GENERAL DESCRIPTION OF DISTRIBUTION, HABITAT, AND ASSOCIATED FAUNA OF DEEP WATER CORAL REEFS ON THE NORTH CAROLINA CONTINENTAL SLOPE

Steve W. Ross*

UNC-Wilmington, Center for Marine Science
5600 Marvin Moss Ln.
Wilmington, NC 28409

*Currently assigned (through Intergovernmental Personnel Act) to: US Geological Survey, Coastal Ecology and Conservation Research Group, Center for Aquatic Resource Studies

Report Prepared for the South Atlantic Fishery Management Council
One Southpark Circle, Suite 306
Charleston, SC 29407

6 October 2004

GENERAL REVIEW

Most habitats of the continental slope, and even the shelf edge, are poorly studied and in many cases completely unknown. Large scale geological surveys of portions of the deeper EEZ (e.g., EEZ-SCAN 87 Scientific Staff 1991; Popenoe and Manheim 2001), have limited biological relevance and little habitat verification. These deeper areas, between 100 to 1000 m, are important frontiers, offering a transition from the continental shelf to the deep sea. Fisheries are expanding rapidly into these deep regions (Roberts 2002), and hydrocarbon exploration and development are now also exploiting these depths. Off the southeastern US (SEUS) coast (including the Gulf of Mexico) there are several unique and productive deep water habitats that can only be adequately sampled with non-conventional methods (e.g., manned submersibles) because the bottom topography is very rugged and/or the habitats are overlain by extreme currents (i.e., Gulf Stream). This report briefly summarizes data relevant to selected such unstudied and vulnerable habitats (i.e., deep coral mounds) on the North Carolina continental slope.

Deep coral reef systems are receiving increasing attention worldwide. These habitats appear to be much more extensive and important than previously known (e.g., SGCOR 2004; unpubl. data), while at the same time being severely threatened by a variety of activities (e.g., fishing, energy exploration) (Rogers 1999; Koslow et al. 2000). These high profile features may concentrate exploitable resources and enhance local productivity in ways similar to seamounts (Rogers 1994; Koslow 1997), but this has not yet been explored. *Lophelia*, the major structure building coral in the deep sea, is fragile, slow-growing (perhaps debatable), and very susceptible to physical destruction (Fossa et al. 2002). Data are lacking on how *Lophelia* coral banks form even though several hypotheses have been posed (Hovland et al. 1998; Hovland and Risk 2003). Data are also equivocal concerning individual coral and coral mound ages (M. Risk, pers. comm.) and the degree to which there is an obligate deep coral fauna. While the genetic structure (population relationships, gene flow, taxonomic relationships) of *Lophelia* in the Northeastern Atlantic is being described (Le Goff-Vitry et al. 2004), 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 considered global priorities (McDonough and Puglise 2003; Roberts and Hirshfield 2003).

Lophelia reefs are widespread, occurring not only on the Blake Plateau and in the Straits of Florida, but also in the Gulf of Mexico, off Nova Scotia, in the northeastern Atlantic, the South Atlantic, the Mediterranean, Indian Ocean and in parts of the Pacific Ocean (Rogers 1999). Small colonies of these corals may be attached to various hard substrates in the appropriate depths throughout the SEUS slope. However, along the 360-500 m depth band of the Blake Plateau , starting off central North Carolina (Fig. 1), scattered (but massive) mounds or ridges (banks) rise from the plateau, and their tops and sides are covered by dense thickets of living (white) deep-sea corals, mostly *Lophelia pertusa* (but also including other genera like *Madrepora*). Along the sides and around the bases of these banks are rubble zones of dead, gray coral branches which may extend tens to hundreds of meters away from the mounds. These ahermatypic, slow-growing stony corals, lacking light-dependent symbiotic algae, are adapted to life in dark, cold waters. Radiocarbon and other dating methods indicated that such deep reefs may be hundreds to thousands of years old (Neumann et al. 1977; Wilson 1979; Mikkelsen et al. 1982; Mortensen and Rapp 1998); however, aging data are so limited (especially along the western Atlantic) that the true distribution of coral ages in the western Atlantic is unclear. The ridges and reef mounds, rising as much as 100 m from the open substrate, accelerate bottom currents which are favorable to attached filter-feeding invertebrates and other biota. Thus, the growing reef alters the physics of the water column, enhancing the environment for continued coral growth and faunal recruitment (Genin et al. 1986).

