Continental Slope Coral Banks of the Southeastern United States: Exploring the distribution, ecology, and biology of deep coral habitats and associated fauna.

Steve W. Ross (Lead Principal Investigator)
UNC - Wilmington, Center for Marine Science
5600 Marvin Moss Ln
Wilmington, NC 28409

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EXECUTIVE SUMMARY

Most activities in this grant overlap and duplicate those in the other NOAA OE grants awarded to Dr. S.W. Ross and co-PIs. These grants have similar objectives and activities and are continuations of the same deep reef research and exploration. The nature of this deep sea work in difficult to sample habitats requires several cruises to complete most objectives; therefore, the products referenced in this report and the appendices resulted from several NOAA OE funded projects. Project objectives under this grant included: 1) Continue to define benthic fish and invertebrate community structures, 2) Classify reef and off-reef habitat zones and document faunal affinities, 3) Obtain proxy productivity records from black corals, 4) Collect *Lophelia*, other corals, and associated fauna for phylogenetic, phylogeographic, and community genetics, 5) Provide at sea education experience and real-time communication to the public, 6) Provide education/outreach products to a variety of audiences, 7) Provide at sea science research experience for an educator, 8) Develop an interactive webquest to complement cruise objectives, 9) Add to High Definition video and digital still images.

During the 2005 cruise, we continued whole water column sampling with multiple techniques to identify the full spectrum of fauna and associated hydrography in each study area. Bottom sampling was emphasized using the Johnson-Sea-Link (JSL) submersible. The submersible was used directly on and near reef habitats to conduct standardized video transects for quantifying biota and habitat and to collect samples. Although we prioritized bottom habitats and communities, we also gathered data on the surface communities (using neuston nets and night lighting), particularly those in *Sargassum*. All methods were standardized to allow statistical comparisons with previously collected data. Over 17 operational days, we conducted 19 submersible dives using the JSL at six different deep coral areas along the southeastern US (SEUS) slope. In addition, 61 non-submersible stations were completed during the cruise.

Some preliminary deep coral habitat results included: 1) The fish fauna is well developed but less species rich than the invertebrate fauna, 2) Several fish species thought to be rare seem to be coral associates, 3) Exploitable fishes use the habitat (wreckfish, rosefish, roughys, hagfish, alfonsino), 4) Fishes common on soft bottom near coral banks are typical of the regional slope community, 5) Deep coral reefs have similar habitat functions as shallow coral reefs (increased faunal diversity, concentrated foods, obligate fauna), 6) There is a primary reef fish fauna unique to deep coral habitat, 7) Mobile invertebrates may be less connected to the coral habitat than fishes, 8) Compared to our study area off Cape Hatteras in similar depths, the slope fauna around the coral banks was quite different probably due to both zoogeographic and habitat influences, 9) Black and bamboo corals analyzed so far are hundreds of years old and seem to be good sources for paleoclimate data.

Future work is needed to provide detailed (multibeam) maps of bottom topography, generate additional data from poorly sampled sites, discover new coral banks, complete genetics and aging/climate objectives, and increase the replication of bottom transects that are critical for determining faunal habitat affinity over the region. We need to expand our study area to better characterize SEUS deep coral banks.

PROJECT PURPOSE AND DESCRIPTION

Most activities in this grant overlap and expand upon those in the other NOAA OE grants awarded to Dr. S.W. Ross and co-PIs. These grants have similar objectives and activities and are basically continuations of the same deep reef research and exploration. The nature of this deep sea work in difficult to sample habitats requires several cruises in order to complete most objectives; therefore, the products referenced in this report and the appendices resulted from several NOAA OE funded projects.

Compared to the continental shelves and estuaries of the United States Atlantic and Gulf of Mexico, continental slope and shelf edge habitats are poorly studied. These deep areas are important frontiers, offering a transition from the continental shelf to the true deep sea. Between North Carolina and Florida there are several unique and productive deep water habitats that can only be adequately sampled with non-conventional methods because the bottom topography is extremely rugged and/or the habitats are overlain by extreme currents (i.e., Gulf Stream). These largely unstudied habitats, particularly deep-sea coral habitats, were targeted for exploration in this project.

Deep coral habitats are much more extensive and important than previously known. The high profile features that characterize deep coral banks concentrate exploitable resources and may enhance local productivity. These precious habitats, however, are severely threatened from activities such as fishing, energy exploration, and ocean acidification. The major structure building coral in the deep sea, *Lophelia pertusa*, is fragile and easily destroyed. Data are lacking on how *Lophelia* banks form even though hypotheses have been posed. Data are also equivocal concerning individual coral growth rates, and data on individual coral ages and coral mound ages are limited and/or questionable. The degree to which there is an obligate deep coral fauna is unclear. While the genetic structure of *Lophelia* in the northeastern Atlantic is being described, such studies are just beginning in the western Atlantic. For these reasons, locating, describing, and mapping deep corals and conducting basic biological studies in these habitats are priorities for our research.

