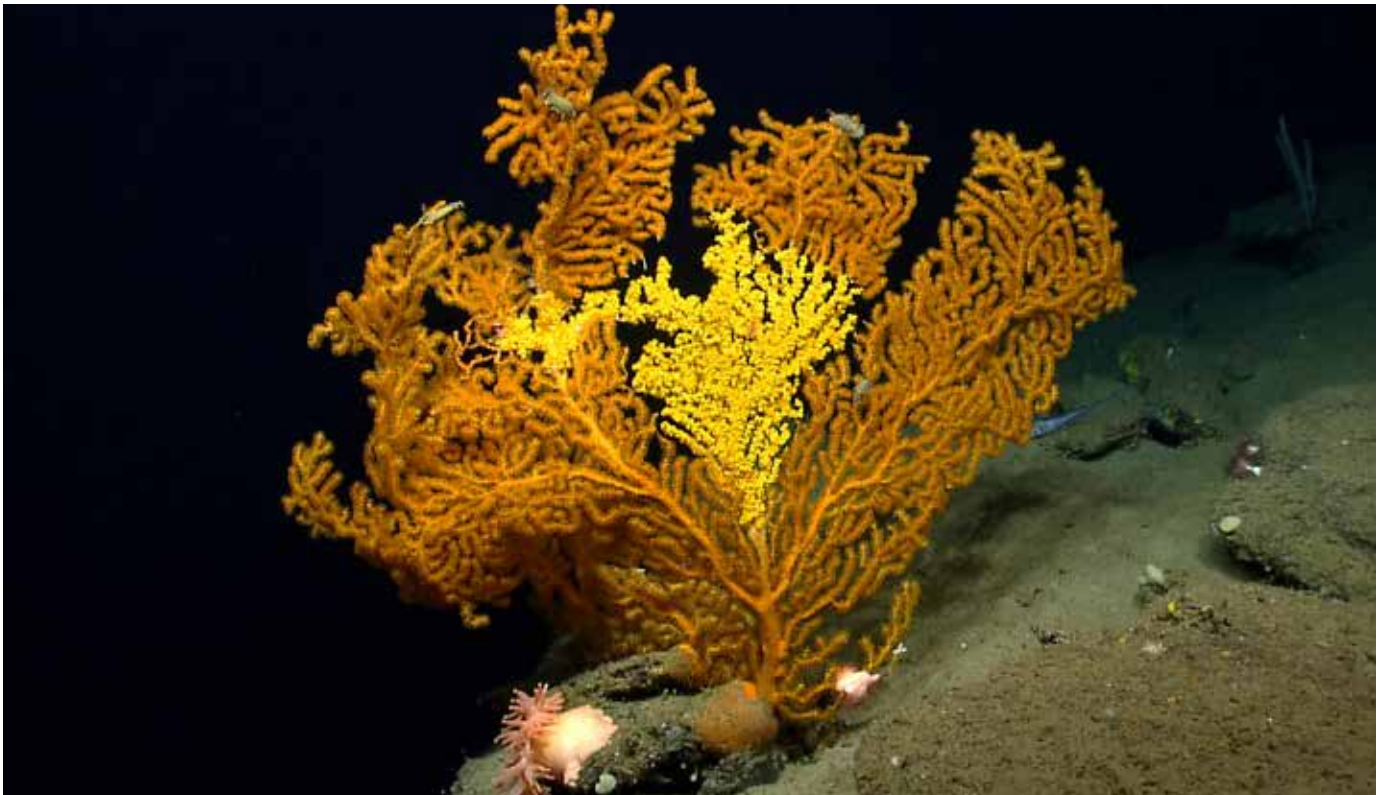


# The Atlantic's Deep Sea Treasures: Discoveries From A New Frontier of Ocean Exploration



A colorful *Paramuricea* coral off the U.S. Atlantic coast.