Deep water coral habitat may be more important to western Atlantic slope species than previously known. *Lophelia*'s first discovery on the Blake Plateau was during the late 1950s (Stetson et al. 1962), and later many deep reef locations were suggested by the U.S. Geological Survey sidescan sonar mapping of the continental slope (EEZ-SCAN 87 Scientific Staff 1991). Although extensive published data are lacking, *Lophelia* reefs may populate the Blake Plateau in great abundance (Stetson et al. 1962; Paull et al. 2000; Reed 2002; Popenoe and Manheim 2001; P. Popenoe, pers. comm.). Commercially-exploited deep-water species congregate around *Lophelia* habitat, and evidence of fishing activities (trash, lost gear) was observed on some deep coral banks. Various crabs, especially galatheids, are abundant on these deep reefs, playing a role of both predator on and food for the fishes. Other invertebrates, particularly echinoderms, also populate the coral matrix in high numbers. On the relatively barren and featureless plain of the Blake Plateau, *Lophelia* reefs appear to be oases offering both shelter and food. Additionally, the coral thickets are surrounded by extensive coral rubble habitat which preliminary data indicate also support a diverse fauna.

Deep coral reefs of all types have been very poorly studied, particularly so in the western Atlantic. References on *Lophelia* banks within the US EEZ are largely geological with a few biotic observations, mostly on invertebrates (see review in Reed 2002; references in Sedberry 2001). Studies elsewhere revealed that these deep reefs harbor extensive invertebrate populations composed of hundreds of species (Jensen and Frederiksen 1992; Rogers 1999; Reed 2002). Fish studies related to the deep coral banks are almost non existent (no detailed faunal surveys are published for the western Atlantic), even in the northeastern Atlantic where these corals are better known (Husebo et al. 2002). Although our investigations so far have revealed that many species of fishes and crabs are closely associated with this unique deep-reef habitat, it is unclear whether the deep coral habitat is essential to selected fishes or invertebrates or whether they occupy it opportunistically (Rogers 1999). Assessing its significance as fish and invertebrate habitat and addressing the extent to which the deep reef fauna is unique is an important research topic that is being investigated (S.W. Ross et al., ongoing studies).

No *Lophelia* reefs lie within established or proposed Marine Protected Areas (MPAs) in the US EEZ, but if such reefs prove to be important habitat with a unique fauna (as they seem to be), they should be candidates for protection as are *Oculina* coral reefs off east-central Florida. There are a variety of potential threats to the deep coral bottoms: mining, precious coral harvest, disposal activities, petroleum exploration and development, fiber optic and other cable laying, anchoring/gear damage, and fishing activities. MPAs or Habitat Areas of Particular Concern (HAPC) may be viable options for protecting these systems, but considerable data, especially detailed maps, are critical for evaluating how and whether to protect deep coral habitat (Miller 2001).

As stated above, publications concerning deep coral banks in the SEUS are limited, and this is particularly true of the reefs off of North Carolina. The non-geological data available for

North Carolina deep corals and some areas of the SEUS are from ongoing studies of a multi-agency research team as follows: Steve W. Ross, lead Principal Investigator (Univ. North Carolina-Wilmington), K.J. Sulak (US Geological Survey), M.S. Nizinski (National Marine Fisheries Service Systematics Lab), and E.D. Baird (NC Museum of Natural Sciences). Although this research team has collected considerable data on NC deep coral mounds and has given numerous verbal presentations, publications are still forthcoming. Considering the needs of the South Atlantic Fishery Management Council to evaluate deep water habitats in a timely manner, the brief descriptions of North Carolina deep coral banks (see Fig. 1) provided below will serve as an interim tool facilitating potential management options for fragile, productive deep water habitats. This synthesis is preliminary, pending final data analyses, and should be used cautiously with prior consent of the author. Additional information should be obtained from S.W. Ross.

NORTH CAROLINA DEEP CORAL BANKS

Although coral areas were discovered on the Blake Plateau in the late 1950's, there is no indication that such corals were known off of North Carolina until the late 1960's (Squires 1959; Stetson et al. 1962). Rowe and Menzies (1968) first indicated that *Lophelia* occurred off Cape Lookout, NC, but this was only noted in a figure caption without further comment. Rowe and Menzies (1969) later suggested that *Lophelia* sp. occurred off the Carolinas in "discontinuous banks" along the 450 m contour, but gave no specific locations or other data.
Likewise, Menzies et al. (1973) gave similar vague reference to a "Lophohelia" (sic) bank off of Cape Lookout, repeating one of the figures in Rowe and Menzies (1969) and presenting a bottom photograph of a reef in 458 m. Cairns (1979) indicated a locality dot off Cape Lookout in his distribution map for *Lophelia* but did not comment further. These records appear to have originated from a short training cruise of the R/V Eastward (E-25-66, I.E. Gray chief scientist) during which a coral bank was photographed by a deep sea drop camera on 30 June 1966 (station E-4937, 475 m). Whether this station was found by chance or was targeted on purpose is unclear. Yet, the photograph in Menzies et al. (1973, Fig. 4-4 B) appears to be from that cruise. Photographs from that station off of Cape Lookout (Fig. 2), are discussed in more detail below.

