertusa*. *L. pertusa* specimens were cultured for 33 days in a fully crossed pCO2 (400, 1000, 3000 ppm) and temperature (9, 12 ˚C) experiment. Net calcification rates were determined from the change in buoyant weight of the corals over the experimental period. The pH-dynamics of the corals' calcifying fluid was also assessed with proton-selective microelectrodes during the final two weeks of experiment. Net calcification rates were significantly impacted by temperature and pCO2. Corals maintained at 9 ˚C exhibited a statistically significant linear decrease in net calcification rate with increasing pCO2, while corals maintained at 12 ˚C exhibited a statistically significant parabolic response to increasing pCO2. Our results show that extreme acidification will negatively impact L. pertusa's calcification rates. The impact of moderate acidification depends on temperature. As L. pertusa is found in temperatures ranging from 6-14 ˚C, individuals inhabiting lower temperatures will be the most vulnerable. Likewise, future ocean warming may partially mitigate the deleterious effects of ocean acidification on this species.

2:45 PM

Janina Büscher, GEOMAR Helmholtz Centre for Ocean Research Kiel

Interacting effects of ocean acidification and warming on the ecophysiology of* Lophelia pertusa *investigated in two long-term laboratory experiments

Two long-term laboratory studies were conducted with the cosmopolitan cold-water coral *Lophelia pertusa* with regards to its sensitivity facing ocean acidification and warming as expected by the end of this century if CO2 emissions continue unabated. Previous experimental climate change studies on cold-water corals primarily applied single stressor and/or short-term approaches. Thus, we investigated the interacting effects of CO2, temperature, and other stressors on various physiological parameters of L. pertusa in two multifactorial long-term experiments. The first comprised set end-of-the century scenarios during the entire experiment duration (six months) and included for the first time the role of food availability in compensating for adverse effects of environmental change. In the second study we aimed at identifying the physiological thresholds of L. pertusa in terms of calcification, respiration, and mortality, as well as microbiological and genetic developments by gradual CO2 and temperature increases over one year of exposure. Results showed that increased food availability stimulates growth under elevated temperature, but has no impact at ambient conditions, while the 'fitness' (RNA/DNA ratios) is generally increased with a higher food input. Surprisingly, under the combined impact of ocean acidification and warming, extra food does not have a positive effect, which implies that under those conditions L. pertusa is either not able to take up additional food particles or cannot utilise them. Results of the second approach point to gradual instead of abrupt changes with altering conditions, but revealed that bioerosion and dissolution play a yet underestimated role in ecophysiological processes in cold-water corals.

3:30 PM

Steven Auscavitch, Temple University

Deep Caribbean seamounts: Insights to cold-water coral distribution and genetic relationships from the Anegada Passage

Cold-water coral communities on seamounts in the tropical western Atlantic Ocean and Caribbean Sea remain largely unexplored, hindering our understanding of biogeographic patterns in the deep-sea. The Anegada Passage, located between the British Virgin Islands and Anguilla, is one of the deepest throughways of North Atlantic water into the Caribbean Basin and is punctuated by several high-profile seamounts. The depth and location of these seamounts with respect to inflowing deep-water masses into the insular Caribbean has been hypothesized as a major factor influencing coral distribution in the area. Here, we present visual survey results and genetic data on coral assemblage structure on seamounts from a recent cruise within the Anegada Passage in 2014. Octocoral assemblages were largely composed of primnoids, chrysogorgiids, isidids, and plexaurids. Framework-forming scleractinian corals were observed at depths down to 1524m and between aragonite omega values of 1.1 to 1.8. Species turnover was associated with changes in water column properties coincident with the transition from North Atlantic Central Water to deeper water masses. Additonally, molecular barcodes of mitochondrial DNA for octocorals indicated strong similarities between Anegada Passage corals and those at similar depths in the Gulf of Mexico, where comparable environmental conditions occur. This suggests that overlying water mass structure, along with topography, may be good indicators of distribution patterns in the Greater-Lesser Antilles Transition Zone. Refining biotic and abiotic drivers of coral diversity and genetic structure in this region will improve our understanding of biogeographic linkages between Caribbean and other North Atlantic deep-sea provinces.

3:45 PM

Evan Edinger, Memorial University, NL, Canada

New observations of deep-sea corals and sponges in Baffin Bay and the Northern Labrador Sea, Canada

Deep-sea corals and sponges are important structure-forming fauna at continental shelf break and continental slope depths throughout the Northwest Atlantic. Using ROV-video observations in Baffin Bay and the northern Labrador Sea, we examined coral and sponge faunas, and factors potentially limiting their distributions in this sub-Arctic to Arctic transition zone. These field observations complement distributional data from fisheries bycatch, especially in areas not currently fished. Coral diversity in the northern Labrador Sea greatly exceeds that in Baffin Bay, where sea pens, especially Umbellula encrinus, and soft corals dominate the coral fauna. Keratoisis bamboo corals found in southeast Baffin Bay appear to be at their northernmost distributional limit in the Northwest Atlantic. Corals in the northern Labrador Sea include extensive forests of large gorgonian corals in the waters between Labrador and Baffin Island. The Labradror sea hosts more diverse assemblages of gorgonians, soft corals, and sea pens than does Baffin Bay. Erect sponge diversity is higher in the northern Labrador Sea than in Baffin Bay. Highly diverse and abundant sponge gardens were observed in Frobisher Bay. The large Geodia sponges apparently occur only south of the Davis Strait sill, but with clear fishing impacts on their abundances at upper slope depths . Sponges in Baffin Bay, including large, erect carnivorous sponges such as Cladorhiza and Chondrocladia, dominate geological environments that typically host diverse coral faunas in the Labrador Sea. Cold bottom water temperatures, low primary productivity, and low calcium carbonate saturation all likely contribute to low coral diversity in Baffin Bay.

4:00 PM

Tina Molodtsova, P.P.Shirshov Institute of Oceanology RAS, Russia

Black corals in the abyss: diversity, biogeography and adaptations. Case study of the Clarion-Clipperton Fracture Zone

The ecosystems of the seafloor associated with polymetalic nodules have, in the last few years, been the growing focus of attention because of the accelerating interest in deep seabed mining. Members of the order Antipatharia are among the deepest known corals and they are an important component of the abyssal faunas of the Pacific, Atlantic and Indian Oceans. Up to now 13 species of black corals have been reported from depths below 3000 m; this number encompasses one species of the family Antipathidae, one species of Cladopathidae and 11 species of Schizopathidae. Black corals inhabiting the abyss are often widely-distributed or cosmopolitan species; however a few species are known only from a single locality. With a few exceptions, species reported from the abyssal zone have congeneres living at shallower depths. A few morphological adaptations of black corals to the abyss include colony and adaptations to scarce food and limited substrate availability. Five species of black corals from three genera have been collected in the Clarion-Clipperton Fracture Zone (CCFZ) at depth 4158–5100 m and at least two more species are known from underwater photographs only. In the CCFZ black corals have been found almost exclusively at nodule-bearing sites and can comprise up to 17% of nodule epifauna reported. This can be correlated with the requirement of most species for a hard substrate for attachment, and because they are suspension-feeders, antipatharians may be one of the groups at potential risk for adverse impacts as a result of deep-sea mining.

4:15 PM

Günter Försterra, Huinay Scientific Field Station, Chile

WANTED: Your opinion how to explain unresolved mass mortalities of cold-water corals in shallow waters of Chilean Patagonia

Mechanical destruction and ocean acidification have been identified as the with distance most severe threats for cold-water corals, while other mortality factors were considered of minor importance. In the Chilean Patagonia, four species of cold-water corals, which have formerly been described from deeper water, form abundant populations in some fjords and channels high up into the euphotic zone. Despite the fact that some of these corals live in water with pH values as low as 7.4, there is evidence for good individual and population health. Nevertheless, in 2012 we documented the death of practically all individuals of the stony coral Desmophyllum dianthus along more than 8 km of coastline of Comau Fjord within few weeks. The mortality affected exclusively individuals of Desmophyllum dianthus while other benthic species, including two other scleractinians, showed no detectable damage. In 2006, we documented a large and dense reef-like population of the hydrocoral Errina antarctica in a remote, shallow channel in the southern Patagonian Province. In 2013 we discovered that all specimens of Errina antarctica in this channel had disappeared. The presence of large amounts of shell rubble of older specimens of the mytilid Aulacomya atra and the absence of living specimens of this species indicate that the mortality may have affected species of different taxa. Based on the gathered data we present hypotheses that may explain the mortalities, discuss their potential implications for other cold-water coral populations and outline ongoing studies that test these hypotheses. The audience is welcome to actively discuss alternative hypotheses.

4:30 PM

Andrea Gori, Universitat de Barcelona

Ecological Restoration of Deep Coral Gardens on the Mediterranean Continental Shelf

Bottom trawling and trammel net fishing are currently causing the removal or damage of deep- water corals and gorgonians all over the world. Fragmentation and reduction of population density of these structural benthic species is one of the major threats for their viability, and may results in a drastic change in the ecological structural and functional role they play. In this presentation, we show a combination of (1) experimental work under controlled conditions and (2) field research used to perform and evaluate the effectiveness of the first ecological restoration targeted to recover deep gorgonian assemblages on the Mediterranean continental shelf. Laboratory experiments showed that a reduction in gorgonian population density significantly affects their capability to capture food and provide suitable conditions for the aggregation of zooplankton and fish larvae. These results demonstrate how fishing impacts not only affect the gorgonians directly removed or damaged, but also impacts the viability of the remaining populations and their ecological role. Based on experimental results, gorgonians entangled in nets were collected from fishermen, and transplanted at high density on artificial structures, which were deployed on the continental shelf in the north of Cap de Creus (Spain) at 85 m depth. Survival of transplanted gorgonians was monitored during one year by means of a remotely operated vehicle. Zooplankton and sediment samples were also collected to follow the recovering of the biodiversity and biomass of the associated fauna.

5:00 PM

Poster Session II

Palm Garden Room

Talk Abstracts for Friday, 9/16

8:30 AM

Sebastian Hennige, Heriot-Watt University, Scotland

How corals apply the Goldilocks Principle to engineer habitat

The occurrence and proliferation of reef-forming cold-water corals is reliant upon optimal current conditions, where provision of organic material is at a velocity suitable for prey capture by the coral. The occurrence of a significant proportion of dead skeletal framework on reefs highlights that when flow is sub-optimal, prey capture and ingestion rates are likely inadequate to facilitate survival. The reef forming coral *Lophelia pertusa* has an optimal range of flow velocities in which they can capture food efficiently. This 'Goldilocks Zone', where the flow is neither too fast nor too slow, will promote coral growth compared to zones of sub-optimal flow velocity. The disruption of flow by the coral also creates sub-optimal velocity regions behind it, potentially contributing to mortality of downstream corals. Here we demonstrate using Particle Imaging Velocimetry how corals modify their flow environment, and how cold-water reefs grow according to the Goldilocks Principle, by using a theoretical laminar flow system and iterative growth of a model coral.

9:00 AM

Dick van Oevelen, NIOZ Royal Netherlands Institute for Sea Research

Newly-discovered recycling pathways in cold-water coral reef communities

Cold-water corals (CWC) are widely distributed around the world and form extensive reefs at par with tropical coral reefs. These CWC reefs are hotspots of biodiversity and organic matter processing and live in an environment that is characterized by 'feast-famine' conditions, in which short periods of high food availability are intermitted by prolonged periods of low food availability. We recently discovered two nutrient recycling pathways within cold-water coral reefs that may aid them to bridge periods of low food supply. Firstly, we show the transfer of coral mucus, which may be a major component of the dissolved organic matter pool in coral reefs into the bulk tissue and phospholipid fatty acids of the common cold-water sponge Hymedesmia coriacea. This demonstrates a direct trophic link between reef corals and sponges. Part of the assimilated mucus was subsequently released by the sponge as detritus, which in turn may be utilized by reef detritivores. Secondly, we report stable isotope tracer evidence for a complete nitrogen cycling, including nitrogen assimilation, regeneration, nitrification and denitrification associated with the cosmopolitan cold-water coral *Lophelia pertusa*. This versatile metabolic machinery provides another pathway through which limiting resources that are essential for CWC to survive in the resource-depleted dark ocean can be retained.

9:15 AM

Frank Parrish, OAA Pacific Islands Fisheries Science Center, Honolulu, HI

In-situ measurements of environmental variables at three Hawaiian deep sea coral beds

Current meters were used to measure the flow rate, direction and temperature of water movement at three sites where the sea floor morphology and the dominant coral community differed (even-bottom with Coralliidae, ledge-top site with Keratoisidinae & Kulamanamana haumeaae, pinnacle summit with K. haumeaae). Duration of the deployments ranged between 7 and 30 months and covered periods running from 2005-2013. The average flow rate was found to be slowest (4.5 cm/sec) at the ledge-top site, and fastest (13.6 cm/sec) at the even-bottom site where the north-south orientation of the current remained the most consistent. The timing and intensity of flow appeared

related to tidal forces, but the temporal scale of the cycle was markedly different between the ledge-top site which was located on the west coast of the Big Island of Hawaii and the two other beds located at the southeast end of the island of Oahu. Smaller-scale differences in flow rates within and just outside each coral bed were identified using independent flow meters placed to estimate a range of values acceptable to coral settlement and growth. Understanding the composition of these coral assemblages and relating in-situ environmental observations to broader scale oceanography can improve our ability to model deep sea coral occurrence.