Deep-sea coral (*Lophelia pertusa* mostly) habitats in depths of 350 to 800 m off the SEUS were explored between 16 Oct and 2 Nov 2005 (Fig. 1). During this project year, we built upon our previous work that has been supported by a variety of sources (NOAA-OE, USGS, MMS, NURC). Below we will encapsulate our major observations to date. We originally proposed several initiatives (multibeam mapping as a basic foundation, faunal surveys, aging, genetics) that formed an interconnected, multidisciplinary approach to advance our understanding of the deep coral habitats. Logistical factors beyond our control forced the multibeam bottom mapping to be abandoned. Our multi-objective approach is integrated into an overall exploration of deep coral habitat physical structure and ecology in the SEUS. Using standardized methods in multiple study areas, we continued to build a database to compare a variety of complex habitats across and within depth and geographic regions.

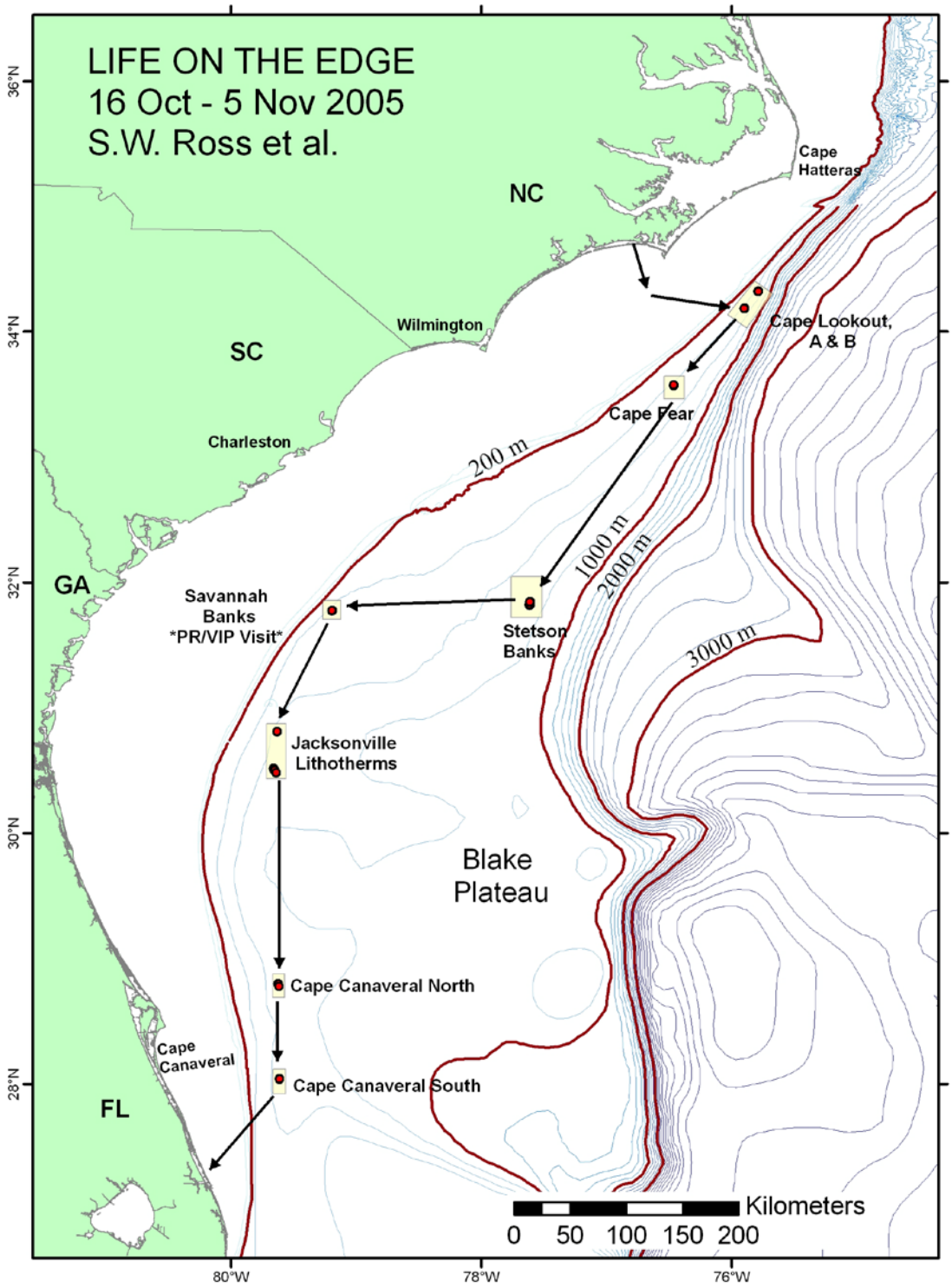

Figure 1. General cruise track for Ross et al. NOAA-OE cruise in 2005, starting in Morehead City, NC and ending at Ft. Pierce, FL. Boxes and red dots indicated areas of deep coral sampling. All areas were sampled except the Cape Canaveral sites. Note that the PR/VIP visit took place in Charleston, SC instead of at sea as suggested on the Figure.