Image adapted from NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

**Off the nation's most populous coastline, where the continental shelf drops off to the abyss of the deep Atlantic Ocean, vibrant and strange deep-sea worlds take shape.** Starting roughly 80 miles off the Virginia coast and stretching up to the U.S.-Canada maritime boundary, a range of undersea canyons cut into the continental shelf, some more than 100 miles long and deeper than the Grand Canyon. Near the northern end of the canyon range, four seamounts—the only ones in the U.S. Atlantic—rise from the depths, extinct volcanoes towering twice as high as any mountain east of the Mississippi. Scientists have long viewed these ocean features as oases in the cold darkness of the deep sea, fostering a remarkable diversity and

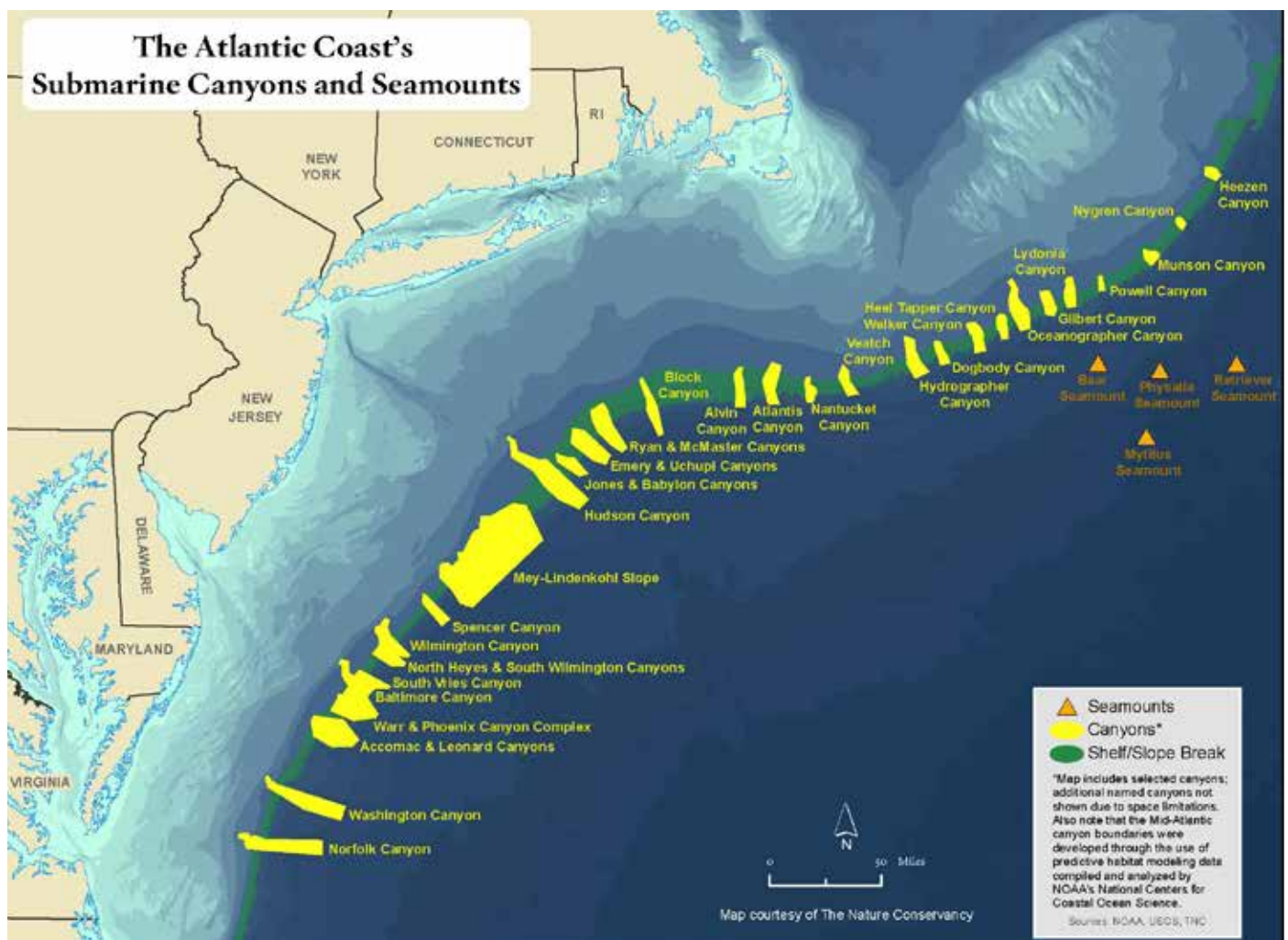
richness of ocean life, from vivid cold-water corals, some the size of saplings and taking centuries to grow, on up the food chain to our deepest-diving whales (the sperm and beaked whale), the world's second-largest whale (the fin whale), and the North Atlantic right whale (the rarest of the Atlantic whales with only approximately 400 individuals remaining).<sup>1</sup>

For the past several decades, limited by technology and resources, we have had only tantalizing glimpses of these unique ecosystems. But over the last four years, an unprecedented scientific effort has been undertaken to change this.