9:30 AM

Sandra Maier, NIOZ Royal Netherlands Institute for Sea Research

Survival in a feast-famine environment: Resource utilization and storage in cold-water coral Lophelia pertusa

The high productivity and diversity of cold-water coral (CWC) reefs is in sharp contrast to the resource limitation in their habitat, which is characterized by rare food peaks intermitted by long famine periods. Since global climate change and ocean acidification potentially increase CWCs' energetic demands, efficient energy storage and utilization might determine their resilience against these global changes. In a stable isotope tracer experiment we simulated such a feast-famine sequence to understand the resource processing and allocation in the CWC species *Lophelia pertusa*. Coral fragments were fed ad libitum with artificially 13C- and 15N-enriched diatoms (Skeletonema marinoi) for three days (simulating the food peak period) and subsequently maintained in 0.35 µm-filtered seawater for four weeks (simulating famine conditions). The 13C and 15N utilization of the algal food peak was followed over the full experimental period by weekly measurements of (a) coral-produced dissolved inorganic carbon (DIC), dissolved organic carbon (DOC) and particulate organic carbon and nitrogen (POC, PON) and (b) biweekly measurements of 13C and 15N storage into bulk coral tissue and specific biogeochemical pools such as fatty acids and amino acids. Directly after feeding on 13C/15N enriched algae (week 0), L. pertusa showed a highly increased production of 13C-DIC (tracer C respiration), and of 13C- and 15N-POM, as well as an increase in the fraction of 13C/15N in their tissue as evidence of C/N storage. With increasing number of weeks from the food peak, corals' tracer C respiration exponentially declined but remained detectable after 4 weeks. Tracer C and N release as particulate organic matter followed this trend, while the fraction of 13C and 15N in coral tissue remained constant. Our results indicate that L. pertusa directly metabolizes a shortly in excess available food source only to some extent, but the predominant fate is allocation into organic storage pools. We explore whether energy is stored particularly in certain components, such as fatty acids, in order to maintain full metabolic function during long periods of food limitation. The importance of these adaptation(s) are discussed in the light of the dynamic CWC reef food web facing new challenges in the future ocean.

9:45 AM

Jill Bourque, USGS

How do different species of deep-sea corals structure adjacent soft-sediment communities?

Deep-sea corals create a complex, three-dimensional structure that facilitates sediment accumulation and influences adjacent sediment environments through altered hydrodynamic regimes. While infaunal communities adjacent to deep-sea corals are known to differ from background soft-sediment communities, individual coral types have different morphologies, potentially providing a range of influence on surrounding sediments. Here we address two main questions: 1) Are the infaunal communities adjacent to deep-sea corals similar among coral types and 2) Do infaunal communities adjacent to coral habitats exhibit regional and depth-related patterns expected for the Gulf of Mexico (GOM). Infaunal communities were examined adjacent to three coral types: two scleractinian corals, *Lophelia pertusa* and *Madrepora oculata*, and octocorals. Sediment cores adjacent to deep-sea coral habitats were

collected to assess diversity, composition, and abundance of macrofauna. Highest and lowest abundances occurred adjacent to L. pertusa and M. oculata habitats, respectively. Polychaetes numerically dominated both L. pertusa and octocoral habitats, while crustaceans were proportionally more abundant near M. oculata habitats. Preliminary multivariate analysis suggests infaunal assemblages near L. pertusa habitats differ from assemblages near both octocorals and M. oculata, while octocoral and M. oculata sediment communities are similar. Enhanced habitat structural complexity associated with L. pertusa and differences in localized hydrodynamic flow may contribute to the dissimilarities in the communities found among the coral types. Our results suggest a decoupling for infaunal coral communities from the general depth-related density patterns present throughout soft-sediment habitats in the GOM, highlighting the importance of deep-sea corals in structuring unique communities in the nearby benthos.

10:30 AM

Furu Mienis, NIOZ Royal Netherlands Institute for Sea Research

How Cold-water Coral Mounds on the Rockall Bank Have Outgrown Themselves

Colony-forming cold-water corals are a clear example of globally occurring ecosystem engineers, modifying the seafloor landscape at large scales. Kilometres long and up to 360 m high mound structures have formed on the SE Rockall Bank. Earlier observations showed that most of the mounds have their summits around 550 m water depth and summits have been reported as being covered with living corals. Recent cruises revealed completely new insights in mound development. Video transects across mounds with different morphology showed that summits of the largest mounds have presently no dense cover of living coral as opposed to smaller mounds with summits well below 550m water depth, which are completely covered with thriving living coral framework. Near-bottom and water column measurements showed that turbulence is likely the most important factor influencing nutrient and food supply and thus coral growth. Large mounds have outgrown themselves and their large size and flat summits are limiting turbulence, thereby limiting oxygen, nutrient and food replenishment, which is vital for ecosystem functioning and reef development. The presence of a healthy coral cover on the summits of the small mounds was also shown by the vertical mound growth rate measured in sediment cores, which showed fourfold higher sedimentation rates on the smaller mounds during the Holocene compared to sedimentation rates measured on the highest mounds.

10:45 AM

Aaron Lim, University College Cork, Ireland

Piddington Mound: Spatial organisation and its influences across an entire Cold-Water Coral reef

Cold-water coral (CWC) reefs are biogenic build-ups that develop in suitable conditions on the seabed. In the North East Atlantic, CWC reefs have been studied in detail and reveal their heterogeneous nature. However, these studies use limited remotely-sensed and video imagery at an appropriate resolution and spatial coverage. This study investigates the distribution and heterogeneity of mound-surface facies across an entire CWC reef in the North East Atlantic and relates this to mound development. Remotely operated vehicle (ROV) video data covering an entire CWC reef is used to create a reef-scale, georeferenced video mosaic. ROV-borne Multibeam Echosounder (MBES) data is collected over the mound and its surrounding area to examine mound morphology and the surrounding sedimentary bedforms. An ArcMap fishnet (60 m x 40 m) with 0.25 m2 cells is draped over the video mosaic. A supervised classification, describing mound surface facies is carried out on the mosaic using the fishnet as a rigid sampling division. Surface sediment from 5 box-core samples is used to ground truth video and MBES observations. Mound surface facies show a significant clustered pattern which gradually changes from the off-mound area to the mound summit. The clustering of mound surface facies has a broad ringing/circular

pattern concentrically based around the mound summit, similar to Wilson's ring model. In a wider context, the heterogeneity of facies, and their distribution across the reef show that interpretations from CWC reef samples do not represent the entire mound surface and should be accompanied by appropriate imagery of the reef.

11:00 AM

Laurence De Clippele, Heriot-Watt University

Using novel acoustic and visual mapping tools to predict the small-scale spatial distribution of live biogenic reef framework in cold-water coral habitats

In the Atlantic many reef and mound complexes are engineered by the coral *Lophelia pertusa*. Predictive models and maps of cold-water coral habitats have been developed to understand the factors that control the distribution of these ecosystem engineers across a range of approaches and of spatial scales. In this study, we predict coral presence at the inshore Mingulay Reef Complex (W Scotland) using the new ArcGIS-based "BGS Seabed Mapping Toolbox" developed for this study, together with random forest modelling. By using this toolbox almost 600 *Lophelia* reef 'minimounds' were semi-automatically delineated from bathymetry data with 2 m resolution, and their characteristics were quantified and captured. Coral presence data were derived from high-definition remotely operated vehicle records of visual (video) and acoustic microbathymetry. With a resolution of 0.35 x 0.35 m the microbathymetry covers the centre of the study area and its high resolution allowed the individual live coral colonies to be located acoustically for the first time. Random forest classification identified: Maximum Water Depth, Maximum Rugosity, Bathymetric Positioning Index, Orientation and Maximum Current Speed as the environmental variables that contributed most to the prediction of live coral presence. Our approach produces predictive maps of live corals across the reef mounds that will be especially valuable for future long-term monitoring surveys, included those needed to understand the impacts of global climatic change. This is the first study using an ROV-based microbathymetric grid and the newly developed "BGS Seabed Mapping Toolbox" to explore the environmental variables that control coral growth on minimounds.

11:15 AM

Katleen Robert, National Oceanography Centre, University of Southampton

Hanging gardens: Vertical walls from images to fine-scale 3D reconstructions

As a result of their heterogeneous nature, deep-sea cliffs are particularly suitable habitats for cold-water corals (CWCs) and associated species. In addition, such steep terrains provide natural protection from human activities such as trawling. As such, it is important to understand their ecology, but traditional multibeam systems (MBS) cannot adequately replicate the 3D structure of these habitats at fine enough resolutions. In this study, we combined sideways ROV MBS data and videos to examine steep terrain from Rockall Bank (SORBEH expedition, Irish Marine Institute) and Whittard Canyon (CODEMAP2015 cruise, ERC Starting Grant no 258482), Northeast Atlantic. Point clouds were extracted from MBS data, but, to obtain even higher resolutions, photogrammetry techniques were applied to create 3D representations of video transects. With these, it was possible to interact in 3D with extensive sections of video, and once georeferenced, very accurate positioning of individual organisms became possible. The reconstructed terrain models enabled individual colonies to be resolved and associated terrain variables to be derived on scales similar to those experienced by megabenthic individuals. These terrain variables were able to identify differences in the environmental conditions selected by CWC and a few associated species. Moreover, both ROV and photogrammetry derived terrain variables could successfully explain biological spatial patterns in CWC presence as well as megabenthic abundance and diversity. These new technologies are allowing us, for the first time, to map the physical 3D structure of previously inaccessible habitats in all their complexity.

11:30 AM

Claudio Lo Iacono, National Oceanography Centre (NOC), University of Southampton

Living reefs and CWC mounds in the Alboran Sea (Western Mediterranean). Holocene evolution and present-day conditions

We present recent insights on early Holocene to present spatio-temporal evolution of Cold-Water Coral (CWC) Mounds in the Moroccan Alboran Sea (Western Mediterranean). Despite most Alboran CWC mounds nowadays being inactive, new findings revealed the existence of living extensive reefs of *Lophelia pertusa* and *Madrepora oculata*. The West Melilla region consists of two clusters of elliptical mounds, ~45 m high, at 400-460m depth. Cabliers is a 25 km long, 140m tall CWC ridge, at 250-710m depth. Stratigraphic analysis, species composition, X-Ray CT scans and radiocarbon dating of gravity cores reveal intense coral growth 13.9-9.8ky BP. The demise of suitable conditions for CWCs in the Alboran Sea roughly coincides with the end of the Organic Rich Layer 1, ~9.2ky BP, as also confirmed by preliminary geochemical analyses. Nevertheless, the northern Cabliers Mound displays constantly high accretion rates until the present, corroborated by ROV footage revealing exceptional dense and thriving reefs distributed over at least 2 km along the top of Cabliers. The mixed Mediterranean-Atlantic ecological signature of the reefs is evident in the co-existence of large *Madrepora* and *Lophelia* colonies and their associated fauna. The advection of chlorophyll-rich Atlantic Waters (AW) in the Mediterranean controls the particularly suitable conditions along the reefs, as confirmed by 35 surface CODE drifters (Medess-Gib experiment) transported to Cabliers following the Eastern Alboran Gyre, suggesting enriched food delivery. This work challenges the traditional notions of environmental factors controlling CWC proliferation, specifically in the Mediterranean, with relevant implications for the conservation of deep-sea natural resources.

11:45 AM

Jürgen Titschack, Center for Marine Environmental Sciences, Germany

Mediterranean cold-water corals – an important regional carbonate factory?

Cold-water coral ecosystems and deposits, dominated by *Lophelia pertusa* and *Madrepora oculata*, are wide spread in the Mediterranean Sea, which resulted in their description as independent benthic community, called white coral community. To evaluate their role as carbonate factories, we investigated aggradation rates and carbonate accumulation rates from three different cold-water coral sites that differ in their regional and geomorphological settings: (i) a cold-water coral ridge (eastern Melilla coral province, Alboran Sea), (ii) a cold-water coral rubble talus deposit at the base of a submarine cliff (Urania Bank, Strait of Sicily) and (iii) a cold-water coral deposit rooted on a predefined topographic high overgrown by cold-water corals (Santa Maria di Leuca coral province, Ionian Sea). The mean aggradation rates of the respective cold-water coral deposits vary between 10 and 530 cm kyr^{-1} and the mean carbonate accumulation rates range between 8 and 396 g cm^{-2} kyr^{-1}. The studied cold-water coral sites reveal significantly higher carbonate accumulation rates than other deep-water depositional environments. Furthermore, the observed rates were even in the range of the highest productive shallow-water Mediterranean carbonate factories (e.g., *Cladocora caespitosa* coral reefs). This clearly indicates the potential of cold-water corals as important carbonate factories and regional carbonate sinks within the Mediterranean Sea.