Objectives

A primary long-range research goal of our team is to define fish and invertebrate community structure across depth gradients and across geographic regions of the southeastern US (SEUS). For this cruise we sampled from off northeastern FL to off central NC (Fig. 1). The goal of this cruise was to locate poorly explored deep coral habitats and define their faunal composition. A subsidiary goal was to document and quantify sessile invertebrate cover and non-living habitat parameters on deep reefs within and across reef types. A final goal was to simultaneously collect physical data about the benthic habitats and water column to construct hypotheses concerning the mechanisms underlying control and differentiation of community structure. These activities were integrated with a coordinated education/outreach program. Note that our original grant objectives (which were approved) included significant mapping objectives using multibeam systems. This had to be deleted since vessel availability changed.

Scientific Objectives

1) Continue to define benthic fish and invertebrate community structures,
2) Classify reef and off-reef habitat zones and document faunal affinities,
3) Obtain proxy productivity records from black corals,
4) Collect *Lophelia*, other corals, and associated fauna for phylogenetic, phylogeographic, and community genetics.

Education/Outreach Objectives

1) Provide at sea education experience and real-time communication to the public,
2) Provide education/outreach products to a variety of audiences,
3) Provide at sea science research experience for an educator,
4) Develop an interactive webquest to complement cruise objectives,
5) Add to High Definition video and digital still images.

APPROACH

We continued our strategy of whole water column sampling with multiple techniques to identify the full spectrum of fauna and associated hydrography in each study area. Bottom sampling was emphasized using mostly the JSL submersible supplemented by trawls. The submersible was used directly on and near reef habitats to conduct standardized video transects for quantifying biota and habitat and to collect samples. Standardized trawl methods were used to sample the habitats surrounding the reef areas. Although we prioritized bottom habitats and communities, we also gathered data on the surface communities (using neuston nets and night lighting), particularly those in *Sargassum*. We were unable to conduct midwater or benthic trawl sampling because the ship was not capable of it. All methods were standardized to allow statistical comparisons with previously collected data.

Over 17 operational days we conducted 19 submersible dives using the JSL submersible at six different deep coral bank areas from Cape Lookout to Jacksonville, FL (Table 1, Fig. 1). Total JSL bottom time was 39 hrs. These dives resulted in about 80 hrs of digital video tape (2 cameras operating per dive) of habitats and fauna, approximately 80 hrs of audio files (two recorders per dive), and numerous samples of invertebrates and fishes. At several locations and depths, benthic invertebrates and fishes were collected. *Lophelia pertusa* and other corals were also collected from all areas for genetics, aging and paleoclimate evaluation.

Most submersible dives followed similar survey techniques, emphasizing collecting and photographing specimens on or near the bottom and standardizing video transects. After the JSL left the support ship, it descended through the water column as quickly as possible and settled on the bottom. During descent, distributions/behaviors of fauna were noted. Specimen collecting (using submersible suction system, rotenone, trap deployment, grab) began soon after landing on the bottom, unless species abundance was low. After some collecting, the video camera was moved to pre-determined pan/tilt positions and the submersible ran video transects. Transects were abbreviated in favor of stationary filming in heavy current and coral/rock areas or if camera angles could not be maintained. We attempted to execute replicate transects in many reef habitat types (various reliefs and amounts of coral/rock, reef valleys, ledge edges) as well as transects over adjacent non-reef habitat. Visual observations were recorded to supplement the video data during transects. Additional specimen collecting occurred after these transects. Still photography and video photography were conducted throughout the dive (not just during transects). Scientists in the bow and stern compartments recorded observations via digital audio tape recorders and digital video cameras.

In addition, 61 non-submersible stations were sampled during the cruise (Table 1, Fig. 1), resulting in thousands of individual specimens. At one station we deployed the CTD (SBE25) Rosette, and at the other 60 stations we deployed surface gear (neuston nets and night lighting/dip nets). Since it was impossible to employ an otter or Tucker trawl from this vessel, we deployed a surface towed 3x2 m neuston net from the side of the ship for 15 min tows (Table 1). As time or circumstances allowed, we conducted night lighting (using dipnets, cast nets, etc.) operations from the sides of the ship during night watches.

Table 1. Deep coral related stations occupied by gear and area during the NOAA-OE southeastern US cruise, 16 Oct – 2 Nov 2005 (S.W. Ross et al.).

Gear Type	Bottom	Surface	Total
Ship deployed			
Neuston nets		42	42
Night lighting/dip nets		16	16
Miscellaneous		3	3
Submersible	19		19
Bottom time (hr)	39		39
TOTAL	19	61	80

From all stations we saved selected representative or unique specimens for on-board photography. Overall, several hundred photographs were taken of many different taxa. We also photographed and videotaped much of our ship board sampling activities.