Each summer and fall since 2011, scientists, engineers, and an array of other specialists from the National Oceanic and Atmospheric Administration (NOAA) and other federal agencies, academic institutions, and nonprofits have boarded vessels and traveled to the shelf break to explore what lies deep beneath the waves. Initially, the focus was on three-dimensionally mapping the canyons and seamounts and the adjacent areas, utilizing different types of sonar to characterize the sea bottom, sub-bottom, and water column. In 2012 alone, one NOAA vessel mapped more than 10,000 linear kilometers of Atlantic seafloor, including all or part of 36 canyons.<sup>2</sup> Scientists then relied on these highly detailed maps to deploy remotely operated submersible vehicles, or ROVs, and towed camera “sleds”; a 2012 cruise towing such a sled took 38,000 photos, capturing one image every five seconds.<sup>3</sup> In 2013, NOAA debuted its newest ROV, *Deep Discoverer*, in the Atlantic canyons. *Deep Discoverer* can go to a depth of 6,000 meters, 50 percent deeper than the previous ROV. It has two hydraulic arms and LED lights, and its six cameras (two of them high-definition) give researchers a 360-degree view from the vehicle.<sup>4</sup>

By the close of summer 2014, almost 90 dives had been done, exploring more than two dozen canyons and inter-canyon areas and seven seamounts (including some in international waters). For ten of the canyons and six of the seamounts, these were the first reported scientific explorations.<sup>5</sup>

**The result has been a steady stream of discovery and revelation:** new and rare species, new understandings about ecological relationships and the diversity of ecological settings in the canyons and seamounts, and new appreciation of how special these deep-sea ecosystems are. We relay some of these discoveries and insights here. This issue brief is based on publicly available dive summaries, logs, and articles and represents only a portion of the scientific information gathered as a result of this unprecedented and innovative exploration initiative.<sup>6</sup> In the years ahead, the tremendous amount of information gathered on these expeditions will be analyzed and additional understandings will emerge. New expeditions are also on the horizon. We have only begun to scratch the surface of these deep-sea worlds.



## OCEAN EXPLORATION IN THE INTERNET ERA

The 2013 and 2014 expeditions to the Atlantic canyons and seamounts embraced “telepresence” exploration, by which visual information from the remotely-operated submersible vehicle (ROV) *Deep Discoverer* was systematically shared via a live Internet feed with a network of onboard and shoreside technicians and scientists. This enabled a large number of scientists from around the country – more than 35 for some dives – to participate remotely and in near real time in the exploration, using instant messaging and a dedicated conference line.

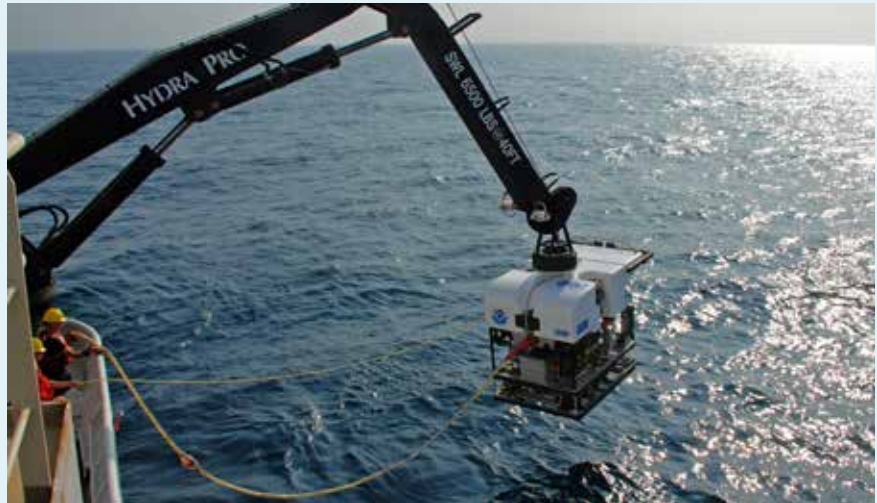


Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

NOAA's remotely-operated submersible vehicle or ROV *Deep Discoverer*, capable of diving 6,000 meters deep and equipped with mechanical arms and multiple cameras, was used to explore the Atlantic canyons and seamounts.