12:00 PM

WRAP UP

Poster Abstracts for Monday, 9/12

POSTER 1

Luciana Gusmão, American Museum of Natural History

Systematics and evolution of venus flytrap anemones (Cnidaria: Anthozoa: Actiniaria)

Sea anemones (Cnidaria: Anthozoa: Actiniaria) are common and conspicuous inhabitants of deep-sea environments worldwide. Six families of anemones have been reported from the deep-sea, although Hormathiidae, Actinoscyphiidae and Actinostolidae are the most diverse families deeper than 100 m. A common morphology exhibited by deep-sea anemones is one analogous to the terrestrial venus flytrap. These anemone species have a small base, cylindrical body, and a wide oral disc that becomes bilobed and concave with tentacles forming a trap that collects particles suspended in the water. Venus flytrap anemones are usually large reaching up to 30 cm in height, often forming big populations up to 5000 m. Although the venus flytrap morphology was originally described in Actinoscyphia aurelia from the North Atlantic, this strategy is much more widespread being present in other species of Actinoscyphia, as well as in species of genera Paraphelliactis and Phelliactis (Hormathiidae). Many records of venus flytrap anemones exist for the Gulf of Mexico, often identified as Actinoscyphia sp.; however, these identifications are not based on taxonomic studies and often no reference specimens exist. Here we describe three new species of venus flytrap anemones from the Gulf of Mexico belonging to each of the genera for which the morphology is known. Using morphological and molecular data we evaluate the phylogenetic relationships among genera of flytrap anemones and its closely related allies; we revisit morphological characters that should be used to circumscribe these taxa. In addition, we discuss the evolution of the venus flytrap strategy within the order Actiniaria.

POSTER 3

Les Watling, University of Hawai'i at Mānoa

The Global Distributions of Bathyal Octocorals are Determined by Intermediate Water Masses

As noted by Watling et al. in their 2013 paper proposing deep-sea biogeographic provinces, the bathyal provinces are the least well known. Most of the substrate at bathyal depths exists in the form of ridges and seamounts and has a high proportion of hard, and sometimes vertical, surfaces. We have compiled a global database of gorgonian octocorals from bathyal depths (300 to 3500 m) and plotted the records in ArcGIS. For the bamboo corals (Isididae: Keratoisidinae) and a few other families information on genetic relatedness was used to determine the distributions of closely related specimens. The major distributional patterns fell into the following groups: 1) NW Atlantic; 2) NE Atlantic; 3) central Pacific (Hawaii); 4) N Pacific; 5) W Pacific; 6) SW Pacific. The N Pacific has a fauna distinct from the rest of the Pacific, and the same is true of the eastern N Atlantic. Genetic data show the same or sister taxa extending from the NW Atlantic through the central Pacific to Tasmania. We propose that bathyal octocoral distributions are strongly influenced by the distribution and movement of intermediate waters. The N Pacific is isolated by the gyre of the North Pacific Intermediate Water. In the eastern Atlantic the major intermediate water mass is Mediterranean Outflow Water, which extends from the Straits of Gibraltar north to the British Isles and south to off W Africa, and westward across the Mid-Atlantic Ridge. The one water mass that unites the NW Atlantic, Hawaii, and Tasmanian faunas is Antarctic Intermediate Water.

POSTER 5

Andrew Shuler, NOAA's National Centers for Coastal Ocean Science

Octocoral Species Diversity on Mesophotic Reefs from the Northern Gulf of Mexico

Gorgonian octocorals are conspicuous and diverse components of the mesophotic benthos in the Northern Gulf of Mexico (nGoMx). Better understanding of this community is important for both researchers and managers. Remotely operated vehicles were used to conduct video transects and collect samples in the nGoMx from 2010 - 2014. This study focused on six mesophotic reefs (60 90 m) in the nGoMx; east and west of De Soto Canyon. Video transects were enumerated using morphospecies groupings. Morphology of collected octocorals was examined using both light and scanning electron microscopy to provide definitive taxonomic identification of common taxa. This study identified 31 species from samples. SEM plates were produced for some taxa for the first time. Analysis of video transects showed highest species richness and rates of accumulation (14 species) at Alabama Alps Reef (west) and Madison Swanson South Reef (east), and lowest richness at (10 species) Coral Trees Reef and Madison Swanson North Reef (east). The largest gorgonian genera were Hypnogorgia, Placogorgia, Paramuricea, Swiftia, and Thesea, averaging 20 cm to 90 cm in height and width depending on genus. Smaller genera included Bebryce, Leptogorgia, Nicella, Scleracis, and Villogorgia. This study identified several genera with shallower ranges than previously reported and identified Thesea citrina and Nicella americana in the nGoMx for the first time. Genetic work is needed to validate current identifications, identify potential cryptic species and increase representation of these taxa in genetic databases.

POSTER 7

Asako K.Matsumoto, Chiba Institute of Technology, Japan

Northernmost tropical-subtropical octocorals, North West Pacific

There are approximately 620 octocoral species (Octcorallia, Cnidaria) recorded in Japanese waters. However, most of corals are reported from the Pacific side and south of Sagami-Bay (3335°N). Very few species of corals are known from the Northern area of Japan. Totally three new species of cold water gorgonian octocorals, Melithaea sagamiensis Matsumoto & Ofwegen, 2015 (Family Melithaeidae), Euplexaura yayoii Matsumoto & Ofwegen, 2016 (Family Plexauridae), Bebryce otsuchiensis Matsumoto & Ofwegen, 2016 (Family Plexauridae), and the new species of Pennatulacean octocoral Stylatula diminutive diminutiva Williams & Matsumoto, 2015 (Family Virgulariidae) are described from Otsuchi Bay, Iwate Prefecture, the Northern Pacific side of Japan main island (39°21' N). Melithaea corymbosa (Kükenthal, 1908) and Melithaea japonica (Verrill, 1865) are newly recorded from the same locality. The northernmost species of the family Melithaeidae is M. sagamiensis with latitude 41.59'N at the Sea of Japan. Previous known latitudes of the coral family Melithaeidae distribution were 34°35S 39°36 N and the northernmost occurrence at Pacific side of Japan was previously 35°N. The northern limit of the genus Bebryce was previously up to 27°N. Its distribution has been restricted to warm, shallow tropical-subtropical waters. The genus Stylatula is found for the first time from the North West Pacific. The results expand the distribution of warm water species of the family Melithaeidae and genus Bebryce to the North. Our results suggest that the warm Kuroshio water current which sourced from the North Equatorial Current can have affect up to latitude 41.59›N (Sea of Japan) and 39°21›N (Pacific side of Japan).

POSTER 9

Alexis Weinnig, Temple University

Carbonic anhydrase activity and gene expression of cold-water coral Lophelia pertusa in response to ocean acidification

Lophelia pertusa is a widely distributed cold-water scleractinian coral that plays a vital ecological role in continental margin ecosystems worldwide. However, these organisms are threatened by ocean acidification; as pH continues to decrease *L. pertusa* will face increasing metabolic costs to the precipitation of its calcareous skeleton, and it may eventually begin to erode away. In order to study the specific nature of the effect of ocean acidification on calcification the activity and gene expression of the enzyme carbonic anhydrase was analyzed for *L. pertusa* colonies from the Gulf of Mexico exposed to varying pH treatments (7.6. 7.75, and 7.9) over a two-week time period. Carbonic anhydrase is involved in coral calcification by converting dissolved inorganic carbon from seawater into carbonate ions, which are then used in calcification. In general, the *L. pertusa* colonies exhibited a negative physiological response (net calcification, respiration, and prey capture rates) to increasing acidification, suggesting these populations will struggle as acidification continues. Identifying variance in carbonic anhydrase enzyme activity and gene expression across pH levels will help to elucidate the mechanisms behind L. pertusa's response to ocean acidification and provide vital information in determining how cold-water corals and their associates will fair in a changing ocean.

POSTER 11

Nicole Bellaflores-Mejia, NYC College of Technology (CUNY)

Molecular characterization of mesophotic black corals (antipatharians) from the Flower Garden Banks National Marine Sanctuary (NW Gulf of Mexico)

Black corals (Cnidaria: Anthozoa: Hexacorallia: Antipatharia) are cosmopolitan in the world's oceans and live as deep as 8,900m. To date, 7 families, 42 genera, and 247 species have been described. We recently participated in a research expedition (Stetson Mesophotic Monitoring Cruise) aboard the R/V Manta to the Flower Garden Banks National Marine Sanctuary (Gulf of Mexico). We utilized the ROV Mohawk to conduct video and collection-based surveys immediately outside the sanctuary. These data supported a new proposal to expand the sanctuary in an effort to protect critical habitats for recreationally and commercially important fish and threatened or endangered species of whales, sea turtles, and corals. We also surveyed banks within the sanctuary for Acanthopathes thyoides and Elatopathes abietina, as well as undescribed species. Based on morphology, Acanthopathes and Elatopathes are currently classified in the same family; however, they do not group together in a molecular phylogeny. These species are considered 'wandering taxa' as they change position depending on the gene (mitochondrial v. nuclear) or algorithm (Parsimony v. Likelihood v. Bayesian) used to build the phylogeny. We successfully collected two A. cf. thyoides and six E. cf. abietina. Elucidating 1) intraspecific variability within A. thyoides and E. abietina or 2) closely related cryptic species could potentially stabilize their phylogenetic position. To create an inventory of all species collected, we are sequencing three mitochondrial intergenic regions (igrN, igrW, igrC) and three nuclear genes (18S, 28S, ITS2). Novel sequence data will be incorporated into the latest antipatharian phylogeny and results will be discussed.

POSTER 13

Mercer Brugler, NYC College of Technology (CUNY)

Molecular characterization of the black coral Telopathes cf. magna from deep waters around New Zealand, Antarctica (Ross & Somov Seas) and Hawai'i

Black corals (Cnidaria: Anthozoa: Hexacorallia: Antipatharia) are a predominantly deep-water group with ~75% of the 247 currently recognized species occurring at depths >50 m (max: 8,900 m). The most recent genus to be described is Telopathes MacIsaac & Best, 2013 and is currently only known from the western North Atlantic off the coast of Canada and the New England and Corner Rise Seamounts (1,073-1,983 m). Telopathes is characterized by its largely pinnulated stalk, sparse branching pattern to the second order that is not restricted to a single plane, and two anterolateral rows of long, simple primary pinnules arranged alternately to subopposite. The description of this monospecific genus included molecular data and in-situ images for multiple life stages, from juveniles (superficially resembling the monopodial genus Bathypathes) to adults (resembling a large, densely branched Bathypathes). In 2015, we examined the NIWA Invertebrate Collection and found thirteen colonies collected from deep waters (250-1,520 m) surrounding New Zealand and Antarctica (Ross & Somov Seas) that resembled T. magna. Recently, we received a subsample of T. cf. magna collected during the 2015 Hohonu Moana Expedition from deep waters south of the Hawaiian Island of O'ahu (359 m). To determine the relatedness of these specimens to the western North Atlantic T. magna, we are analyzing morphology and DNA, the latter of which includes three mitochondrial intergenic regions (igrN, igrW, igrC) and two nuclear genes (ITS2, SRP54). These data have the potential to significantly extend the known range of T. magna and elucidate new species of Telopathes.

POSTER 15

Esprit Heestand Saucier, University of Louisiana at Lafayette, LA

Systematics of the deep-sea bamboo coral genus Acanella

Acanella, a genus of deep-sea bamboo coral, has a globally cosmopolitan distribution and has been collected between 300 and 2875 m depth. It is found on hard and soft substrata and may be relatively abundant when present. Acanella is an important foundational species for deep-sea habitats, providing both anchorage and protection for some species and is a food source for others. We analyzed DNA and morphology of 134 colonies to re-examine characters used to diagnose the genus and its species. Based on sequences of mitochondrial gene regions mtMutS -5' and -3' and nuclear 18S, eight haplotypes were identified (types A-H) from 98 Acanella specimens, which were used to produce a haplotype network and maximum likelihood tree to examine the relationship among the haplotypes. At least five of the haplotypes are associated with described species, while the other two come from colonies that do not match any known species description. The haplotype network and maximum likelihood tree, using all gene regions, reveals a strong biogeographic signal separating the two major clades of Acanella. Haplotype A is the most common sequence found among our samples; it is found world-wide and corresponds to specimens initially identified to three different species but likely comprises only a single species, A. arbuscula. We propose taxonomic revision of species in the genus.

POSTER 17

Charlotte Seid, Northeastern University

A Reference DNA Collection to Facilitate Deep-Sea Coral Research

The Ocean Genome Legacy Center at Northeastern University (OGL) is a nonprofit DNA biorepository dedicated to preserving marine genomes and making them widely available to the global scientific community. Currently, the OGL collection contains 23,000+ DNA and tissue samples representing 4,500+ marine species, including 100+ deep-sea coral samples contributed by researchers such as the science team of the NOAA Okeanos Explorer. In a new grant-funded initiative, OGL is expanding this reference collection of DNA and tissue samples from deep-sea corals, with a focus on the Order Antipatharia. This collection will serve as a publicly available scientific resource and a secure archive to support subsequent work on coral identification, basic research, and conservation applications. We invite the deep-sea coral research community to participate in our initiative to preserve, document, and archive antipatharian DNA and tissue samples that are legally obtained, well documented, and vouchered.