The USGS survey of the US EEZ mapped, using side scan sonar, a number of features termed coral mounds, including some off of NC (EEZ-SCAN 87 Scientific Staff 1991). George (2002) also discussed a coral bank southeast of Cape Fear, NC ("Agassiz Coral Hills") in 650-750 m dominated by *Bathypsammia tintinnabulum*. Additional data to be scanned for evidence of deep corals in this area were summarized by Arendt et al. (2003). To date three major coral mounds have been located and studied off of North Carolina (Ross et al. unpubl. data), and several other possible mounds may exist. Data are still being analyzed related to these ongoing studies; however, a general description of the coral mounds and associated fauna follows. While some structural and faunal differences have been observed among these mounds, data are not yet extensive enough to determine if such differences are significant or persistent. More detailed results will be presented in several peer reviewed publications now being prepared by Ross et al.

Cape Lookout *Lophelia* Bank A

Aside from a few maps (see above) there are no published data from this coral mound. This area was apparently first occupied by the R/V Eastward (see above) which gave a location of 34° 18' N, 75° 48' W. Two trawl stations and a sonar survey of the Eastward station area in May 1983 using the R/V Delaware II (S.W. Ross, chief scientist), revealed no indication of hard bottom or coral. The Eastward navigated with LORAN A, and since their station was about 1-1.5 nmi (2-2.7 km) from the large coral bank area later sampled with Johnson-Sea-Link (JSL) submersible (Fig. 3), it is likely that the less accurate LORAN may have put the Eastward station off of the actual reef. However, the possibility that a reef does exist on or near the E-4937 station cannot be discounted without a more detailed survey of that location. The USGS side scan survey (EEZ-SCAN 87 Scientific Staff 1991) illustrated reefs in this area, and coordinates from that survey were used to guide an undersea survey using the Navy's NR-1 nuclear research submersible (Sulak and Ross, unpubl. data) during 15-18 Nov 1993. However, there also seems to be a navigation issue with this cruise in that locations plotted from the NR-1 track are offset about 0.5 nmi (1 km) from the large mounds later located by Ross et al. (Fig. 3, unpubl. data). The later ship sonar survey of the NR-1 locations did not yield any obvious reef areas. Between summer 2000 and summer 2004 Ross et al. (unpubl. data) sampled this area extensively using a variety of methods throughout the water column. Their major method for collecting bottom data on the reef proper was the JSL research submersible. Fifteen dives were made on coral mounds in this area (Fig. 3, Table 1), and observations from these totaling nearly 33 hours (bottom time) are the basis of the descriptions of habitat and fauna below.

Preliminary observations suggest that this area contains the most extensive coral mounds off North Carolina; however, it must be emphasized that data are lacking to adequately judge overall sizes and areal coverage. Ross et al. JSL dives in this area ranged from 370-447 m (Table 1). Mean bottom temperatures ranged from 6.3 to 10.9° C, while mean bottom salinities were always around 35 ‰ (Table 2). There appear to be several prominences capping a ridge system, thus, presenting a very rugged and diverse bathymetry (Fig. 4), but there are also other mounds away from the main ridge sampled (Fig. 3). The main mound system rises vertically nearly 80 m over a distance of about 1 km, and in places exhibits slopes in excess of 50-60 degrees. Sides and tops of these mounds are covered with extensive colonies of living *Lophelia pertusa* (Fig. 4), with few other corals being observed. Dead colonies and coral rubble interspersed with sandy channels are also abundant (Fig. 4). Extensive coral rubble zones surround the mounds for a large, but unknown, distance (exact area not yet surveyed), especially at the bases of the mounds/ridges, and in places seem to be quite thick. These mounds appear to be formed by successive coral growth, collapse, and sediment entrapment (Wilson 1979; Popenoe and Manheim 2001). These topographic highs accelerate bottom currents which favor attached filter-feeders.