### HIGHLIGHTS FROM THE 2011–2014 EXPEDITIONS TO THE ATLANTIC CANYONS AND SEAMOUNTS

- During a 2013 cruise, scientists discovered a new seamount, which they dubbed “Discovery.”<sup>7</sup>
- More than 40 species of coral have been identified in the submarine canyons, at least three of which are believed to be new species.<sup>8</sup> Many corals, sponges, and anemones observed during the dives were so rare or unusual that they could not be readily identified.
- In some canyons, coral abundance was astounding. In Heezen Canyon, scientists came across what they described as an underwater “forest” of *Paragorgia*, *Primnoa*, and *Paramuricea* corals, some seven or more feet high and hundreds of years old.<sup>9</sup> In Block Canyon, scientists were impressed by large, fan-shaped colonies of bamboo corals six feet tall and ten feet wide, some in abundant “bramble” formations that appeared as tangled clumps of intertwined branches, and even spiraling, whiplike colonies extending more than eight feet from the bottom.<sup>10</sup>
- The exploration identified several new methane cold seeps (see “What Is a Methane Seep?”) and confirmed the existence of the only previously known canyon seep (in Baltimore Canyon). Five active cold seeps have now been identified off the U.S. East Coast.<sup>11</sup> Based on data from water column anomalies collected during

the expeditions, scientists now project that there are more than 570 seep sites between North Carolina’s Cape Hatteras and Massachusetts’s Georges Bank.<sup>12</sup>

- In 2014, in its deepest dive yet, the ROV *Deep Discoverer* descended 4,692 meters to explore an unnamed seamount and encountered a potential new species of sea star (commonly known as starfish).<sup>13</sup> Other 2014 dives identified additional potential new sea star species.
- A 2013 dive in Lydonia Canyon encountered what scientists believed to be a new species of nudibranch or sea slug.<sup>14</sup>

### WHAT IS A METHANE SEEP?

Cold seeps slowly release methane from beneath the seafloor and provide habitat for chemosynthetic species, organisms that are able to chemically derive their food. Bacterial mats coating the ocean bottom and extensive beds of specialized mussels that thrive in the high-methane environment characterize these sites. Certain species of larger organisms, like tubeworms, shrimp, gastropod snails, and clams, are also known to cluster at seeps. Scientists still know relatively little about this rare and productive habitat.<sup>15</sup>





Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

In Heezen Canyon, scientists came across an underwater coral “forest”—some seven or more feet high and hundreds-of-years old.

## THE DEEP-SEA CORAL COMMUNITIES OF THE ATLANTIC CANYONS AND SEAMOUNTS

Scientists believe that as many as 66 percent of all coral species are deep-sea species, occurring at depths greater than 50 meters.<sup>16</sup> Their graceful shapes belie the fact that water pressure 1.5 miles down is more than 3,480 pounds per square inch.<sup>17</sup> Deep-sea species have the same vibrant colors and tree-like shapes as their tropical reef cousins but do not need sunlight to survive. In fact, deep-sea corals may have served as the evolutionary cradle for tropical coral species.<sup>18</sup>

Strong currents sweep the walls and outcroppings of the Atlantic canyons and seamounts, exposing ample hard substrate for sessile organisms like corals, sponges, and anemones to take hold, and bringing in nutrients to support their growth. Scientists have long recognized that deep-sea coral communities in the canyons and on the seamounts are significantly more diverse and abundant than in adjacent areas.

## BUBBLEGUM CORALS

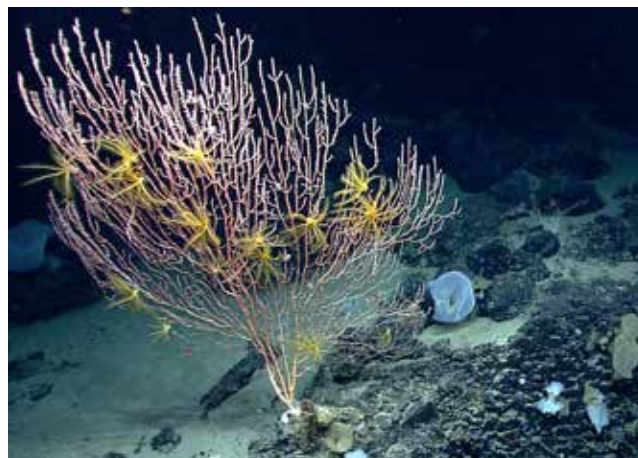


Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

Red and white bubblegum corals (*Paragorgia arborea*), named for their bulbous branch ends, were among the most commonly found corals on recent expeditions. Bubblegum corals are thought to reach the largest size of any seafloor organism on the planet.<sup>19</sup> During the recent expeditions, scientists found a colony nearly 15 feet tall in Baltimore Canyon.<sup>20</sup>