POSTER 19

Cheryl Morrison, US Geological Survey

Genetic Connectivity among Offshore and Emergent Southeastern Alaskan Fjord Populations of a Foundation Species, the Red Tree Coral (Primnoa pacifica)

Red tree corals, Primnoa pacifica, are large gorgonians that are the dominant structure-forming coral species in the Gulf of Alaska (GOA). Red tree corals serve as important habitat to fishes and invertebrates, yet this long-lived species are highly susceptible to disturbance from fisheries, and as such, some protection has been afforded to several offshore populations in the GOA. Red tree corals are often a dominant component of emergent fjord communities in southeastern Alaska, occurring as shallow as six meters. The variable combination of tides, storms, freshwater discharge, plus complex passageways to the sea may restrict larval exchange between offshore and fjord P. pacifica populations, or conversely, fjord populations could become important larval sources should offshore populations become depleted. Microsatellite markers were used to characterize the spatial scale and pattern of genetic connectivity across a large portion of the range of P. pacifica in the North Pacific Ocean. Over 300 discreet, geo-referenced samples of P. pacifica were collected via remotely operated vehicles or SCUBA divers on NOAA-sponsored research cruises in 2013-2016 from three offshore GOA populations (Dixon Entrance, Cape Ommaney, the Fairweather Grounds) and three fjords (Tracy Arm, Endicott Arm and White Thunder Ridge in Glacier Bay National Park). A complex pattern of connectivity was recovered, with offshore populations being more highly connected than fjord populations. This study provides important insights regarding the most appropriate tools available to resource managers to protect sensitive coral habitats and the ecosystem services they provide.

POSTER 21

Luisa Duenas, University of Los Andes, Columbia

Phylogeography and genetic variation in the widespread precious coral Hemicorallium imperiale across ocean basins

Understanding the contribution of soft barriers to diversification in the marine realm is of paramount importance to comprehend biogeographical patterns particularly for widespread species. The precious deep-sea coral Hemicorallium imperiale is known for its broad distribution across the Pacific and Southern Oceans. This condition makes this species a perfect model to assess genetic variation and phylogeography across an oceanic scale, while evaluating the role of the ACC in its genetic structuring. Through phylogeographic and population genetic methods we evaluated three populations: North Pacific (NP), South Pacific (SP) and Southern Ocean (SO). We found that H. imperiale does not conform to a panmictic population scenario. Although we found shared haplotypes between NP and SP, and SP and SO, genetic structuring only separates the NP population, while the SP and SO appear to be connected. Our results reject the hypothesis that the ACC is a barrier against gene flow. The most probable origin for this species is the North Pacific with a subsequent colonization of the Southern Hemisphere during the Miocene. Populations of Hemicorallium faced a profound reduction in their size at the Pliocene-Pleistocene boundary probably due to a combination of climate change and catastrophic events, however these were capable of recovering fully. This study has laid the importance of intrinsic and extrinsic factors in the phylogeography and genetic structuring of widespread marine species.

POSTER 23

Anna M Addamo, National Museum of Natural Sciences (MNCN-CSIC), Spain

A cosmopolitan species as model for genetic connectivity of deep-sea coral populations, key in addressing evolutionary and ecological questions in larval dispersal.

A wide interest for cold-water coral reefs has been expressed in the last decade; several expeditions and projects have been realized, increasing the scientific knowledge and giving an important baseline for a potential and efficient conservation plan. Nevertheless, reproductive strategy and larval dispersal capability of deep-sea corals are still largely unknown biological processes. In this study, larval dispersal and marine connectivity among deep-sea coral reefs has been indirectly inferred from genetic markers. Several individuals of Desmophyllum dianthus were collected from 13 localities in the Mediterranean Sea, Atlantic and Pacific oceans, and were analysed using 30 microsatellites isolated for this species. Beside significant genetic differentiation between populations inhabiting northern and southern hemispheres, a peculiar phylogeographic structure has been found in the South Pacific and Atlantic oceans. The results suggest a genetic pattern of isolation-by-distance in the former case, and a discrete larval dispersal (strongly depth-current-dependent) among individuals from Chile, New Zealand, Australia and Argentina.

POSTER 25

Emma Hickerson, NOAA

Characterizing Mid and Outer Continental Shelf Mesophotic Communities in the Northwestern Gulf of Mexico

The northwestern Gulf of Mexico harbors extensive mesophotic habitats that support diverse communities of invertebrates and fish. As additional high resolution bathymetric mapping is conducted in the area, new potential habitat is being identified. This study presents sessile benthic community characterizations resulting from surveys to explore potential mesophotic habitat on potentially sensitive biological features and live bottoms, as defined by the Bureau of Ocean Energy Management (BOEM), surrounding thirteen banks. We present biotic densities and identify species driving differences between communities, in addition to highlighting protected and endemic species distributions. The resulting datasets are directly supporting ongoing boundary expansion efforts by the Flower Garden Banks National Marine Sanctuary and BOEM's re-evaluation and assessment of oil and gas regulatory activities.

POSTER 27

Tim Shank, WHOI

Depth and Habitat Related Faunal Diversity in Northwestern Atlantic Submarine Canyons: Implications for Conservation and Management

Recently developed habitat suitability models were used to predict deep-sea coral locations in Northwestern Atlantic Canyons (NWACS). Towed seafloor imaging surveys with TowCam were used to characterize faunal composition, distribution, abundance, and associated habitats from 25 canyons in the Northeastern US, including Toms, Hendrickson, Veatch, Gilbert, Ryan, Powell, Munson, Washington, Accomac, Leonard, Wilmington, Spencer, Lindenkohl, Carteret, Dogbody, Chebacco, Filebottom, Heel Tapper, Welker, Sharpshooter, Clipper, and Block canyons. Significant differences in sessile invertebrate species composition and distribution within and among canyons were observed, apparently driven by depth and habitat type. High abundances and diversity of scleractinians, antipatharians, octocorals and sponges were correlated with vertical canyon walls, margins, sediment, cobble, boulders, and coral rubble habitat. Several species of Antipatharia, Octocorallia, and Scleractinia colonized the upper margins of canyon walls, debris fields and horizontal cracks in vertical walls, respectively. In most canyons, the observed species diversity and abundance peaked between 900 to 1200 meters. Species not previously reported from the NWACS, including the black corals Parantipathes sp. and Bathypathes sp., were documented. The NWACS are both geologically dynamic and biologically diverse, with, in some cases, individual canyons having a distinct geological and biological signature over the examined depth range. The ability to locate and define the composition and distribution of vulnerable marine ecosystems, as well as to validate predictive ecosystem modeling, is critical for management and conservation of living resources. These coral ecosystem assessments and habitat suitability modeling in Mid-Atlantic canyons of the United States facilitated the design and proposed implementation of the largest, proposed marine protected area for the conservation and management of deep-water coral ecosystems.

POSTER 29

Amy Baco-Taylor, *Florida State* University

An Examination of Variation in Benthic Megafuanal Community Structure with Depth and Side of a Seamount

Increasing evidence suggests that seamounts communities are not homogenous across a given feature, harboring a number of habitats that increase the overall diversity of seamount communities. A number of environmental parameters may influence the distribution of benthic species on seamounts. As part of a larger project to examine the effects of trawling on seamounts, we conducted AUV Sentry photo transects along 3 sides of Pioneer Bank Seamount in the Northwestern Hawaiian Islands. A total of over 90,000m of transects were conducted at depths from 200-700m. Environmental data including depth, substrate type, slope, slope orientation, rugosity, salinity, temperature, and oxygen data were collected simultaneously. We present a preliminary analyses of the benthic megafauna communities present on the seamount and correlate variations in community structure to variations in measured environmental parameters to gain a better understanding of the scale of variability that occurs on a single feature. Our results add further evidence to the growing body of literature that demonstrates there is substantial variability in the composition of communities found around individual seamounts. These scales of variability need to be incorporated into science and management plans.

POSTER 33

Claudio Lo Iacono, The National Oceanography Centre, University of Southampton

Cold-water corals from the Levantine Mediterranean Sea: describing and quantifying a singular Dendrophyllia ramea population

During the CYCLAMEN expedition (CYCLAMEN project, supported by the TOTAL Foundation, http://cyclamen.cyi.ac.cy/) on board the RV AEGAEO in June 2015, the deepest population in the Mediterranean of the deep-water coral *Dendrophyllia ramea* was found in coastal areas off eastern Cyprus (Protaras, 35º02'N; 34º05'E). Footage from the ROV Max ROVER revealed a well-developed population of *D. ramea* located on a sandy seabed between at 125170 m depth that belongs to the medium to outer insular shelf. The maximal measured density was 4 colonies m-2 and the average up to 1.6±1.4 colonies m-2. The population consists of isolated branches of small size and large colonies, some ~50 cm max length. Surprisingly, the corals thrive on soft bottoms, representing a novel aspect of the research on *D. ramea* in the Mediterranean, since the species is still considered to be exclusively associated with rocky substrates. Coral population and spatial distribution, as well as potential relationships with environmental features are explored as an approach to describe the habitat suitability of the species in the area.

POSTER 35

Alanna Durkin, Temple University

Spatial analysis of cold-water coral and cold seep distributions and habitat chemistry in the Gulf of Mexico

Although it is home to cold-water coral reefs and diverse octocoral communities, the deep Gulf of Mexico is probably better known for its extensive cold seeps. These chemosynthetic habitats support diverse, unique communities through bacterial primary production while sometimes excluding background deep-sea species vulnerable to the chemical toxicity of the seeps. Through microbial reactions, seeps also contribute authigenic carbonate rocks to the habitat that can be utilized by cold-water corals and other suspension feeders after seepage has subsided. Using AUV photo and chemical data from nine different sites in the Gulf of Mexico, foundation species distributions were explicitly mapped along environmental gradients to closely examine the boundaries between neighboring corals and cold seeps. To visualize the distance between coral and seep habitats,

a photomosaic of seafloor images was constructed for each site and overlaid with chemical data layers in ArcGIS. Redox potential, an indicator of hydrogen sulfide, was found to be slightly higher and dissolved oxygen slightly lower on average at seep-influenced areas. This distinction was particularly pronounced young, active seeps with visible bacterial mats or brine stains on the sediment. The redox potential and dissolved oxygen levels at older seeps inhabited by the symbiotic megafauna of mussels, clams or tubeworms had average values similar to coral-occupied areas, but a more narrow range or variation.

POSTER 37

Chryssi Mytilineou, Hellenic Centre for Marine Research, Greece

Distribution of* Isidella Elongata *in the Deep Waters of the E. Ionian Sea

Isidella elongata specimens caught as by-catch during experimental trawl surveys carried out in the deep waters of the E. Ionian Sea, were recorded using photographs of the catch of each haul. In total, 204 hauls were undertaken at depths ranging between 300 and 1180 m in the framework of the INTERREG II and RESHIO projects from April to September 2000. The aim of the surveys was to explore pristine deep-water grounds and fisheries resources. In total, 199 individual *I. elongata* were caught in 54 of the hauls (26.5%) reacing a catch per unit effort of 18.4 specimens/km2. *I. elongata* was collected at depths ranging between 356 and 1080 m. All were found in hauls characterized by muddy bottoms. In most cases, fragments of live colonies of this coral were collected indicating the potential damage of this fragile coral species, which is known to be vulnerable to trawling. Other deep-water corals caught together with *I. elongata* in the study area were the black coral *Leiopathes glaberrima* and the tall sea pen *Funiculina quadrangularis*. The spatial distribution of the *I. elongata* seemed to be continuous in the deep waters of the E. Ionian Sea, although deeper areas showed a higher occurrence (300-500 m depth: 12.2 specimens/km2, 500-700 m depth: 15.9 specimens/km2, 700-900 m depth: 25.9 specimens/km2, 900-1200 m depth: 22.5 specimens/km2). The protection of this vulnerable species implies new measures for the deep-water fisheries in the Mediterranean Sea.

POSTER 39

Veerle Huvenne, National Oceanography Centre, University of Southampton

Effectiveness of the Darwin Mounds Marine Protected Area, following eight years of fisheries closure

Pressure on deep-sea ecosystems continues to increase as anthropogenic activities move into ever deeper waters. To mitigate human impacts on vulnerable deep-sea habitats, various conservation measures exist, including the designation of fisheries closures and Marine Protected Areas (MPAs). However, little evidence exists about their effectiveness, nor about recovery rates of these vulnerable ecosystems. Here we present a rare follow-up study assessing the status and recovery of a deep-sea fisheries closure and MPA, eight years after designation. The Darwin Mounds form a unique cold-water coral ecosystem at ~1000m water depth in the northern Rockall Trough, NE Atlantic. Following discovery and initial surveys in 1998-2000, the area was closed to all bottom contact fisheries, especially trawling, in 2003. Our repeat survey in 2011, using high-resolution sidescan sonar data collected by Autonomous Underwater Vehicle (AUV) and video footage from a Remotely Operated Vehicle (ROV), demonstrates the importance of the precautionary principle in deep-sea conservation. It shows that the fisheries closure is relatively well respected, even if some violation still occurs. As a result, the Western Darwin Mounds have been successfully protected, with similar proportions of live coral occurrence in 2011 as observed in 1998-2000. However, the Eastern Darwin Mounds suffered severe damage pre-closure, and so far show no recolonisation and very little regrowth. This underlines once again the low resilience and slow recovery of deep-sea ecosystems. This work was supported by the NERC MAREMAP programme, the ERC CODEMAP project (Starting Grant no 258482), the Lenfest Ocean programme and the Joint Nature Conservation Committee.