Because fishes are somewhat disturbed by submersibles, data on the fish community has accumulated slowly; however, this group is quite diverse on the coral habitat. Although Ross et al. have so far identified over 43 benthic or benthopelagic fish species on and around these coral banks, only data from the primary coral areas are presented here. Of the twenty five total fish species occurring on prime coral habitat of Bank A, nine dominate the data (Table 3, Fig. 5).

Beryx decadactylus (Fig. 5) usually occurs in large aggregations moving over the reef, while most other major species occur as single individuals. Many of these species are cryptic, being well hidden deep in the corals (e.g., *Hoplostethus occidentalis*, *Netenchelys exoria*, *Conger oceanicus*). The morid, *Laemonema melanurum*, is one of the larger fishes abundant at every site with corals. This fish seems to rarely leave the prime reef area. Trash and entangled fishing gear were observed on this reef, suggesting some level of commercial fishing pressure.

Initially the most impressive biological aspect of these coral mounds (aside from the corals themselves) was the well developed and abundant invertebrate fauna (Table 4). We have not yet detected major differences in the invertebrate fauna among the three North Carolina banks; therefore, this paragraph is relevant to all three areas. Galatheid crabs (especially *Eumunida picta*) and the brisingid basket star (*Novodinia antillensis*) were particularly obvious, perching high in coral bushes to catch passing animals or filter in the currents (Fig. 5). One very different aspect of the North Carolina deep coral habitat compared to the rest of the South Atlantic Bight is the massive numbers of a brittle star (*Ophiacantha bidentata*) covering both dead and living coral colonies (somewhat apparent on the coral behind *B. decadactylus*, Fig. 5 and Fig. 8). These are perhaps the most abundant macroinvertebrate on these banks. In places the bottom is covered with huge numbers of several species of anemones (Figs. 5, 8, 10). The abundance of filter feeders suggest a food rich habitat.

Cape Lookout *Lophelia* Bank B

Except for a few maps (see above) there are no published data from this coral mound. The USGS side scan survey (EEZ-SCAN 87 Scientific Staff 1991) illustrated reefs in this area, and, as above, coordinates from that survey guided the cruise using the NR-1 nuclear research submersible (Sulak and Ross, unpubl. data) during 15-18 Nov 1993. The same navigation issue with this cruise described above was also apparent in this area, NR-1 stations being about 1-1.4 nmi (2-2.6 km) from major mounds located later by Ross et al. Between summer 2001 and summer 2004 Ross et al. (unpubl. data) sampled this area using a variety of methods throughout the water column. The JSL submersible was the major method for collecting bottom data on the reef proper. Five dives were made on coral mounds in this area (Fig. 6, Table 1), and observations from these totaling 10.4 hours form the basis of the descriptions of habitat and fauna below.

The least amount of data are available for this area. Mounds appear to cover a smaller area than those described above, but here again better mapping data are needed. Ross et al. JSL dives in this area ranged from 396-449 m (Table 1). Mean bottom temperatures ranged from 5.8 to 10.4° C, and as above mean bottom salinities were always around 35 ‰ (Table 2). These mounds rise at least 53 m over a distance of about 0.4 km. There is a small mound away from the main system (Fig. 6), and in general these mounds (Fig. 7) were less dramatic than those described above. They appeared to be of the same general construction as Bank A, appearing to be built of coral rubble matrix that had trapped sediments. Extensive fields of coral rubble surrounded the area. Both living and dead corals were common on this bank, with some living bushes being quite large (Fig. 7).

Preliminary analyses (Ross et al. unpubl.) have identified 11 fish species from this bank, but it is clear that the species list would be much higher in this well developed habitat if there were more samples. The dominant fish species appears to be *Helicolenus dactylopterus*, followed by *L. melanurum*, *H. occidentalis*, *L. barbatulum*, and *N. exoria* (Table 3, Fig. 8). Although *H. dactylopterus* (Fig. 5) can be common on all habitats, it clearly occurs most often around structures. It is intimately associated with the coral substrate, and it is very abundant around this reef habitat.

The invertebrate fauna on this reef system does not appear substantially different from Bank A (see above, Table 4, Fig. 8).

Cape Fear *Lophelia* Bank

Aside from the map in EEZ-SCAN 87 Scientific Staff (1991) there are no published data from this coral mound and no indication that it was sampled before the studies initiated by Ross et al. (unpubl. data) between summer 2002 and summer 2004. Ross et al. located this bank based on estimated coordinates from the USGS survey (EEZ-SCAN 87 Scientific Staff 1991). As above, the JSL submersible was the major method for collecting bottom data on the reef proper. Seven dives were made on coral mounds in this area (Fig. 9, Table 1), and observations from these totaling 15.4 hours were used to describe the habitat and fauna.