To learn more about the ecological riches of the Atlantic’s canyons and seamounts, and to view a video compilation from the recent NOAA expeditions, please visit <http://www.nrdc.org/oceans/canyons/default.asp>

- Exploration of the New England seamounts in the early 2000s found 45 coral species, only 11 of which had been previously known to science.<sup>21</sup>
- The 2012–2014 expeditions confirmed the incredible diversity of deep-sea corals in the region. Dives in 2013 found no fewer than 10 different coral species in all 10 canyons explored, and in just one dive in Nygren Canyon at least 27 coral species were identified.<sup>22</sup>
- In Block Canyon, two potential new species were documented: one black coral and one bubblegum coral.<sup>23</sup>
- In a dive between Nygren and Heezen Canyons, scientists found a potential new soft coral species as well as an octocoral that could not be identified.<sup>24</sup>
- In 2012, scientists discovered the stony coral *Lophelia pertusa* in Baltimore Canyon, making the canyon the first known location of the species between Cape Lookout and Cape Cod.<sup>25</sup> Subsequent explorations found the species in nearby Norfolk Canyon as well.
- In 2012, black corals, not previously identified in any Atlantic canyon, were found in Gilbert Canyon. The following year, scientists found black corals in a number of other Atlantic canyons.<sup>26</sup>
- In 2013, the stony coral *Solenosmilia* was found at a depth of more than 4,500 feet in Norfolk Canyon. This is likely the first observation of this species, a reef-forming relative of *Lophelia*, in a Mid-Atlantic canyon.<sup>27</sup>



A bamboo coral with crinoids on Mytilus Seamount.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

- The 2014 expeditions found two species of precious or red corals not previously known to occur in the area.<sup>28</sup>
- Dozens of coral species found on the recent dives remain undocumented and may be new to science. In 2013 alone, more than 40 species of coral were found in the Atlantic canyons, and it is likely that at least a few of these, as well as various sponge and anemone species encountered by the scientists, will be found to be new to science as well.<sup>29</sup>



In 2012, *Lophelia pertusa* was found for the first time in the Mid-Atlantic in Baltimore Canyon.

Image courtesy of Deepwater Canyons 2012 Expedition, NOAA-OER/BOEM.



## THE FOUR TYPES OF ATLANTIC COAST CORALS

At least four major groups of deep-sea corals inhabit the Atlantic canyons and seamounts:

- **Stony corals** are hard, reef-forming corals that can also exist as solitary cup corals.
- **Black corals**, typically rust, yellow, or white, are named for their noteworthy black skeletons. In 2009, a black coral found off the Hawaiian coast was determined to be 4,265 years old, possibly the oldest known living marine organism.<sup>30</sup>
- **Alcyonaceans**, which include both what are considered true soft corals and gorgonians, are a highly diverse coral type. They come in a variety of lacy shapes and include bamboo, precious, bubblegum, and tree corals.
- **Sea pens** are solitary soft corals capable of anchoring with a “foot,” even in soft sediment.<sup>31</sup>



Image courtesy of NOAA Okeanos Explorer Program, 2013  
Northeast U.S. Canyons Expedition.

Stony corals and a sea star in Heezen Canyon.



Image courtesy of NOAA Okeanos Explorer Program, 2013  
Northeast U.S. Canyons Expedition.

*Anthomastus*, a type of soft Alcyonacean coral, in Oceanographer Canyon.



Image courtesy of NOAA Okeanos Explorer Program, 2013  
Northeast U.S. Canyons Expedition.

A possible new species of black coral in Block Canyon.



Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard:  
Exploring Atlantic Canyons and Seamounts, 2014.

Close-up of a sea pen colony at 2,023 meters deep on Retriever Seamount.



Squat lobsters, crustaceans that lack the familiar tail of American lobsters, are frequently found living in both hard and soft corals throughout the region (here photographed in a black coral).