POSTER 41

Tania Lewandowski, NOAA Fisheries

The Northeast Fisheries Observer Program (NEFOP) Deep-Sea Coral Program and Data Analysis

The National Marine Fisheries Service (NMFS) deploys fishery observers to collect catch and bycatch data from US commercial fishing and processing vessels. The Northeast Fisheries Observer Program (NEFOP) collects data from fishing vessels operating from Maine to North Carolina. These observers record catch, by-catch, gear characteristics, fishing effort, and a myriad of additional biological data. NEFOP training curriculum and associated sampling protocols were changed in 2013 to include an enhanced deep-sea coral bycatch component. A training module was developed to prepare observers for identifying and processing coral samples. In collaboration with deep-sea coral experts, a reference guide was developed along with implementing new sampling and recording protocols. Pre-2013, observers recorded low numbers of deep-sea corals in bycatch. Low abundance of corals in the bycatch was likely due to: 1) the inability of fishing gear to "catch" corals; 2) the need for observer coral bycatch identification training; and, 3) the need of standardized a sampling and recording process. Since implementing this program, deep-sea coral bycatch has remained low, however, the number of recorded and verified samples has increased. Photographic records and specimens are archived within the NEFOP Species Verification Program. Deep-sea coral experts recently reviewed and identified these records. Fishery dependant, deep-sea coral bycatch data, collected by observers, can lead to a better understanding of fisheries interactions with deep-sea corals. These data can assist conservation efforts for deep-sea corals and their habitats by informing managers of coral occurrence in the northeast region.

POSTER 43

Emile Colpron, Memorial University of Newfoundland

Determining deep-sea coral distributions in the Northern Gulf of St. Lawrence using bycatch records and local ecological knowledge (LEK)

This study used a combination of coral bycatch records and fish harvesters' local ecological knowledge (LEK) to identify 11 species/groups of deep-sea coral that occur in the Northern Gulf of St. Lawrence (NAFO Divisions 4RS3Pn) in Eastern Canada and to map the distribution of seven of these. Coral bycatch records came from DFO (Fisheries & Oceans Canada) groundfish survey trawls and fisheries observer records while the LEK of fish harvesters was recorded during interviews and mapping exercises with Northern Gulf fish harvesters. Nephtheid soft corals and sea pens (Pennatulacea) were found to be the most common groups of deep-sea coral occurring in the Northern Gulf, with nephtheids being found at depths from 10-500m in all areas where hard substrates are available for attachment, and sea pens being found in large concentrations at the bottoms of the deeper-water channels, including the Laurentian Channel. Fish harvesters' LEK identified a greater diversity of corals than the bycatch records, while the bycatch records were more precise in the locations of encounters and taxonomy. Fish harvesters identified coral distributions missed by trawl surveys and fisheries observer records, specifically in coastal inshore areas that are not covered in regional survey trawls, such as Bay St. George, where Scleractinian cup corals and two species of large gorgonians were reported to occur by fish harvesters. Combining trawl survey data and LEK observations clarified the diversity and distribution of corals within the Northern Gulf of St. Lawrence, and emphasized the complementary nature of scientific surveys and fish harvester observations.

POSTER 45

Rich Langton, NOAA

Is the common sea pen (Pennatula aculeata) nursery habitat for Acadian redfish (Sebastes spp.) in the U.S. Gulf of Maine?

The common sea pen (*Pennatula aculeata*) is a deep, cold-water coral in the soft sediments of the Gulf of Maine, often occurring in dense patches. While providing physical habitat structure, it is routinely removed as bycatch during commercial fishing activities. A study in Atlantic Canada (Baillon et al. 2012) examined sea pens from trawl bycatch and found larval redfish (Sebastes spp.) sheltering within polyps. As a result, an argument was developed for the protection of sea pens as important habitat for redfish. Here we assessed the relationship between sea pens and larval redfish in the U.S. Gulf of Maine, based on 117 specimens collected during a fishery independent shrimp survey in 2015. We did confirm the presence of larval Acadian redfish (*Sebastes fasciatus*) in association with sea pens. These results are consistent with the pair-wise associations of species from the Canadian study. We also found that there was a high incidence of redfish larvae entangled in the arms of sea pens where viviparous adults, often shedding larvae, co-occurred with sea pens in the trawl net. While Baillon et al. demonstrated a poor relationship between the abundance of shedding female redfish in catches and sea pen associated larvae, we did not take this into account in the present analysis. Our results confirm the general relationship of these species, but the strength of the relationship cannot be determined without taking the state of co-occurring redfish in the trawls into account.

POSTER 47

David Huff, University of California, Santa Cruz

Associations between deep-sea coral and sponge assemblages and demersal fishes in the Southern California Bight

Deep-sea corals and sponges (DSC) and demersal fishes in the Southern California Bight are vulnerable to anthropogenic disturbances resulting from bottom fishing, pollution, sedimentation, ocean acidification, and climate change. To protect these sensitive species, it is necessary to understand their biotic and physical relationships, and what constitutes essential habitat. However, patterns of benthic diversity and distribution have not been well-resolved for many deep-sea species assemblages. We analyzed underwater video transects collected over a ten-year period, documenting the locations and abundance of DSC and demersal fishes in the Southern California Bight. Our multivariate analysis revealed distinct assemblages based on depth and bottom type, and identified several fish species (e.g., *Sebastes levis and Ophiodon elongatus*) that were predominantly associated with particular DSC. Furthermore, we developed models that describe the environmental conditions that comprise the habitat of important DSC and fish species throughout the Southern California Bight. Understanding relationships between environmental conditions and demersal community assemblages provides a means to estimate how future oceanic conditions could influence the abundance and distribution of DSC.

POSTER 49

Robert McGuinn, Center for Coastal Environmental Health and Bio-molecular Research (NOAA/NOS/NCCOS)

Bio-regional-Scale Analysis of Deep-Sea Coral Assemblage Composition Using NOAA's National Database of Deep-Sea Corals and Sponges

The United States National Oceanic and Atmospheric Administration (NOAA) Deep Sea Coral Research and Technology Program has developed a comprehensive geo-database for deep-sea corals and sponges as a resource for both scientists and resource managers. The database currently integrates more than 250,000 deep-sea coral records and more than 70,000 deep-sea sponge records, most from U.S. waters. Records were compiled from museums, bycatch from fisheries and fisheries surveys, scientific literature, and in situ observations collected by NOAA and other research institutions. The schema accommodates both linear (trawls, transects) and point (samples, observations) data types, along with images and associated information related to biology, environment, provenance and accuracy. Currently, the region with the most records is the U.S. Pacific Coast (60%), while the U.S. East Coast and Caribbean has the least amount of records (2.4%). The database structure can accommodate information on abundance, density, and associated habitat characteristics. The database content and taxonomy are based on international standards (Darwin Core, World Register of Marine Species). We provide an example data analysis exploring differences in coral assemblages by marine ecoregion and depth zone within two data-rich focal regions (the Pacific and Gulf of Mexico). Basic statistical summaries of the community structure, composition, and biodiversity are provided. The relevance of these findings to conservation and management of these habitats are discussed. This project demonstrates how a comprehensive National Database can be used to gain new insights into deep sea community composition and biodiversity.

POSTER 51

Dave Packer, NOAA/NMFS/NEFSC, James J. Howard Marine Sciences Laboratory

Variation in seafloor communities across the western New England Seamounts and adjacent submarine canyons: implications for conservation

Conservation of biological diversity in the deep sea will require spatial management approaches to avoid significant impacts. Most problematic is the lack of geographically comprehensive surveys of seafloor fauna to identify representative sites. Data produced from archived underwater imagery can potentially overcome this problem. We used imagery collected over approximately one decade in the western New England Seamounts region (Bear, Physalia, Retriever, Mytilus) and over four decades in the adjacent Georges Bank submarine canyons area (Oceanographer, Lydonia, Gilbert, inter-canyon region between Lydonia and Powell Canyons) to assess whether seamounts and canyons each require specific conservation attention. All fauna were identified to lowest possible taxon with annotated depth and habitat type. Analyses were conducted primarily on data aggregated to family level or above. Results of MDS procedures revealed both Oceanographer and Lydonia canyons were similar, and all seamounts were similar (50% similarity) except Physalia. The inter-canyon area between Powell and Lydonia was dissimilar from all other locations. When the data were concatenated by habitat type and 100 m depth zones, there was clear separation between seamounts and canyons. When only coral taxa were analyzed, resultant patterns were similar with the exception of the seamounts. That is, Mytilus and Physalia were different from Bear and Retriever and from each other. Overall these results indicate that seamounts and canyons harbor communities unique enough to warrant consideration of inclusive conservation actions to ensure ecological representation within a network of conservation areas. Examination of each site at species level may reveal more detailed spatial structure.

POSTER 53

Guarani Cavalcanti, Petrobras

Ecological criteria for environmental categorization of deep-sea coral mounds: preliminary studies to support environmental management in Campos Basin (Southeast Brazil)

Deep-sea coral mounds in Southeast Brazil, have a wide range of dimensions and biological composition. Despite these differences, these mounds are considered, conservatively, as equally sensitive for environmental assessment purposes. However, it is necessary to establish ecologically relevant criteria to rank their relative importance in order to identify coral ecosystems that should be primarily protected in a decision-making process. In order to evaluate the ecological relevance, 13 criteria related to the biological composition of the mounds were chosen, including the presence of living reef-framework species, the number of morphotypes that contribute to the carbonate substrate, presence of taxa that contribute to three-dimensionality and faunal aggregation. These criteria were applied to 153 coral mounds, between 500 and 1000 m depth, in 12 areas located in Campos Basin In parallel, differentiation among mound/areas was made by canonical discriminant analysis, considering either the full set of criteria or only a selection of these. Both approaches showed similar patterns. Integrated analysis allowed the classification of the areas related to its biological importance into three categories: medium, high and very high. Note that there is no low category, since all the coral communities are considered ecologically relevant. The present evaluation allowed a careful coral mound selection that should be mostly preserved in the studied region.

POSTER 55

Pam Goddard, NOAA Fisheries

Validation of distribution models for corals and sponges in the eastern Bering Sea

Species distribution modeling is a useful tool for deep-sea coral management. However, validation of model predictions with independent surveys is rarely attempted. We conducted an underwater camera survey of the eastern Bering Sea slope and outer shelf as a test of species distribution modeling of deep-sea corals, sponges and sea whips based on bottom trawl survey data. The camera survey also was conducted to determine density and size of the taxa. The trawl model predictions generally were confirmed by the camera observations (area under the receiver−operator curve [AUC] values of 0.63 to 0.73). Combining bottom trawl and camera survey model predictions improved predictive ability (AUC values of 0.74 to 0.90 for camera observations). Corals were distributed in Pribilof Canyon and the slope area to the northwest of the canyon, and colony densities averaged 0.005 ind. m−2 and ranged from 0 to 0.28 ind. m−2. The low densities were consistent with the absence of hard substrates for coral attachment in most areas of the eastern Bering Sea. Sponge and sea whip density averaged 0.11 ind. m−2, with sponge density ranging from 0 to 13.1 and sea whip density ranging from 0 to 8.4 ind. m−2. Invertebrate heights were generally small, with most taxonomic groups < 20 cm in average height. This type of study is vital to providing the best scientific advice for spatial management of structure-forming invertebrates, so that decisions concerning the protection of these vulnerable communities can be implemented with a clear basis for priorities.

POSTER 57

Matthew Poti, NOAA

A systematic, regional approach to predictive modeling of habitat suitability for deep-sea corals in U.S. waters

Recently, predictive modeling has emerged as an essential tool to inform researchers and policy-makers involved in conservation, management and exploration of deep-sea coral (DSC) habitats throughout U.S. waters. From 2011-2016, we developed a series of regional-scale predictive models of habitat suitability for several taxonomic (e.g., *Lophelia pertusa*, *Gorgonian Alcyonacea*) and functional (e.g., framework-forming corals) groups. These models have resulted in a comprehensive, consistent series of predictive maps spanning four U.S. regions - Northeast/ Mid-Atlantic, Southeast Atlantic, Gulf of Mexico, and Main Hawaiian Islands - with a spatial resolution of ~400 m. Multiple measures of model performance, including cross-validation statistics and novel metrics of model fit and stability, and maps of spatial uncertainty were generated to support decision-making. Maximum Entropy (MaxEnt) models were fit to coral presence records and spatial environmental predictors, including topographic, oceanographic, and geographic variables. We enhanced the standard MaxEnt approach in several ways to improve model selection, performance assessment, consistency and interpretability. We implemented a stepwise model selection process to identify models that balanced predictive power (via cross-validation statistics) with complexity (via information criteria). Using the selected models, we predicted the relative likelihood of occurrence of suitable habitat within each model grid cell. To allow consistent comparisons across coral groups and regions, we converted the standard MaxEnt "logistic" predictions, which are uncalibrated, into habitat suitability likelihood classes calibrated by a cross-validation procedure. Finally, we compared and contrasted environmental predictor relationships across coral groups and regions, yielding insights into correlates of DSC distributions at a range of spatial scales.

POSTER 59

Paola Soto

Potential Distribution of Five Species of Reef Building Deep Water Corals in the Eastern Pacific Ocean

Deep water corals build reefs are considered as among the most important ecosystems of the deep sea, because they host high levels of biodiversity. These kind of reefs have low growth rates, and that makes them vulnerable to anthropogenic impacts. As a consequence, increasing efforts to protect them are under way at national and international level; they are based on good information on the geographic location of the formations, only available for areas such as the Atlantic Ocean. Direct records of the presence of reefs are lacking, the use of tools such as the analysis of ecological niche and potential distribution are needed. Habitat suitability models were constructed for the five species of reef building azooxanthellate corals that occur in the Eastern Pacific: *Dendrophyllia californica, Dendrophyllia oldroydae, Desmophyllum dianthus , Madrepora oculata and Lophelia pertusa*. The variables that explained better the distribution of four species were depth, temperature and omega aragonite, while for D. dianthus silicates had great influence on its presence. The area with highest probability of occurrence for M. oculata was off Ecuador, Panama and the Galapagos Islands, while for *L. pertusa* was the coast of California. *D. dianthus and D. oldroydae* present high probability of occurrence in western coast of USA and Central America. Finally, *D. californica* is expected to occur especially in Gulf of California. With this information, decision makers may be able to better direct its efforts towards protecting specific areas, and to take conservation measures and formulate useful management initiatives to protect these ecosystems.