Sampling in this area was focused on a relatively small area (Fig. 9), but data are lacking to accurately estimate the size and area covered by coral mounds or rubble zones. Ross et al. JSL dives in this area ranged from 371-449 m (Table 1). Mean bottom temperatures ranged from 8.7 to 11.7° C, and as above mean bottom salinities were always near 35 ‰ (Table 2). These mounds rise nearly 80 m over a distance of about 0.4 km, and exhibit some of the most rugged habitat and vertical excursion of any area sampled (Fig. 10). This mound system also appears to be of the same general construction as Banks A and B, being built of coral rubble matrix with trapped sediments. Fields of coral rubble are common around the area. Both living and dead corals were common on this bank (Fig. 10).

The greatest numbers of large fishes were observed on this bank. Twelve total fish species were observed here, but as above, this list should increase with increasing sampling effort. As on Bank A, *B. decadactylus* was the most common fish, followed closely by *Polyprion americanus* (wreckfish) (Table 3). So far, of the three North Carolina banks, this is the only area where wreckfish have been observed (Fig. 11), and on some dives 8-10 large individuals were seen swimming slowly along the sides of the ridges. However, it is very likely that wreckfish occur on the other banks. As on the other two banks, *L. melanurum* was common here, always on prime reef habitat. *Conger oceanicus* (always large adults) and *Myxine glutinosa* (Fig. 11) were both frequently observed on this bank.

The invertebrate fauna on this reef system does not appear substantially different from Banks A and B (see above, Table 4, Fig. 11).

Potential NC Coral Mounds

Several potential deep coral banks (Fig. 1) were identified in the USGS survey of the EEZ off of North Carolina (EEZ-SCAN 87 Scientific Staff 1991). During the above referenced NR-1 survey (Sulak and Ross unpubl. data, 1993) and again during a cruise of the R/V Cape Hatteras (S.W. Ross, Chief Scientist, 2001), attempts were made to locate the bank between Cape Lookout Bank A and Bank B (Fig. 1). However, no coral mounds were observed in this area. It is possible that there are coral mounds in this area but the small search pattern and potential navigation issues prevented finding them.

Other banks may exist on the slope south of 33° N (Fig. 1). As far as known these have not been accurately located or confirmed as coral banks, although the location referenced by George (2002) is near one of these areas. These banks would be important to confirm as they would occur in what may be a transition area between a region of coral/sediment built mounds composed almost entirely of *Lophelia pertusa* and the area to the south where coral development is generally quite different.

SUMMARY AND RECOMMENDATIONS

The three North Carolina *Lophelia* mounds (as far as known to date) represent the northernmost coral banks in the SAB, and significant deep coral habitats are not apparent on the US east coast again until north of Cape Cod. Because these banks seem to be a northern terminus for a significant zoogeographic region, they may be unique in biotic resources as well as habitat expression. These three NC banks are generally similar in physical attributes and faunal composition. Some observed differences, however, are being investigated. These systems support a well developed community that appears to be different from the surrounding non-reef habitats. In fact, preliminary analyses suggest that the fish community on these deep reefs is composed of many species that do not (or at least rarely) occur off of the reefs. Therefore, they may be considered primary reef fishes, in a way similar to those on shallow reefs. Many fish species thought to be rare and/or outside their reported ranges have been found on these reefs (Ross et al. unpubl. data). Most likely these species only appeared to be rare because they occurred in a difficult to sample environment. Thus, these deep coral habitats support a fish community that appears to be tightly coupled to the habitat and has essentially escaped detection until recently. However, invertebrate associations with the reef habitat seem to be more opportunistic than is the case for certain fish species. Additional data are required from diverse habitats to confirm this.

Some commercially-exploited deep-water fishes, like wreckfish (*Polyprion americanus*) (Vaughan et al. 2001) and blackbelly rosefish (*Helicolenus dactylopterus*), utilize *Lophelia* habitat extensively. Other potentially exploitable species are also associated with deep corals (royal red shrimps, rock crabs, bericiform fish species, eels). Signs of past fishing effort were observed on some North Carolina banks, but the extent to which fishermen sample these areas is unknown. The potential for new deep water fisheries on and around these banks is unknown.