All fish specimens (except most larvae) and many of the invertebrate specimens from all cruises have been identified. Taxonomic identification is a time consuming process because many species collected are from outside their reported ranges and taxonomic keys are not complete for deep-water fauna (especially invertebrates). Consultation with other experts on identifications is sometimes required. After identification, specimens are treated for long term storage, which

includes writing final labels for each jar. Several specimens will be (and are) permanently housed in major museum collections. Over the past several years, we have also spent considerable time maintaining, correcting, organizing, and updating our Access computer databases. All data are now current and correct in electronic format and are readily available for various analyses. This is an ongoing operation. Video tape analysis is a high priority, and we have made great progress on that part of the project. Dive tapes and audio logs have been reviewed multiple times to extract species count data, habitat data, and biological/ecological data. This process is complete for our fish analyses and these data have been added to the computer database. We have analyzed all tapes for *Eumunida picta* (galatheid crab) data, except the 2005 tapes, and that task is ongoing. In addition to *E. picta* data, we will extract coral distribution data from the videotapes recording during all (2001-2005) submersible cruises.

Project Management

The following personnel have current major roles (noted) in collecting and analyzing the data and managing aspects of this project:
Dr. S.W. Ross (UNCW, USGS): Lead PI and Chief Scientist, Overall project and grant management, fish identification, video analysis for fishes, report and publication writing.
Dr. M.S. Nizinski (NOAA, NMFS): Co-PI, invertebrate identification and management of invertebrate data, publication writing.
E. Baird (NCMNS): Co-PI, management of all education aspects of the project, produce education products, coordinate public relations and web activities.
Dr. K.J. Sulak (USGS): Co-PI, did not participate, no longer associated with project.
Dr. Cheryl Morrison (USGS): Co-PI, management of coral genetics data
A.M. Quattrini (UNCW): Research Assistant, Data management, GIS, fish identification, video analysis, publication writing.
T. Casazza (UNCW): Research Assistant, Sargassum and all surface collection data analysis, fish identification, collection gear management, publication writing.
M. Partyka (UNCW): Research Assistant, Assist data management, graphics, GIS, navigation.
J. McClain (UNCW): graduate student, Overall project assistance.
A. Howard (independent videographer): Collect High Definition surface and underwater video of all cruise activities and interviews with personnel. Produce films for public release about our projects.
Dr. J. Murray Roberts (Scottish Assoc. for Marine Science): invited scientist

FINDINGS

All fish specimens collected during this 2005 cruise were identified, counted, measured and archived. Overall 14 fish species were collected via JSL from coral bank area bottom samples (Table 2) and 58 resulted from all surface collections (Table 2). Great progress was made in the time consuming video data analyses. Analyses were completed for the benthic fish deep coral data and using the data from all years a manuscript was completed and published (Ross and Quattrini 2007, see appendix). A second benthic fish paper is near completion.

The invertebrate collections that were transferred to the Smithsonian (location of one of the co-PIs) are being sorted and analyzed. Videotapes are being analyzed for invertebrate data, particularly galatheid crabs. Subsamples of collections were sent to an expert (Dr. Lea-Anne Henry) to be analyzed for hydroids. This was completed and a manuscript submitted for publication.

Table 2. Fish species collected and identified from all areas during the 2005 NOAA-OE cruise off the southeastern US. Fishes were collected on the bottom with the JSL submersible. All other fishes were collected at the surface with night lighting/dip nets (NL) or a Neuston Net (NN). OD represents flyingfishes found on the deck of the ship. n=Total number of stations.

Family	Species	NL (n=16)	NN (n=42)	OD (n=2)	JSL (n=19)	Total # (n=60)
Myxinidae	*Eptatretus minor*				1	1
Scyliorhinidae	*Scyliorhinus retifer*				1	1
Narcinidae	*Benthobatis marcida*				1	1
Rajidae	*Fenestraja plutonia*				1	1
Moringuidae	*Neoconger mucronatus*		1			1
Synaphobranchidae	*Dysommina rugosa*				2	2
Ophichthidae	*Myrophis platyrhynchus*		2			2
	Ophichthus gomesii		1			1
Congridae	*Ariosoma balearicum*		48			48
	Paraconger caudilimbatus		2			2
Synodontidae	*Synodus foetens*		1			1
Myctophidae	*Centrobranchus nigroocellatus*		1			1
	Diaphus dumerilii				1	1
	Gonichthys cocco		1			1
	Hygophum sp.		1			1
	Myctophum asperum		4			4
	Myctophum nitidulum		4			4
	Myctophum spp.		3			3
	Undetermined		2			2
Macrouridae	*Nezumia sclerorhynchus*				3	3
Lophiidae	*Lophius gastrophysus*				1	1
Antennariidae	*Histrio histrio*		2			2
Chaunacidae	*Chaunax stigmaeus*				2	2
Mugilidae	*Mugil curema*		10			10
Belonidae	*Platybelone argalus*	2	3			5
	Tylosurus acus	1	1			2
Exocoetidae	*Cheilopogon cyanopterus*			1		1
	Cheilopogon exsiliens	1				1
	Cheilopogon furcatus	2		1		3
	Exocoetus obtusirostris	2				2
	Hirundichthys affinis		1			1
	Parexocoetus brachypterus	12	3			15
	Prognichthys occidentalis	1	3			4
	Cheilopogon melanurus	1				1