Poster Abstracts for Thursday, 9/15

POSTER 2

Andrea Gori, Universitat de Barcelona

Physiological performance of the cold-water coral Lophelia pertusa under natural low oxygen conditions in the Angola margin (southeastern Atlantic Ocean)

The reef forming cold-water coral *Lophelia pertusa* is a cosmopolitan species with a wide bathymetric distribution range. Its occurrence and distribution patterns have been related to several environmental factors such as seawater temperature and density, water flow regimes, aragonite saturation state, dissolved oxygen (O2) concentration and food supply. Large *Lophelia pertusa* reefs developing on coral mounds have been recently discovered along the Angola margin in the south eastern Atlantic Ocean,; these very well developed and healthy reefs thrive today under very low O2 concentration. Using an experimental setup, this study assessed respiration, excretion and calcification of *Lophelia pertusa* under this naturally low O2 concentration as well as under saturated O2 concentrations. The aim of the work is to increase the current knowledge on the metabolic response and calcification rates of *Lophelia* under these two different scenarios, exploring the potential limitations for coral metabolism and growth in the Angola reefs under the low O2 conditions.

POSTER 4

Fiona Murray, Heriot-Watt University

Meeting carbon budget demands under different feeding regimes in the cold-water coral Lophelia pertusa

Cold-water corals are amongst the most three-dimensionally complex deep-sea habitats known and their structures support high local biodiversity. The remoteness of their habitat and short research history means that to date little is known of the energy allocation of these organisms, which is key to understanding their ecology. Here we report measured L. pertusa carbon budget parameters for respiration (407 µg CaCO3 g-1 h-1), calcification (18.55 µg CaCO3 g-1 h-1) and carbon excretion (6209µg CaCO3 g-1 h-1) primarily through mucus production, as well as carbon uptake from corals well fed and starved on two different food sources (Artemia salina nauplii or Skeletonema costarum). Results showed great variability in all parameters measured, most notably in dissolved organic carbon (DOC) production. Carbon export of these freshly collected samples (6634 µg CaCO3 g-1 h-1) was found to be higher than the carbon intake from either food source (6367 µg CaCO3 g-1 h-1 for A. salina, 547 for µg CaCO3 g-1 h-1 S. costatum), highlighting the need for adequate acclimatization times for physiological experimentation and that energetic requirements following perturbation may exceed the basal energetic intake.

POSTER 6

Di Tracey, National Institute of Water and Atmospheric Research

Age and growth of a reef-forming deep-sea coral Solenosmilia variabilis in the New Zealand region

Understanding recovery rates of deep-sea coral habitats and their associated communities is growing globally but limited in the New Zealand region by our lack of knowledge on the age and growth of some key species. One of the most widespread and abundant habitat forming deep-sea corals in the South Pacific is Solenosmilia variabilis. The age of this species was assessed using radiocarbon content (14C) on branch sections sampled from the Graveyard Knolls, Chatham Rise, and Louisville Seamount Chain, about 950 km east of New Zealand in the High Seas. Age estimates of long dead, recently dead, and live stony coral matrices were obtained to progress our understanding of their living distribution. Overall linear growth rates ranged from 0.25 to 1.3 mm/yr. Using a conservative estimate of matrix height of ~20cm, it could take hundreds of years (~150-660) for a colony to attain this height, or ~2000 years to build a diameter of 1 metre. The age of the large coral die-off events on the Louisville seamount chain was determined to be over at least 10,000 years, coincident with the last glacial termination and a time of oceanographic change within New Zealand region intermediate waters. Defining the age, growth and timeframes for the restoration of deep-sea coral matrices in the region may inform risk assessments and aid in the management of deep-sea habitats.

POSTER 8

Bárbara de Moura Neves, Memorial University of Newfoundland

It looks just like a polyp: a highly specialized endoparasitic copepod associated to Paramuricea sp. (Cnidaria: Plexauridae) in the Northwest Atlantic.

Octocorals host a variety of organisms that use the corals for protection or for a place to shelter, feed, or rest. Copepods in the family Lamippidae are exclusively endoparasites of octocorals, and can be highly specialized for a life inside their hosts. While inspecting colonies of the octocoral Paramuricea sp. from Newfoundland and Labrador (Northwest Atlantic) we found copepods assigned to the lamippid genus Linaresia inside the calyces of three octocoral colonies. Infected calyces were visibly larger than non-infected ones and could contain both female and male copepods. Octocoral polyps were no longer present inside the calyces, which had been taken over by the female copepod, which resembles the octocoral polyp with a set of eight erect arms. There was only one female and up to three male copepods per calyx. More than 160 females were found in one single colony 49 cm long by 55 cm wide. *Linaresia* has been previously reported from the Mediterranean Sea (shallow-water), Gulf of Mexico (73 m), and Hawaii (366 m). Here we extend the geographic and bathymetric range of this copepod genus, with specimens sampled off Newfoundland and Labrador at 157 m, 972 m, and 1314 m. Furthermore, this is the first report of *Linaresia* inhabiting *Paramuricea* in the western Atlantic, where it has been previously recorded only in the *octocoral Placogorgia* (Gulf of Mexico). Additional inspections might further extend the geographic range of this copepod, and future studies might shed light on ecological aspects of the association.

POSTER 10

Furu Mienis, Royal Netherlands Institute for Sea Research

Microbial assemblages on a cold-water coral mound at the SE Rockall Bank

The microbial community composition over Haas Mound, one of the most prominent cold-water coral mounds of the Logachev Mound Province was analysed by Roche GS-FLX amplicon sequencing targeting both Bacteria and Archaea. Overlaying water was collected from depths of 400m as well as 5 and 10m above the bottom using a CTD/Rosette system. Near-bottom water, sediment, and samples of mucus and skeleton of the coral Lophelia pertusa were obtained with a box-corer. We outline patterns of microbial distribution, vertically - from the seafloor through the water column - and laterally - across mound - and couple these to mound topography and turbidity. A strong link was found between the microbial community composition and the specific biotopes. At all locations, the near-bottom water differed significantly from water at 5m above the bottom, illustrating that near-bottom water in between coral framework represents a separate microbial habitat. Near-bottom water was distinct from other biotopes by outstanding relative abundance of the class Halobacteria (1.2%) and the genera Nitrosopumilus (3.2%), uncultured Xanthomonadales (1,6%), Defluviicoccus (1.3%), Marinicella (1.2%), and Brocadiaceae W4 lineage (1.1%). The Endozoicomonas found in near-bottom water (0.2%) is probably related to the presence of (dissolved) mucus in the water. The genus was not found in sediment, nor in overlaying water at 5m above the bottom. The overlaying water community (sampled at 400m and at 500-1200m) was structured according to depth and correlated variables i.e. temperature, salinity and density (17% explained). Turbidity of the overlaying water explained an additional 14%, correlating with sampling year.

POSTER 12

Tina Molodtsova, *P.P.Shirshov Institute of Oceanology* of the Russian Academy of Sciences

New association between a deep-water black coral and a scale-worm (Annelida, Polynoidae) from the Hawaiian Islands

Symbiotic relationships between antipatharian corals and scale-worms (Annelida, Polynoidae) are well documented in the literature, with the polychaetes inhabiting either the external surfaces of their antipatharian hosts, or living in worm-runs, a kind of galleries formed by interlaced and fused host branchlets. During a recent expedition to the Northwestern Hawaiian Islands aboard the R/V Okeanos Explorer (EX1504L2, July 31-August 22, 2015) we observed a substantial number of Bathypathes sp. (Antipatharia: Schizopathidae) colonies, previously reported as Bathypathes alternata Brook, 1889, which housed a symbiotic scale-worm. The polychaete was always observed nestling along the polyps on the main stem of the coral, with the tentacles forming a soft tunnel around the polychaete worm. Neither worm-runs nor apparent changes in pinnule arrangement, as described in other associations of scale-worms with antipatharians, were observed. However, in the Bathypathes sp. colonies housing the symbiotic polychaete, the antipatharian polyps had flattened oral surfaces and longer tentacles near the base of the colony, where the scale-worm occurred. We also found symbiotic polynoids or traces of their presence in numerous preserved Bathypathes sp. specimens housed at the US National Museum of Natural History, suggesting that polynoids are common symbionts of Bathypathes sp. in Hawaii. The association between a scale-worm and Bathypathes sp. reported here is the first finding of soft tissue modifications in antipatharians as a response to the presence of symbiotic polychaetes that does not presents concomitant modifications in the hard skeleton.

POSTER 14

Ian Rocha, LABTOX – Laboratório de análises ambientais LTDA

Ophryotrocha *sp. (Annelida: Dorvilleidae): an associated species to* **Lophelia pertusa** *reefs for use in ecotoxicological testing*

The use of deep-water species in laboratory studies faces several difficulties, especially for long-term studies. The free living Polychaete species *Ophryotrocha* sp. has been maintained in culture at Labtox for several consecutive generations since 2011. They were collected as associated fauna with *L. pertusa*, by ROV at 208-252 m depth in Santos Basin, Brazil during surveys of PETROBRAS research project SENSIMAR. The culture was kept in a cold chamber (10 and 12 ˚C), in the dark, using 10L glass aquariums with natural filtered seawater (45µm) and salinity of 35 ppt. Every two months, 250 adults were transferred to a clean aquarium and a new culture was started. A mixture of alfalfa, dry grass and seafood flakes was given as food supply. A continuous reproduction of juveniles for utilization in ecotoxicological studies was possible due to such conditions. The life cycle from larval stage to the first reproduction is 50 days, with an average of 466 eggs per breed, and the hatching occurs after approximately 15 days. The preliminary results obtained in the acute tests (LC50; 96 h) with sodium dodecyl sulfate (5.5 mg.L-1), zinc (3.56 mg.L- 1) and copper (0.57 mg.L-1) showed a similar sensitivity to shallow water Polychaete species used in the environment assessment. In general, *Ophryotrocha* species are suitable as test organisms due to the small size, easy handling and culture, short life cycle and the transparency of the egg masses, which facilitates the use of the reproduction and embryonic development as an endpoint.

POSTER 18

Jürgen Titschack, Heriot-Watt University

Lophelia pertusa morphotype differentiation in computed tomography data a first approach

Lophelia pertusa is well-known for its high morphological plasticity with morphotypes ranging from very large, elongated and heavily calcified (brachycephala) to small, fragile (gracilis) corallites. Thereby it seems that the variability is mainly caused by two factors: (i) the degree of calcification resulting in considerable thickness variations of the outer theca ranging from thin (<1mm) to thick (~1 cm), and (ii) the corallite length (the calices opening seems to be rather constant). So far, observations of the various morphotypes in Lophelia pertusa are exclusively qualitative, which prohibits an in-depth comparison of these morphotypes, such as the identification of morphological endmembers and subsequently their potential preferential occurrences within and between regions or through time. Computed tomography (in this case medical CT) can be used to produce virtual three-dimensional models of various specimens from seabed surface as well as sediment core samples. These virtual models can be used for further analysis. We explored the capability of a calice segmentation and parameterisation to separate morphotypes by their basic calice charateristics (e.g., length, width, volume). The presented methodology forms the potential basis for a quantitative, observer-independent characterisation of morphotypes of Lophelia pertusa and their subsequent automatic classification in the future.

POSTER 20

Lea-Anne Henry, Heriot-Watt University

Deep corals, deep learning: a novel deep net architecture for real-time semantic segmentation of cold-water coral reefs

Deep learning is at the technological forefront of artificial intelligence and image analysis in many domains. However, a major step-change from the automation of sparsely classified information and pre-selected features to full autonomy is needed to attain the speed and accuracy to address urgent Big Data challenges. We present results from a novel deep net architecture that simultaneously localises and classifies image pixels in a fully convolutional neural network (FCNN) with dense conditional random fields (DCRFs). The net was trained and validated on cold-water coral reef images and benchmarked datasets. In total, 159 images from CWC reefs off Scotland and in the High Seas Atlantic. The net achieved up to 97% accuracy in identifying several classes of corals and sponges, and even discriminated between dead and live coral framework, doing so in seconds flat. The integrated FCNN-DCRF surpassed all other human and previous deep net performance benchmarks in speed and accuracy, and we are now working towards on-board capacity for real-time data segmentation for autonomous underwater vehicles. This breakthrough showcases a transformative new tool that can revolutionise our capacity to monitor changes in CWC reef ecosystems.