The banks so far examined off of North Carolina are different than much of the coral habitat to the south on the Blake Plateau. Although requiring confirmation, these mounds along the 360-450 m depth zone appear to be formed by successive coral growth, collapse, and sediment entrapment (Wilson 1979; Popenoe and Manheim 2001). Their tops and sides are mostly covered by dense thickets of living (white) *Lophelia pertusa*, and they are surrounded by coral rubble zones. These features are almost exclusively dominated by *L. pertusa*, the diversity of other corals being low. Bottom currents that are too strong may prevent mound formation (Popenoe and Manheim 2001) because sediments can not be trapped. Assuming currents also carry appropriate foods, it may be that currents with variable speeds or at least currents of moderate speeds (fast enough to facilitate filter feeding but not too fast to prevent sediment entrapment) coupled with a supply of sediment are the conditions facilitating coral mound formation (Rogers 1999). See Reed (unpubl. rept. to SAFMC 2004) for a review of Blake Plateau and Florida deep coral habitat.

Recommendations

Detailed mapping of the slope is critical to better understand these habitats and evaluate their contributions to slope ecology. Such mapping is the foundation for most other research and management activities. Multibeam mapping should be conducted as soon as possible, especially in the depth range of 350-500 m. While this recommendation relates to the whole slope of the SEUS, priority should be given to known coral sites and areas of suspected coral mounds.

If HAPCs or MPAs were to be proposed for the deep coral banks off of North Carolina, Cape Lookout Banks A and B should be contained in one unit (i.e., box) and the Cape Fear Bank in a separate box.

If protected areas are established for SEUS deep coral banks, long term monitoring and research plans should accompany this strategy.

Any deep water fisheries that currently exist or that develop on or near the deep coral banks should be carefully monitored and regulated as deep water fauna are highly vulnerable to over fishing and the habitat is subject to permanent destruction.

Of the vast number of important ecological/biological studies that could be proposed, a broad trophodynamics study of the coral banks and surrounding area (whole water column) would probably provide the most impact for funds expended. Knowing the flow of energy in a system facilitates evaluation of anthropogenic impacts and the allows predictions about the consequences of natural change.

A regional working group composed of scientists and relevant agency personnel should be formed to begin evaluating data, deep reef status, and to take the lead on formulation of plans to study and manage these habitats.

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Table 1. Johnson-Sea-Link research dives conducted on deep coral (*Lophelia*) banks off of North Carolina by S.W. Ross et al. from summer 2000 through summer 2004. Start, end and total times represent bottom times in minutes. CL=Cape Lookout, CF=Cape Fear.