	Undetermined		2		2
Hemiramphidae	*Euleptorhamphus velox*	4			4
	Hemiramphus balao	3			3
	Hemiramphus brasiliensis	3	4		7
	Hemiramphus spp.		2		2
Holocentridae	Undetermined		6		6
Syngnathidae	*Cosmocampus albirostris*		1		1
Scorpaenidae	*Helicolenus dactylopterus*			2	2
	Idiastion kyphos			2	2
	Phenacoscorpius nebris			1	1
	Setarches guentheri			2	2
	Trachyscorpia cristulata			1	1
Triglidae	*Prionotus* sp.		1		1
Coryphaenidae	*Coryphaena equiselis*	1	7		8
	Coryphaena hippurus	3	38		41
	Coryphaena sp.		1		1
Carangidae	*Alectis ciliaris*		3		3
	Caranx crysos		23		23
	Caranx spp.		27		27
	Decapterus punctatus		1		1
	Decapterus spp.		13		13
	Elagatis bipinnulata		7		7
	Selar crumenophthalmus		1		1
	Selene sp.		10		10
	Seriola dumerilii		6		6
	Seriola spp.		13		13
	Trachinotus carolinus		6		6
	Trachinotus falcatus		1		1
	Trachinotus goodei		3		3
	Trachinotus spp.		1		1
Lobotidae	*Lobotes surinamensis*		4		4
Gerreidae	*Eucinostomus lefroyi*		2		2
Sciaenidae	*Menticirrhus americanus*		1		1
Mullidae	*Upeneus parvus*		773		773
	Undetermined		2		2
Kyphosidae	*Kyphosus incisor*		1		1
	Kyphosus sectatrix		5		5
	Kyphosus spp.		2		2
Pomacentridae	*Abudefduf saxatilis*		16		16
Scombridae	*Auxis thazard*		1		1

	Euthynnus alletteratus		18			18
Xiphiidae	*Xiphias gladius*		1			1
Istiophoridae	*Istiophorus platypterus*	1	5			6
	Makaira nigricans	1				1
Balistidae	*Balistes capriscus*		4			4
	Canthidermis maculata		12			12
Monacanthidae	*Stephanolepis hispidus*		30			30
Tetraodontidae	*Sphoeroides* spp.		2			2
Diodontidae	*Diodon holocanthus*	1	1			2
Total # Individuals		39	1151	2	21	1213

Some Preliminary Deep Coral Habitat Results

See various manuscripts in the Appendix.

$ Deep coral banks are more common on the Blake Plateau and more diverse than previously indicated. It is increasingly clear that there is still much coral habitat to be documented. A new area investigated (North Stetson) exhibited substantial coral development.

$ The Savannah Banks seem to be inundated by sediments, and may be in the process of being covered.

$ Currents around the coral banks can be complex and quite strong. We encountered strong currents on many dives.

$ There are few obvious impacts to habitat and fish populations on the deep coral areas.

$ Different fish communities populate different banks along the SEUS continental slope. The highest species richness is found off North Carolina.

$ Some fishes never occur on off reef, soft substrate habitats that surround the coral banks, and other fishes never occur on the reef proper.

$ Invertebrates, especially decapod crustaceans and echinoderms, seem to dominate the overall fauna of the deep coral banks.

$ The video data documenting habitat usage and behaviors of both invertebrates and fishes were some of the first collected for many species.

$ We collected several fish and invertebrate species (awaiting identification) that may be either new species (invertebrates) or range extensions. Particularly for invertebrates, we collected several animals that were problematic to identify and may be undescribed.

$ Two new fish species (an eel and a hagfish) were collected around coral banks off North Carolina. This further indicates the previous lack of sampling on these unique habitats.

$ Reproductive data were added on a deepwater skate species, *F. plutonia*. Previously, no information existed on this species. Our literature review on this species also supports lack of data on several species of deepwater skates.

$ We observed and collected at least five different species of galatheid crabs.

$ *Eumunida picta* is a dominant invertebrate on deep coral banks.

$ Midwater fishes also use the habitat, potentially transferring energy through a large part of the water column. Benthic invertebrates (i.e., galatheids) were observed capturing midwater fauna.

$ Commercially important species use these coral banks (e.g., wreckfish, rosefish), and some species of fishes and invertebrates seem depend on this habitat.