POSTER 22

Daan Gerla, NIOZ Royal Netherlands Institute for Sea Research

Cold-water Coral Feeding Rates

The functional response, i.e. food uptake rate as function of food availability, largely determines the interactions in food webs and is thus an important element of any ecosystem, including those of cold-water coral reefs. However, the functional responses of cold-water corals (or of corals in general) have thus far only been determined in few cases and under specific circumstances. Here, we introduce functional response theory for passive filter feeders (such as corals) and apply it to a diverse collection of experimental data on the feeding of cold-water coral species. Specifically, from the data we estimate the rates at which a unit volume is cleared of food, yielding coral biomass-specific clearance rates, or "effective filter rates". We then establish correlations between specific clearance rate and experimental conditions. Correlations with initial food concentration and duration of the experiment convey information on the shape of the functional response and limitation of food uptake by food processing capacity. Correlations with factors such as flow velocity and sediment load tell us how the functional response is modified by the environment. These factors are then included mechanistically in the formulation of the functional response, yielding a model that predicts coral feeding rates under field conditions. This model is then confronted with data from the field.

POSTER 24

Tina Kutti, Institute of Marine Research, Norway

Polyp addition and rhythms in growth in a fully developed* Lophelia pertusa *coral reef recorded by the deep-sea cabled observatory (LoVe), Hola Trough, northern Norway

Little is known about the contemporary growth and development of *Lophelia pertusa* cold-water coral reefs. Such information is, however, critical for determining the health and the resilience of the reefs to anticipated climate change and other sources of human impacts, such as bottom trawling and oil exploration. This study describes the development of one *Lophelia pertusa* reef of the Hola reef aggregation (northern Norway) that is under continuous monitoring by the deep-sea cabled observatory LoVe. Using hourly photo images, from October 2013 to November 2015, the addition of new polyps and removal of coral polyps were documented at a temporal resolution unparalleled by other studies. Sensor data from the observatory demonstrates a high degree in variability in background ecological condition, which could be linked to the performance of the coral. Interestingly *Lophelia pertusa* growth at this mature reef was much lower than that expected based on earlier growth measurement of coral fragments/nubbins in the Atlantic Ocean. For the full 22 months examined a polyp addition rate of only 4.3% was observed. Furthermore, the addition of new polyps was just barely balancing the predation of coral polyps that occurred at a rate of 4.5%. It is therefore expected that as this particular reef a net erosion may occur. In all, the study demonstrates the importance of long-term in-situ data collections to document natural variability in performance and growth of *Lophelia pertusa*. Such data is critical for the determination of the resilience of the reef to anthropogenic impact. This reef where erosion and predation processes are larger or equal to growth could be particularly vulnerable to anthropogenic stress.

POSTER 26

Keri Feehan, University of Maine

Reproduction of Desmophyllum dianthus from the Chilean Fjords

The Chilean Patagonian fjords are the only known location where Desmophyllum dianthus occurs in shallow waters (>50m). For this study corals were collected via SCUBA approximately every three months from August 2012 to September 2013 from three sites within the Northern Patagonian fjords Lilihuape and Punta Huinay in the Comau fjord, and Punta Mamurro in Reñihue fjord. This study determined that Desmophyllum dianthus is gonochoristic, having both male and female individuals. This species is also highly seasonal, spawning in the austral winter (August) and beginning gamete production in early spring. The fjord was coolest and most saline in August 2012, potentially cueing spawning. No planula larvae were found in any of the 8,000 histological sections. Due to the presence of late stage oocytes in August 2012, it is likely D. dianthus's mode of reproduction is spawning rather than brooding. However this distinction could not be determined in this study. Oogenesis starts in September producing previtellogenic oocytes (size range: 25 200 μm) that slowly developed into vitellogenic oocytes by June. Vitellogenic oocytes ranged from 200 380 μm. Fecundity is relatively high compared to other deep-sea scleractinians, ranging from 2,448 (± 5.13 SE) to 172,328 (±103.67 SE) average potential oocytes per polyp. This research provides the first insight into Desmophyllum dianthus reproductive biology and yields an important baseline for continuing work on this benthic habitat builder in the Chilean fjords, and in the deep ocean.

POSTER 28

Rhian Waller, University of Maine

Cold Water Coral Ecosystems in Glacier Bay National Park, Alaska

Glacier Bay National Park (GBNP) protects unique deep-water fjords that are internationally recognized as refuges for many species of marine mammals and seabirds. Over the years there have been a few reports of cold-water corals (*Primnoa pacifica*) being present in GBNP at both shallow (~10m) and deep (~400m) depths. In March 2016 we launched a joint SCUBA and ROV research cruise to characterize these ecosystems within the park boundaries and sample corals for taxonomic, genetic and reproduction studies. A total of 17 SCUBA dives and 11 ROV dives were completed during our 12-day cruise that covered Glacier Bay's East and West Arms and the central channel. During this cruise SCUBA divers photographed and sampled known shallow populations of corals in the East Arm, and discovered new shallow populations in the West Arm, notably close to glacier fronts. The ROV visualized extensive *Primnoa pacifica* habitats at depths between 300-500m in the East and West Arms, as well as a large community (>30 colonies) inhabiting a rocky prominence in the Central Channel Area. *Caryophyllia arnoldi* cup corals were observed for the first time in Glacier Bay National Park, also notably close to the glacier terminus and in areas with dense hydroid mats. Mobile fauna were also observed using the corals as cover or as feeding sites.

POSTER 30

Steven Auscavitch, Temple University

New insights to biogeographic patterns among cold-water coral-dominated benthic communities across the Drake Passage

Biogeographic patterns among deep-sea benthic communities in the Southern Ocean remain poorly understood due to poor sampling resolution and spatial remoteness. Yet, cold-water corals have been found to be relatively abundant and taxonomically diverse on many seafloor features. In the Drake Passage, several hard-bottom features, including at least 20 seamounts, remain uncharacterized with respect to their benthic megafaunal assemblages. Here we present community assemblage records from several locations across the Drake Passage in order to better understand the faunal relationships between cold-water corals and the communities they support. Towed camera surveys were conducted on 9 topographic features ranging from shelf environments on the southern Chilean Margin, Western Antarctic Peninsula shelf, and seamounts in the central Drake Passage. We provide the first quantitative measurements of megafaunal abundance at two seamount complexes in the central Drake Passage and present preliminary multivariate analyses to examine factors influencing species distributions. We have identified three biogeographic groupings based on species assemblages and environmental variables specific to major water masses boundaries in the region: Subantarctic Mode Water (318-523m), Antarctic Intermediate Water (504-1128m), and Circumpolar Deep Water (1837-3034m). Further exploration of megafaunal associations between seafloor structures may provide clues as to how sub-Antarctic communities are connected throughout the Southern Ocean and how they will respond to rapid climatic forcing in the area.

POSTER 32

Len Zedel, Memorial University of Newfoundland

Boundary Layer Velocity Structure in a Cold-Water Coral Area of Haddock Channel, Southwest Grand Banks

Bottom boundary layer currents in coral habitat in Haddock Channel were characterized using two 2-MHz acoustic Doppler profilers. The profilers were deployed on the seafloor, depth 700 m, looking upward, for 85 hours, beginning July 17th, 2007. The vertical profiling range was 4 m, with 1 m depth resolution. One instrument was placed in a coral (*Keratoisis grayi*) thicket (Coral Site), the second was deployed 100 m away in an area with similar sea floor characteristics, but from which corals had been removed by a research bottom trawl (Mud Site). Velocity profiles from the two sites are compared to evaluate the degree to which corals alter the characteristics of the bottom boundary layer. Friction velocities (u*) at flow speeds less than 5 cm/s, were consistently higher at the Coral Site (at times by a factor of 3). Bed roughness values at the Coral Site (mean zo= 0.51 +/- 0.28 cm), were generally higher at flow speeds below 5 cm/s, compared to the Mud Site (mean zo= 0.27 +/- 0.40 cm). The higher u* and zo values at the Coral Site observed at lower flow speeds suggest that turbulence due to (coral) roughness elements is significant at low flow speeds. We explore changes in acoustic backscatter levels as a proxy for suspended material in the water. Curiously, backscatter increased faster with flow speed at the Mud Site for speeds between 2.5 and 7 cm/s while above 7 cm/s, Coral Site backscatter intensity increased substantially, while Mud Site backscatter intensity declined.

POSTER 34

Laurence De Clippele, Heriot-Watt University

An integrated ecological and geophysical study of cold-water coral habitats

Cold-water coral reefs are listed by the United Nations as Vulnerable Marine Ecosystems and are in need of protection. These long-living, slow growing reefs are hotspots of biodiversity threatened by fishing activities and climate change. To be able to protect these ecosystems efficiently, there is a need to improve our understanding of the distribution of these cold-water corals, their habitats and the diversity and distribution of their associated fauna. Here high-definition video material, acoustic data (e.g. bathymetry, backscatter), predictive models and maps were used in this project to help fill gaps. This helps us to enhance our knowledge on the function of cold-water corals in the deep sea and on the factors that control the distribution of these organisms. An overview of results from three different reefs is shown here. The first is from the Mingulay reef complex (Scotland) where small-scale spatial distribution patterns of the deep-sea coral *Lophelia pertusa* were explored. The second reef is located on Rockall bank, the Logachev carbonate mounds, where we investigated the spatial distribution of black corals and the role they play for the local megafauna. The third reef is located in Norway, the Tisler reef, where the reefs expansion and the coral morphology was related to the local hydrodynamics.

POSTER 36

Kevin Power, Memorial University of Newfoundland

First insights into the morphology and envirnoment of carbonate mounds at the Porcupine Bank Canyon, NE Atlantic

The Porcupine Bank Canyon is a submarine canyon incised into the Irish continental margin, where cold-water coral reefs have thrived for some time along the canyon edge (650 mbsl). This has led to the growth and development of several large carbonate mounds. Here, two of these mounds (Querci & Ziggy) are described for the first time. Given their unique position on the canyon edge, the mounds contain some non-typical sediment facies. Talus slopes at the flank of the canyon show extensive fields of coral rubble, populated by large quantities of crinoids. Vertical faces of exposed bedrock provide solid substrates for the holdfasts of very large, long-lived Leiopathes, as well as Antipathies, Stichopathes, and Lophelia. Winnowed areas expose hardground strata of consolidated coral debris cemented together by micrite, and vertical bank of sediment now completely colonised by large Desmophyllum, growing on top of each other in competition for space. Mound summits are capped by dense living communities of CWC reef building organisms. The carbonate produced on the mounds is continually flushed down the canyon, where it accumulates in thick successions. Our initial explorations of the mounds now seem trivial: the canyon itself is a "carbonate canyon". We utilise ROV-borne multibeam and video data along the canyon edge and face to describe its sediment facies. CTD casts allow the classification of the water column affecting mound development. Furthermore, a series of ROV push cores and scleractinian samples will allow the reconstruction of mound development & the regional paleo-oceanographic conditions.

POSTER 38

Evan Edinger, Memorial University of Newfoundland

Stylaster campylecus parageus from the NE Pacific: Microanalytical evidence for monthly growth banding and an intact record of sea surface productivity

Deep sea *Stylasterids* are widely distributed in the Northeast Pacific Ocean. Live colonies of *Stylaster campylecus parageus* were collected at depths of 250 - 350m, offshore from NW British Columbia, Canada and NW Washington State, USA. This species progressively re-mineralizes its skeleton as it grows. The skeletal material is thus extensively overprinted with secondary aragonite - particularly nearing the center of coral growth. Nonetheless, we obtained primary cross-sectional profiles of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca, using Secondary Ion Mass Spectrometry (SIMS), supplemented by SEM-BSE imaging to ensure exclusion of individual spot analyses that encountered re-mineralization. SEM-BSE also revealed growth bands not visible with traditional light microscopy. Sr/Ca values displayed two maxima over sections covering approximately 12 growth bands, with corresponding minima in Mg/Ca and Na/Ca. The intra-annual temperature variation in the collection area is less than ±1°C, and the observed trace element variations were interpreted as primarily influenced by surface water productivity. Based on the cyclicity of the profiles, and the biannual increase in productivity previously documented in the collection area, the growth bands are interpreted as monthly. Using this approach and interpretation, an average radial growth rate of 1.4 ±0.1 mm yr-1 (1s) and an average axial growth rate of 17.3 ±1.1 mm yr-1 (1s) were determined for our samples, with ages varying from 3 to 6 years. A relatively fast growth rate for *S. campylecus* is also compatible with the observation that *Stylasterids* are one of the earliest re-colonizing species observable after bottom trawling.

POSTER 40

Michèle LaVigne, Bowdoin College, Maine

Growth Rate Nonlinearity in Bamboo Corals: Implications for Intermediate Ocean Proxy Reconstructions

Bamboo corals (family *Isididae*, order *Alcyonacea*) are gorgonian octocorals named for their structure of alternating calcite internodes and proteinaceous gorgonin nodes, which acquire carbon from distinct sources. Ambient dissolved inorganic carbon is incorporated into the calcitic internodes, while carbon incorporated into the proteinaceous nodes is derived from the corals food source, particulate organic carbon. A single bamboo coral can thus provide century-long high-resolution temporally linked records of intermediate and surface water conditions. Previous work has used the 14C bomb spike recorded in organic nodes to calculate a mean coral growth rate for proxy record chronologies. New high-resolution 'reconnaissance' radiocarbon data from the nodes of six bamboo corals allow for the identification of two tie points within the 14C bomb spike, which provide evidence for declining radial growth rate with coral age and radius. A simple mathematical model was used to predict radial growth rate as a function of radius to interpolate between chronology tie points under the assumption that a constant volume of organic material is deposited per year. Application of this model to elemental proxy records from calcitic internodes reveals a more realistic representation of proxy data with time. Internally reproducible Ba/Ca calcite records from corals spanning the California Current System oxygen minimum zone reveal interannual variations in intermediate water biogeochemistry in this key region. Coupling more precise chronologies with proxy records has the potential to further elucidate the mechanisms linking intermediate water carbon cycling and climate in the past.