			Time			Start		End		S	E
Station	Date	Location	Start	End	Total	Latitude	Longitude	Latitude	Longitude	Depth (m)	
JSL 4206	28 Jul 00	CL Lophelia A	0842	1036	114	34° 19.633	75° 46.330	34° 19.447	75° 47.249	430	389
JSL 4207	28 Jul 00	CL Lophelia A	1556	1745	109	34° 19.569	75° 47.134	34° 19.417	75° 47.295	418	405
JSL 4361	22 Sep 01	CL Lophelia A	0844	1123	159	34° 19.685	75° 47.372	34° 19.689	75° 47.528	427	384
JSL 4362	22 Sep 01	CL Lophelia A	1621	1836	135	34° 19.425	75° 47.488	34° 19.418	75° 47.507	399	370
JSL 4363	23 Sep 01	CL Lophelia A	0902	1115	129	34° 19.423	75° 47.453	34° 19.412	75° 47.497	417	371
JSL 4364	23 Sep 01	CL Lophelia A	1602	1853	171	34° 18.840	75° 47.013	34° 18.765	75° 47.130	441	398
JSL 3304	11 Aug 02	CL Lophelia A	0833	1100	147	34° 19.720	75° 47.043	34° 19.510	75° 47.207	447	386
JSL 3305	11 Aug 02	CL Lophelia A	1630	1859	149	34° 19.460	75° 47.198	34° 19.477	75° 47.200	416	385
JSL 3306	12 Aug 02	CL Lophelia A	0832	1059	147	34° 19.477	75° 47.200	34° 19.452	75° 47.251	418	384
JSL 3307	12 Aug 02	CL Lophelia A	1624	1711	47	34° 19.485	75° 47.452	34° 19.499	75° 47.545	416	383
JSL 3430	23 Aug 03	CL Lophelia A	1624	1859	155	34° 19.366	75° 47.334	34° 19.404	75° 47.249	415	394
JSL 3431	24 Aug 03	CL Lophelia A	0836	1052	136	34° 19.517	75° 47.044	34° 19.421	75° 47.237	432	388
JSL 3432	24 Aug 03	CL Lophelia A	1647	1857	130	34° 19.427	75° 47.158	34° 19.482	75° 47.213	424	385
JSL 4692	15 Jun 04	CL Lophelia A	0829	1033	124	34° 19.428	75° 47.172	34° 19.444	75° 47.218	426	383
JSL 4693	15 Jun 04	CL Lophelia A	1620	1827	127	34° 19.436	75° 47.140	34° 19.512	75° 47.148	431	392
JSL 4365	24 Sep 01	CL Lophelia B	0842	1115	153	34° 11.344	75° 53.795	34° 11.406	75° 53.743	431	414
JSL 4366	24 Sep 01	CL Lophelia B	1618	1732	74	34° 10.754	75° 53.507	34° 10.765	75° 53.370	449	437
JSL 3429	23 Aug 03	CL Lophelia B	0854	1110	136	34° 11.151	75° 54.028	34° 11.421	75° 53.753	435	415
JSL 4694	16 Jun 04	CL Lophelia B	0829	1041	132	34° 11.277	75° 53.618	34° 11.284	75° 53.788	440	396
JSL 4695	16 Jun 04	CL Lophelia B	1649	1859	130	34° 11.406	75° 53.647	34° 11.411	75° 53.739	442	414
JSL 3308	13 Aug 02	CF Lophelia	0829	1058	149	33° 34.330	76° 28.054	33° 34.434	76° 27.905	449	373
JSL 3425	21 Aug 03	CF Lophelia	0821	1047	146	33° 34.380	76° 27.930	33° 34.465	76° 27.866	386	374
JSL 3426	21 Aug 03	CF Lophelia	1636	1903	147	33° 34.381	76° 27.906	33° 34.326	76° 27.911	371	377
JSL 3427	22 Aug 03	CF Lophelia	0833	1051	138	33° 34.278	76° 27.750	33° 34.477	76° 27.697	381	418
JSL 3428	22 Aug 03	CF Lophelia	1611	1817	126	33° 34.384	76° 27.949	33° 34.441	76° 27.886	377	371
JSL 4696	17 Jun 04	CF Lophelia	0831	1025	114	33° 34.367	76° 27.708	33° 34.360	76° 27.670	390	402
JSL 4697	17 Jun 04	CF Lophelia	1642	1824	102	33° 34.570	76° 27.835	33° 34.587	76° 27.773	405	411

Table 2. Bottom temperature and salinity data from Johnson-Sea-Link (JSL) dives on three *Lophelia* coral bank areas off of North Carolina (S.W. Ross et al. unpubl. data).