$ We greatly increased our knowledge about coral species diversity in general in this region. There appeared to be more species of corals to the south, albeit the banks were less well

developed, compared to those off NC.

- $ Corals may live at least 200 to 500 years in this area and several species may provide a valuable historical record of productivity.
- $ A suite of highly variable microsatellite DNA markers for northeastern Atlantic and Gulf of Mexico *Lophelia* have been developed.
- $ Five SEUS *Lophelia* populations that were surveyed harbored substantial genetic diversity and low clonality.
- $ Weak but significant genetic structuring was detected among the five SEUS *Lophelia* populations indicating the majority of recruitment occurs locally.
- $ Comparisons of SEUS with Gulf of Mexico *Lophelia* populations indicated strong genetic structuring, likely the result of highly restricted gene flow between these regions.

Problem Areas

We had fewer problems with the HBOI operation this year compared to previous cruises. Both the ship and submersible crews worked hard (before and during the cruise) to fill our sampling needs. However, there are still some limitations with HBOI operations and this ship in particular. The ship's crew is not well trained in the use of some sampling gear (benthic trawls, dredges, etc.) and this prevented a lot of potential sampling from occurring. We could only deploy one piece of gear at a time, a limitation we have not had on other ships. See previous progress reports for details on ship and submersible operations.

The biggest problem with this cruise was inclement weather. Staging a submersible cruise in this region in October is not advisable. We had to come into port for two days to avoid a hurricane and high winds, which also prevented many JSL dives. Overall, poor weather cost us 17 submersible dives.

Additional Work

Our goals of locating deep coral banks, characterizing their macrofauna, and building a data base to document trophodynamics and basic biology/ecology on the SEUS slope requires multiple cruises, spanning several years. This project builds and improves on our past data, providing a strong foundation for additional studies. Each past cruise has yielded new discoveries, not just more replications, which is a strong argument to continue this research. We emphasize that sampling replication in time and space is a significant attribute of our projects, strengthening our ultimate conclusions. Our cruises have yielded many new faunal records (Quattrini et al. 2004; Meister et al. 2005; Quattrini and Ross 2006; Ross and Quattrini 2007), new species (McCosker and Ross in press; Fernholm and Quattrini in press), new ecological data on species assumed to be rare, and new data on habitat distributions/structures, new data on population structures.

Future work is needed to provide detailed (multibeam) maps of bottom topography, generate additional data from poorly sampled sites, discover new coral banks, complete genetics and aging/climate objectives, and increase the replication of bottom transects that are critical for determining faunal habitat affinity over the region. We need to expand our study area to better characterize SEUS deep coral banks. In addition to continuing to address our original objectives, the following questions are also components of our work: How extensive is the habitat and what is its distribution? What biological resources are unique to or dependant on deep coral bank habitat? What is the status of this habitat and its community (declining?, stable?, growing?) and how resilient is the habitat? Can deep coral banks support exploitable resources or should they be protected from anthropogenic disturbance?

EVALUATION

Overall, this was a very successful cruise. Summarizing the cruise track during the 18 days, we covered over 1,500 nautical miles; however, this does not account for the large amount of survey transects completed in each study area. Even so, covering this much territory and sampling on schedule (weather permitting) in each target area was considered a great accomplishment. No objective was completely missed, even though some were addressed better than others. Every study area (except those around Cape Canaveral) was sampled. Weather presented significant problems during the last half of the cruise. See previous progress reports for details on ship and submersible operations.

Dissemination of Results

A number of peer reviewed publications have been completed and are planned for these data in conjunction with data from the other cruises. Published papers and some reports are included in the Appendix. Although some papers await more complete data analysis, we are currently producing manuscripts and presentations. We will be presenting several talks from our data at the Fourth International Deep-Sea Corals Workshop in late 2008. Some manuscripts have been completed (see also previous grant reports) and are in various stages of publication as follows:

Ross, S.W., T.L. Casazza, A.M. Quattrini and K.J. Sulak. 2007. Anguilliform larvae collected off North Carolina. Mar. Biol. 150(4): 681-695.

Caruso, J.H., S.W. Ross, K.J. Sulak and G.R. Sedberry. 2007. Deep-water chaunacid and lophiid anglerfishes (Pisces: Lophiiformes) off the Southeastern United States. J. Fish Biol. 70(4): 1015-1026.

Ross, S.W. and A.M. Quattrini. 2007. The Fish Fauna Associated with Deep Coral Banks off the Southeastern United States. Deep-Sea Research Part I 54(6): 975-1007.

Ross, S.W. and M.S. Nizinski. in press. State of the U.S. Deep Coral Ecosystems in the Southeastern United States Region: Cape Hatteras to the Florida Straits. NOAA Tech. Memo. NMFS-OPR-29. Silver Spring, MD.