POSTER 42

Kimberly Galvez, University of *Miami*

The Variability of Cold-water Coral Growth in Glacial versus Interglacial Times

Cold-water corals (CWC) make up a complex system and are prolific sediment producers in the deep-water environment in many modern oceans. They are greatly impacted by various factors such as currents and water mass properties that occur during glacial and interglacial cycles. Cores retrieved from two CWC mounds in the Straits of Florida are studied to gain a quantified insight of how these glacial interglacial cycles influence the structure and composition of the mounds. Several sequences of coral growth interruptions are clearly observed in the cores. Age-dating the core through 14C, U/Th, and Sr dating is necessary in order to find the rates in which the mounds are growing and correlate interruptions of coral growth that occurred throughout the growth of the mounds. A complete analysis of the composition and structure of the mounds are required to gain proper insight to develop a thorough analog of the history within the Straits of Florida and to reveal the glacial/interglacial growth periods of the mounds. Grab samples of live corals will be run through extensive analyses in order to compare species of corals from one portion of the Straits to the next and any changes that differentiate previous coral growth with modern. This is the first study in this area to compare geological and biological aspects in that carbonate mound development is directly linked to the possibility of biodiversity within CWCs to establish growth patterns of CWCs and the structures to which they form.

POSTER 44

Nadine Tisnérat-Laborde, Laboratoire des Sciences du Climat et l'Environnement, France

Radiocarbon variability in northeast Atlantic intermediate waters during the past six decades recorded in cold-water corals

The radiocarbon content of northeastern Atlantic upper intermediate water is intimately linked to cross thermocline exchange and advection of water masses along the basin scale re-circulation pathways. These water masses mainly result from the mixing of the subpolar and subtropical Atlantic intermediate water masses. With the introduction of bomb 14C produced by atmospheric nuclear weapon testing in the 1950s and early 1960s, radiocarbon time series in intermediate ocean can provide unique information on the variability of intermediate ocean circulation. Here, we present four annually resolved time series of pre- and post-bomb radiocarbon for intermediate waters obtained for three locations in northeast Atlantic. Continuous 14C records were obtained from long-lived specimens of the branching scleractinian cold-water corals *Madrepora oculata* and *Lophelia pertusa*. The studied corals were collected alive from the Norwegian Sea (67°N, 9°E, 350 m water depth), from the Bay of Biscay (46°54'N, 05°19'W, 691 m water depth) and from Rockall Trough (55°27'N, 15°03'W, 773 m water depth). These time series provide new constraints on the age and growth rate of two of the most important framework-building cold-water coral species. Moreover, the coral 14C records reveal a previously undocumented 14C dynamic for the eastern Atlantic intermediate waters over the past 60 years, most likely related to the cross thermocline exchanges and variations through time of the Atlantic mid-depth gyre circulation.

POSTER 46

Nancy Prouty, USGS Pacific Coastal and Marine Science Center

Development and application of deep-sea coral organo-iodine as a novel tool for chronology

Deepsea black corals (*Leiopathes sp.)* are long-lived (up to 4,000 yrs old), and grow in a tree-like fashion depositing growth rings in their skeleton. We employed a novel approach to combine the identification of *Leiopathes* growth bands captured in high-resolution SEM with synchronous peaks in skeleton iodine composition, validating for the first time that both can be used as annual chronometers. Using independent iodine age models in conjunction with the radiocarbon records, ocean reservoir age records can be developed for the last ~500 to 1000 years. Three specimens from the Gulf of Mexico were imaged in thin section using scanning electron microscopy at 900x magnification; peaks in iodine intensity were identified using energy dispersive x-ray spectroscopy. Age determination by counting visual growth bands and iodine peaks were compared to both radiocarbon and U/Th-derived ages. For example one specimen has an iodine peak count age of 695 ±70, and growth band age of 785 ± 80, which compare well to the radiocarbon age of 670 ±40 years and a U/Th age of 780 ±16 years. Organo-iodine was the dominant iodine species in the black corals, demonstrating that binding of iodine to organic matter plays an important role in the transport and transfer of iodine to the deep-sea corals. Riverine delivery of terrestrial-derived organo-iodine is the most plausible explanation to account for annual periodicity in the deep-sea coral geochemistry. Using the independent (iodine derived) age models in conjunction with the radiocarbon data, a high resolution ocean reservoir age record was developed for the last 600 years. Reservoir ages varied from 120 to 550 14C years on decadal to centennial time scales. The modern reservoir age in the GOM is 235 ±11 14C years. A likely explanation for the variability found in these reservoir ages is related to changes in the strength of the Yucatan Current.

POSTER 48

Robert Sherrell, Rutgers University

Experimental paleo-proxy calibration in cold water corals

Cold-water corals (CWCs) display an almost cosmopolitan distribution over a wide range of depths. Similar to their tropical counterparts, they provide continuous, high-resolution (annual to seasonal) records of up to a century or more. Several CWC elemental and isotopic ratios have been suggested as useful proxies, but robust calibrations under controlled conditions in aquaria are needed. Whereas a few experimental proxy calibrations have been performed for tropical corals, they are still pending for CWCs. This reflects the technical challenges involved in maintaining these slow-growing creatures alive in aquaria during the long-term experiments required to achieve sufficient skeletal growth for geochemical analyses. In this presentation we will show details of the set up and initial results of a long-term experiment being run at the ICM aquaria facilities in Barcelona, where live specimens (>150) of the CWC *Desmophyllum dianthus*, are kept under controlled and manipulated chemistry (pH, phosphate, barium) and feeding conditions. With this set-up, we aim to experimentally calibrate specific elemental ratios including P/Ca, Ba/Ca, B/Ca and U/Ca as proxies of nutrient dynamics, pH, and carbonate ion concentration. We present preliminary results using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS), which allows quantitative analyses on spot sizes of tens of microns. We will also attempt measurements using NanoSIMS, to resolve nano-scale details in relative composition. Preliminary data obtained from these techniques will be presented, together with monitoring parameters regarding coral growth and physiology including skeletal growth, coral calcification and respiration.

POSTER 50

Lissette Victorero, National Oceanography Centre
University of Southampton

Reconstruction of the formation history of the Darwin Mounds, N Rockall Trough: how the dynamics of a sandy contourite affected cold-water corals

Cold-water coral (CWC) mounds, formed through a feed-back process of CWC growth and sediment baffling, have been studied all along the NE Atlantic continental margin. They have been identified as important recorders of paleo-environmental signals in areas where the surrounding sediment record is too compressed or has been eroded. Understanding CWCs response to past environmental changes can aid in identifying current and future threats to these habitats. However, major questions remain concerning their initiation and early development in relation to the surrounding sediment dynamics. For the first time, two small mounds have been cored through the mound base enabling a reconstruction of their development using a multidisciplinary approach based on CT-scanning, grain-size analysis and radioactive dating. The Darwin Mounds, located in the Rockall Trough, formed during the early Holocene (~10ka BP) through sediment baffling by *Lophelia pertusa*. The initiation of both mounds corresponded to increased current velocities resulting in coarser sediment deposition and a relatively high coral density. The mound growth was rapid between ~10-9.7ka BP with further vibrant growth periods around ~ 8.8, 6.5 and 3.4ka BP. The demise of the mounds ca. ~3ka BP was likely caused by an intensification in bottom current velocities causing a hostile environment for coral growth in the contourite setting. In a wider context, the development of the Darwin Mounds appears to have responded to the relative strength and position of the Subpolar Gyre, which affected food supply to the corals, sedimentation rates, current speeds and other water mass properties in the area.

POSTER 52

Leigh Marsh, University of Southampton

Disturbance in the deep: a model for ecological succession in the deep sea?

As humanity increasingly looks to the oceans as a solution to the shortfall of mineral resources on land, an incredible 1.2million km2 of the deep seafloor has been licensed for mineral prospecting. The lack of long-term temporal observations of the response of marine assemblages to natural disturbance events means that the fundamental ecological resilience and recovery rates of these organisms to anthropogenic impacts (such as mining activity) remains undetermined. Pyroclastic flows and landslides produced by volcanic activity on island arcs generate large quantities of ash, pumice, and volcanic rock that are delivered to the shallow and deep-sea environments. Pyroclastic flows provide a natural analogue to sediment re-suspension from deep-sea mining, while the emplacement of volcanic rock into the deep ocean represent a fresh substrate (akin to those exposed by the mining of cobalt-rich ferromanganese crusts) for investigating recolonisation and successional dynamics of deep-sea faunal assemblages. The spatial and temporal distribution of pyroclastic flows and historic submarine landslides around the volcanic island of Montserrat have been documented by repeated high-resolution bathymetric surveys, coring of the new deposits, and most recently, in-situ Remotely Operated Vehicle (ROV) investigations. Crucially, these studies provide age constraints on both the pyroclastic flows and the submarine landslide deposits. Coupling this knowledge with ROV imagery available from the dated volcanic events could provide an insight into rates of recovery of marine ecosystems as deep as 1,000 m following large-scale geological disturbances over longer time frames (decadal to millennial) than previously documented.

POSTER 54

Taylor Heyl, WHOI

Composition, Distribution and Abundance of Anthropogenic Marine Debris in Northwest Atlantic Submarine Canyons

Submarine canyons are important productive habitats in the deep-sea. Additionally, they serve as down-slope conduits for transporting sediment and organic material, thus enhancing local and regional species diversity, including species and ecosystems vulnerable to anthropogenic activities. In 2012 and 2013, we documented and characterized deep-sea coral and sponge ecosystems in virtually unexplored northeast and mid-Atlantic canyons using WHOI's TowCam, a towed imaging system, on the FSV Bigelow. Specifically, thirty-eight digital-image TowCam surveys were completed in 10 canyons. More than 91,000 images, documenting not only deep-sea coral and sponge ecosystems and habitat features, but also anthropogenic debris, were collected. Canyons surveyed include Toms Canyon complex, Ryan, Veatch, Gilbert, Powell, and Munson canyons. Each of these canyons hosted debris across depths of ~550 to 2100m. Debris consisted mostly of fishing equipment, including fishing lines, traps, and nets. Potentially land-based debris (e.g., plastic bags and magazines) was also present in all canyons surveyed. These substrates likely enhance colonization and often served as habitat for specific sessile and mobile species. Comparisons of debris accumulation in these canyons revealed depth-related differences that likely correspond to the offshore extent of fishing activities. Our results will be compared to density and abundances of debris in other deep-sea environments. The occurrence of anthropogenic debris on Northeast US canyon floors suggests transport ships and fishing-related activities, and perhaps, rapid transport of debris through near-shore zones and entrainment in bottom currents, contribute to the deposition of debris in these deep-sea environments.

POSTER 56

Sam Georgian, Temple University

Biogeographic variability in the physiological response of the cold-water coral Lophelia pertusa to ocean acidification

Understanding how biogeographically separated populations will respond to ocean acidification will increase our ability to predict the future of vital ecosystems. Cold-water corals are important drivers of biodiversity in ocean basins around the world and are considered one of the most vulnerable ecosystems to ocean acidification. We tested the short-term physiological response of the cold-water coral *Lophelia pertusa* to three pH treatments (pH=7.9, 7.75, and 7.6) for Gulf of Mexico (USA) and Tisler Reef (Norway) populations, and found that reductions in seawater pH elicited contrasting responses. Gulf of Mexico corals exhibited reductions in net calcification, respiration, and prey capture rates with decreasing pH. In contrast, Tisler Reef corals showed only slight reductions in net calcification rates under decreased pH conditions while significantly elevating respiration and capture rates. These differences are likely the result of environmental differences (eg. depth, pH, or food supply) between the two regions, invoking the potential for local adaptation or acclimatization to alter their response to global change. Together, these results provide insights into the resilience of L. pertusa to ocean acidification as well as the potential influence of regional differences on the viability of species in future oceans.

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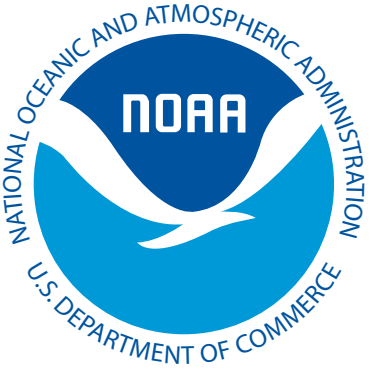

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THE FUTURE OF DEEP-SEA CORALS

The 6th International Symposium on Deep-Sea Corals brings together scientists, industry specialists, students and managers with recent, state-of-the-art knowledge on the distribution, linkages, ecosystem function and biodiversity of cold-water corals and their habitats. Our current knowledge and outlook of the driving factors and consequences of past and present biogeography and ecological constraints, climate change, natural and anthropogenic impacts, and the conservation and management of cold-water coral ecosystems will be discussed. The latest topical research on ocean acidification, biogeography, larval dispersal, genetic connectivity and evolution, autecology, reproduction, predictive habitat modeling, (paleo)productivity, new proxies in paleoceanography, conservation strategies, national and international management, and the design and development of marine protected areas are featured.

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