Station	Date	Site	Mean Temp (°C) ± SE	Temp Range (°C)	Mean Salinity (ppt) ± SE	Salinity Range
JSL 4206	28 Jul 00	CL Lophelia A	8.49 ± 0.021	5.64-10.64	35.20 ± 0.002	34.04-36.20
JSL 4207	28 Jul 00	CL Lophelia A	8.63 ± 0.006	6.23-9.44	35.20 ± 0.001	34.06-35.81
JSL 4361	22 Sep 01	CL Lophelia A	9.49 ± 0.002	9.09-9.92	35.22 ± 0.000	35.02-35.60
JSL 4362	22 Sep 01	CL Lophelia A	10.13 ± 0.003	9.22-10.57	35.31 ± 0.001	34.99-35.70
JSL 4363	23 Sep 01	CL Lophelia A	10.44 ± 0.002	9.90-10.80	35.35 ± 0.000	35.11-35.52
JSL 4364	23 Sep 01	CL Lophelia A	10.06 ± 0.005	9.00-10.86	35.30 ± 0.001	35.03-35.53
JSL 3304	11 Aug 02	CL Lophelia A	9.61 ± 0.009	6.30-10.88	35.26 ± 0.001	33.91-36.03
JSL 3305	11 Aug 02	CL Lophelia A	9.24 ± 0.003	8.97-10.12	35.21 ± 0.001	34.70-35.69
JSL 3306	12 Aug 02	CL Lophelia A	10.90 ± 0.008	8.87-14.85	35.39 ± 0.002	34.02-36.09
JSL 3307	12 Aug 02	CL Lophelia A	10.15 ± 0.002	9.83-10.54	35.30 ± 0.001	34.99-35.49
JSL 3430	23 Aug 03	CL Lophelia A	6.33 ± 0.003	5.90-6.88	35.06 ± 0.000	34.90-35.56
JSL 3431	24 Aug 03	CL Lophelia A	7.08 ± 0.007	6.20-8.29	35.08 ± 0.000	34.92-35.28
JSL 3432	24 Aug 03	CL Lophelia A	8.27 ± 0.003	7.45-9.04	35.11 ± 0.200*	34.91-35.31*
JSL 4692	15 Jun 04	CL Lophelia A	9.81 ± 0.001	9.55-9.99	35.28 ± 0.000	35.19-35.36
JSL 4693	15 Jun 04	CL Lophelia A	9.11 ± 0.003	8.04-9.57	35.20 ± 0.000	35.02-35.34
JSL 4365	24 Sep 01	CL Lophelia B	10.01 ± 0.002	9.58-10.30	35.27 ± 0.000	35.13-35.41
JSL 4366	24 Sep 01	CL Lophelia B	9.81 ± 0.002	9.61-10.14	35.25 ± 0.000	35.11-35.43
JSL 3429	23 Aug 03	CL Lophelia B	5.82 ± 0.001	5.42-5.97	35.04 ± 0.000	34.99-35.12
JSL 4694	16 Jun 04	CL Lophelia B	10.43 ± 0.005	9.39-11.19	35.36 ± 0.001	35.20-35.53
JSL 4695	16 Jun 04	CL Lophelia B	9.95 ± 0.002	9.70-11.34	35.32 ± 0.000	35.02-35.83
JSL 3308	13 Aug 02	CF Lophelia	9.13 ± 0.002	8.42-9.53	35.18 ± 0.001	34.80-35.45
JSL 3425	21 Aug 03	CF Lophelia	9.54 ± 0.001	9.54-9.72	35.20 ± 0.000	35.10-35.34
JSL 3426	21 Aug 03	CF Lophelia	10.18 ± 0.005	9.25-11.22	35.29 ± 0.001	35.00-35.60
JSL 3427	22 Aug 03	CF Lophelia	8.69 ± 0.004	7.93-9.83	35.15 ± 0.001	34.75-35.61
JSL 3428	22 Aug 03	CF Lophelia	9.13 ± 0.002	8.68-9.70	35.19 ± 0.000	35.14-35.26
JSL 4696	17 Jun 04	CF Lophelia	9.10 ± 0.001	9.00-9.54	35.14 ± 0.000	35.05-35.30
JSL 4697	17 Jun 04	CF Lophelia	11.70 ± 0.002	11.01-12.09	35.48 ± 0.000	35.33-35.67

*JSL 3432 salinity data taken from video records

Table 3. Dominant benthic fish species (in order of decreasing abundance) observed during submersible dives on three North Carolina deep coral reef areas based on unpublished data of S.W. Ross et al. (2000-2003). Species that are currently or potentially of commercial importance are noted with an *. Common names are given where known.

Cape Lookout *Lophelia* Bank A

*Beryx decadactylus** (red bream)	
*Helicolenus dactylopterus** (blackbelly rosefish)	
Hoplostethus occidentalis	
Laemonema melanurum	
*Conger oceanicus** (conger eel)	
Netenchelys exoria	
Laemonema barbatulum (shortbeard codling)	
Idiastion kyphos	
Scyliorhinus retifer (chain dogfish)	
TOTAL NO. SPP.	25

Cape Lookout *Lophelia* Bank B

*Helicolenus dactylopterus**	
Laemonema melanurum	
Hoplostethus occidentalis	
Laemonema barbatulum	
Netenchelys exoria	
TOTAL NO. SPP.	11

Cape Fear *Lophelia* Bank

*Beryx decadactylus**	
*Polyprion americanus** (wreckfish)	
Laemonema melanurum	
*Conger oceanicus**	
Myxine glutinosa (Atlantic hagfish)	
TOTAL NO. SPP.	12

Table 4. Dominant benthic macroinvertebrates occupying deep coral (*Lophelia*) banks off of North Carolina. This list is preliminary (from S.W. Ross et al. unpubl.) and is not separated by area as invertebrate data have not been fully analyzed. Some taxa can only be given general common names at this time.

Lophelia pertusa (coral)
Madrepora oculata (coral)
Eumunida picta (squat lobster)
Ophiacantha bidentata (brittle star)
Echinus gracilis (urchin)
E. tylodes (urchin)
Novodinia antillensis (brisingid starfish)
Bathynectes sp. (portunid crab)
Rochina crassa (spider crab)
Cidaris rugosa (pencil urchin)
Peltaster placenta (starfish)
Poraniella pulvillus (starfish)
Ilex spp. (Squids)
Actinaugi rugosa (Venus flytrap anemone)
anemones
glass sponges
hermit crabs
shrimps
Octopi