Brooks, R.A., M.S. Nizinski, S.W. Ross and K.J. Sulak. in press. Sublethal Injury Rate in a Deepwater Ophiuroid, *Ophiacantha bidentata*, an Important Component of Western Atlantic *Lophelia* Reef Communities. Mar. Biol.

McCosker, J.E. and S.W. Ross. in press. A new deepwater species of the snake eel genus *Ophichthus* (Anguilliformes: Ophicthidae), from North Carolina. Copeia.

Williams, B., M. Risk, S.W. Ross and K.J. Sulak. in press. Stable isotope records from deep-water Antipatharians: 400-year records from the south-eastern coast of the United States of America. Bull. Mar. Sci.

Fernholm, B. and A.M. Quattrini. in press. A new species of Hagfish (Myxinidae: *Eptatretus*) associated with deep-sea coral habitat in the Western North Atlantic. *Copeia*.

Partyka, M.L., S.W. Ross, A.M. Quattrini, G.R. Sedberry, T.W. Birdsong, J. Potter. in press. Southeastern United States Deep Sea Corals (SEADESC) Initiative: A Collaborative Effort to Characterize Areas of Habitat-Forming Deep-Sea Corals. NOAA Tech. Memo. Silver Spring, MD.

Gartner, J.V., Jr., K.J. Sulak, S.W. Ross and A.M. Necaise. In review. Persistent near-bottom aggregations of mesopelagic animals along the North Carolina and Virginia continental slope. Mar. Biol.

Partyka, M.L., A.M. Quattrini and S.W. Ross. In review. Notes on the reproductive biology of *Fenestraja plutonia* (Garman, 1881) off North Carolina, USA. J. Fish. Biol.

Henry, L-A., M.S. Nizinski and S.W. Ross. In review. Diversity, distribution, and biogeography of hydroid assemblages collected from deep-water coral habitats off the southeastern United States. Deep-Sea Res. Part I.

Non-peer reviewed documents produced in relation to these projects included:

Ross, S.W. 2006. Review of distribution, habitats, and associated fauna of deepwater coral reefs on the southeastern United States continental slope (North Carolina to Cape Canaveral, FL). 2nd Ed. Rept. to South Atlantic Fishery Management Council, Charleston, SC. 37 p.

Ross, S.W., A.M. Quattrini and M. Partyka. 2006. Integrating deep coral studies in the Gulf of Mexico and Western Atlantic Ocean. Final Rept. to Minerals Management Service.

Holmes, C.W., S.W. Ross and N.A. Buster. 2007. Archives in the deep: a 2000 year history of oceanography and climate change recorded in Western North Atlantic deep-sea corals. USGS Fact Sheet 2007-3012.

Morrison, C.L., R.L. Johnson, T.L. King, S.W. Ross, M.S. Nizinski. 2007. Molecular Assessment of Deep-sea Scleractinian Coral Biodiversity and Population Structure of *Lophelia pertusa* in the Gulf of Mexico. Completion report for USGS OCS Ecosystem Program Task entitled, "Deepwater Program*:* Ecological Processes and Geographic Affinities in Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on *Lophelia* Coral.

The following manuscripts have most of the data analyzed and are being written with expected submissions by end of 2007:

Ross, S.W. and A.M. Quattrini. In prep. Geographic patterns of deep-sea reef fishes on the Blake Plateau.

Nizinski, M.S. and S.W. Ross. Predatory activities of the deep-water squat lobster, *Eumunida picta* (Decapoda: Chirostylidae), inhabiting *Lophelia* banks on the continental slope off North Carolina.

Nizinski, M.S., J. McClain, and S.W. Ross. Distribution, abundance, habitat utilization and behavioral observations of the deep-water squat lobster, *Eumunida picta* (Decapoda: Chirostylidae), inhabiting *Lophelia* banks on the continental slope off the SEUS.

Nizinski, M.S. New species of *Munidopsis* associated with deep water *Lophelia* reefs off the SEUS.

Nizinski, M.S. and S.W. Ross. Habitat utilization and species-specific associations between galatheoids and deepwater corals off the southeastern United States.

Many talks and posters were presented by our group during this period:

2007. Ross, S.W., A.M. Quattrini, and M.N. Nizinski. Megafaunal communities of deep-sea coral habitats of the southeastern United States. American Fisheries Society, San Francisco, CA.

2006. Nizinski, MS. Deep coral habitats of the southeastern United States continental slope. University of Rhode Island, Graduate School of Oceanography, Advancing Oceanography series. Invited seminar.

2006. Casazza, T.L. and S.W. Ross. Comparisons of open ocean surface fish communities off North Carolina in two habitats. American Society of Ichthyologists and Herpetologists, New Orleans, LA.

2006. Ross, S.W., A.M. Quattrini, K.J. Sulak. Deep coral banks fish communities along the southeastern US slope. American Society of Ichthyologists and Herpetologists, New Orleans, LA.

2006. Necaise, A.M., S.W. Ross, A.M. Quattrini, and K.J. Sulak. The fish community of a canyon ecosystem on the middle continental slope off Cape Hatteras, NC: Comparisons North and South.

2006. Gartner, J.V., Jr., S.W. Ross, A.M. Necaise, and K.J. Sulak. Persistent near-bottom aggregations of mesopelagic animals along the North Carolina and Virginia continental slopes. American Geophysical Union.

2006. Ross, S.W., A.M. Quattrini, A.M. Necaise, and K.J. Sulak. Benthic fishes of deep coral habitats along the southeastern US slope. American Geophysical Union, Hawaii.

2005. Nizinski, M.S., S.W. Ross, and K.J. Sulak. Habitat utilization and species-specific associations between galatheids and deepwater corals off the southeastern United States. Third International Symposium on Deep-Sea Corals, Miami, FL.

2005. Birdsong, T., J. McDonough, M.S. Nizinski, J. Potter, S.W. Ross, G. Sedberry, A. Shepard. Southeastern U.S. deep sea corals initiative (SEADESC): Characterizing known locations of habitat-forming deep sea corals in the South Atlantic Bight. Third International Symposium on Deep-Sea Corals, Miami, FL.

2005. Ross, S.W., A.M. Quattrini, A.M. Necaise, and K.J. Sulak. Benthic fishes of deep coral habitats along the southeastern US continental slope. Third International Symposium on Deep-Sea Corals, Miami, FL.

2005. Brooks, R.A., M.S. Nizinski, S.W. Ross, and K.J. Sulak. Sublethal injury rate in a deepwater ophiuroid, *Ophiacantha bidentata*, an important component of western Atlantic *Lophelia* reef communities. Third International Symposium on Deep-Sea Corals, Miami, FL. Poster.

2005. Nizinski, M.S., S.W. Ross, and K.J. Sulak. Habitat utilization and species-specific associations between galatheids and deepwater corals off the southeastern United States. Sixth International Crustacean Congress, Glasgow, Scotland.

2005. Quattrini, A.M., S.W. Ross, and K.J. Sulak. An initial assessment of the fish community and habitats within a proposed outer continental shelf MPA off North Carolina. American Society of Ichthyologists and Herpetologists, Tampa, FL.

2005. Casazza, T.L., S.W. Ross, A.M. Quattrini, and K.J. Sulak. Anguiliiform larvae collected off North Carolina. American Society of Ichthyologists and Herpetologists, Tampa, FL.

Education and Outreach summary

There have been regular education and outreach activities using our data since the beginning of these cruises. The IIS website created for the NC Museum internet site is being maintained on the museum server, and revisions to the Museum website are ongoing, including additions of photos and videos. Numerous requests for curriculum materials have come in to the Museum during the last four years. These have come not only from across NC, but from many states (e.g., CA, VA, MD, IL) and many foreign countries, including Germany, Saudi Arabia, and France. Requests for cruise materials have come not only from grade schools, but from community colleges, marine life centers, and informal science centers. Art Howard continued work on the High Definition video shot during this cruise. We have located some funding to help produce the HD films and a film is planned for release in July 2007.

The Life on the Edge 2005 mission provided two classroom educators and one informal educator with first hand experience in science research at sea. Doni Angell, a middle school teacher from the North Carolina mountains, Renee Green, a third grade teacher from the piedmont, and M.T. Palmer Coordinator of Distance Learning and Outreach at the NC Museum of Natural Sciences (NCMNS), all spent ten days on board assisting the researchers, writing daily logs, answering questions from the web, and learning about how science research takes place on board a ship. More than 200 questions were received on the North Carolina Museum of Natural Sciences website during the cruise, coming from 7 counties in North Carolina, 7 different states, and 3 countries including Canada, Russia and South Africa.

Photographer Art Howard participated in the first ten days of the 2005 mission, collecting hundreds of hours of High Definition footage of both on deck and below surface work. That footage, along with previously collected material, is being used to create a high definition move for the NC Museum of Natural Sciences. This production should premiere in the fall of 2007. An unexpected result of the participation of Art Howard has been the inclusion of portions of this footage in several other outreach opportunities, including the National Park Service production of "Ribbon of Sand" about the NPS Cape Lookout area and in the Smithsonian Institutions new Oceans Hall. Lead P.I. Steve Ross has also secured funding through the South Atlantic Marine Fisheries Council to use the footage to produce a DVD to highlight deep water coral research and conservation issues which should be completed by August 2007.

The Life on the Edge research has also become a primary focus topic for the new wing (the Nature Research Center) at NC Museum. Dr. Steve Ross was a featured presenter at the preliminary exhibit planning meeting and the footage collected by Art Howard has been used to model the new "Daily Planet" theater in the wing. This research has also been presented to several classes of students from NC State University.

APPENDIX

Manuscripts published, in press or accepted by agencies related to the projects funded by NOAA-OE to S.W. Ross (lead PI)