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



A whiplash squid waits in the water column while hunting in the deep Atlantic.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

### OTHER ANIMALS OF THIS UNDERWATER WORLD

Deep-sea coral communities form the foundation of the deep-sea ecosystems in the Atlantic canyons and seamounts. The deep-sea corals and associated species like sponges and anemones are sanctuaries for marine life, providing food, shelter from predators, and nursery areas for young fish and crustaceans, and supporting a diversity of commensal species (those that live exclusively on and within coral hosts).<sup>32</sup> The ecological value of the canyons is further enhanced by strong currents that channel in nutrients and small marine life. The canyons' diversity of habitat types and the temperature fronts and upwellings common to these ocean features all serve to concentrate marine life, with cascading effects up through the food chain. For their part, the seamounts are like "biological islands in the deep sea," ideal incubators for new life largely because of their isolation, unique topography, and current patterns.<sup>33</sup>

The result is a rich menagerie of deep-sea life in and around the Atlantic canyons and seamounts. During 2012 dives in Norfolk and Baltimore Canyons, scientists identified at least 30 species of fish.<sup>34</sup> Creatures of the deep ocean are frequently unusual in form, adapted to find their ecological way in dark and often harsh environments. They have names to match: whiplash squid, pompom anemone, dumbo octopus, sea butterfly (which is actually a snail), vampire squid, sea toad, tonguefish, and bathysaurus (which looks as prehistoric as it sounds).



A dumbo octopus, so named for its ear-like fins, on the Atlantis II Seamount Complex.

Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard: Exploring Atlantic Canyons and Seamounts 2014.



A prehistoric-looking bathysaurus in Veatch Canyon.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.





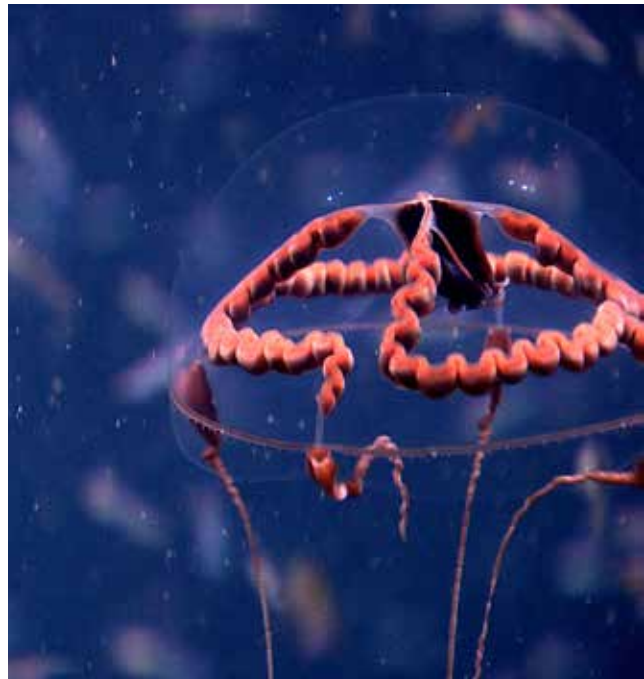
An octocoral was observed with the brittle star *Ophicreas oedipus* in Atlantis Canyon. Neither species is believed to have been found before in the region's canyons.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



This unusual pink web found in Nygren Canyon is believed to be a type of mollusk egg case.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



A rare hydromedusa jellyfish in Washington Canyon.

Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard: Exploring Atlantic Canyons and Seamounts 2014.



The following are just a few of the new, rare, or rarely observed species and species interactions encountered during the expeditions:

- In 2014, scientists saw several kinds of sea stars that they believe could be new species.<sup>35</sup> Other sea stars observed, as well as a sun star, had only been rarely encountered before.<sup>36</sup>
- Recent explorations revealed “mermaid purses” (sharks’ egg cases) on several types of corals in Heezen and Nygren Canyons.<sup>37</sup> They also found cephalopod (e.g., octopus and squid) eggs inside a glass sponge in Hydrographer Canyon.<sup>38</sup>
- Brittle stars, a group of echinoderms that resemble starfish, were observed living on *Swiftia* sea fans; this was not a previously documented association.<sup>39</sup> One octocoral (a subclass of corals named for their eightfold structural symmetry), *Metallogorgia melanotrichos*, was observed with the brittle star *Ophiocreas oedipus* multiple times in Atlantis Canyon; neither species is believed to have been found before in the region’s canyons.<sup>40</sup>
- A highly intricate and geometric pink web observed during an August 2013 dive stumped scientists. Their best guess: it was the egg case of an unknown mollusk.<sup>41</sup>
- In Lydonia Canyon, researchers observed what they believed could be a new species: a purple deep-sea nudibranch of the genus *Tritonia*. Nudibranchs, commonly known as sea slugs, come in a brilliant array of shapes, colors, and sizes; this particular genus of nudibranch preys on certain deep-sea corals.<sup>42</sup>
- On the last dive of the 2013 season, a rare Greenland shark was sighted between Alvin and Nantucket Canyons.<sup>43</sup> These mysterious deep-sea sharks are considered the slowest of all fish species, with a maximum cruising rate of just 1.6 miles per hour.<sup>44</sup>
- In September 2014, a hydromedusa jellyfish was discovered in Washington Canyon. It had last been reported in the region almost a century ago and was designated a new species at the time.<sup>45</sup>
- A rarely-seen species of deep-water skate was spotted at 2,000 meters, or 1.25 miles deep.<sup>46</sup>
- A rarely-seen pompom anemone species and a coral-eating aplacophoran mollusk were observed on Physalia Seamount in 2014.<sup>47</sup>

- In 2014, scientists were surprised to come across “octopus grottoes,” a unique series of cavelike structures near Veatch Canyon each with its own resident octopus.<sup>48</sup>
- In 2013, rare benthic ctenophores (comb jellies) were observed.<sup>49</sup>
- Even though they are rare, scientists saw three bioluminescent dandelion siphonophores during 2014 dives.<sup>50</sup>
- A pink flatworm that had not been seen in dives to date was spotted near Powell and Lydonia Canyons in 2013.<sup>51</sup>
- A 2014 dive turned up a rarely-documented instance of sea star predation on bamboo coral.<sup>52</sup>



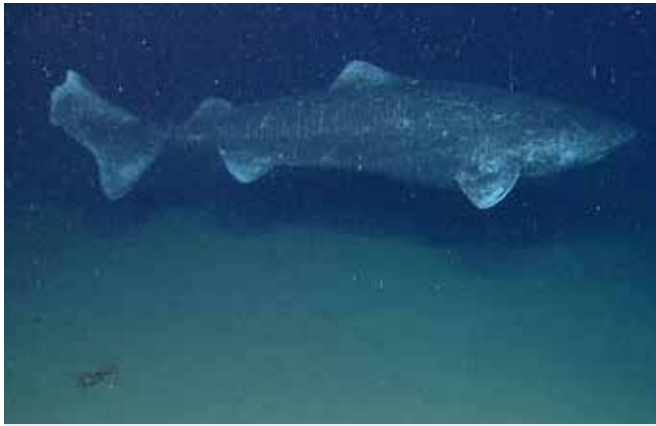
A possible new species of deep-sea nudibranch, genus *Tritonia*, observed in Lydonia Canyon.

Image adapted from NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



Scientists were surprised to see this glass sponge containing cephalopod eggs in Hydrographer Canyon.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



A rare Greenland shark, believed to be the slowest of all fish species, encountered on the last day of the 2013 expeditions.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



A infrequently-seen deep-water skate on the Veatch Canyon floor.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



This rare glowing dandelion siphonophore is composed of many individual animals working together to absorb nutrients.

Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard: Exploring Atlantic Canyons and Seamounts 2014.



An uncommon benthic ctenophore was an exciting find for deep-sea biologists.

Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.



Scientists found this rarely-observed pom-pom anemone on Physalia Seamount.

Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard: Exploring Atlantic Canyons and Seamounts 2014.



## THE ATLANTIC'S DEEP-SEA ECOSYSTEMS NEED OUR PROTECTION

Deep-sea ecosystems are highly vulnerable to human disturbance. Compared with their shallow-water counterparts, deep-water species tend to have a longer life span, later sexual maturity, slower growth rates, and lower natural mortality, all of which generally make them slow to recover from disturbance.<sup>53</sup>

Deep-sea corals are at particular risk. Some species are estimated to be hundreds to thousands of years old with a growth rate of only 1.5 to 2.5 millimeters a year.<sup>54</sup> Thus, significant physical damage, such as from a fishing net dragged along the ocean floor, can have devastating effects, eliminating these fragile deep-sea organisms within any ecologically relevant period of time.

The Mid-Atlantic Fishery Management Council is currently developing a plan to protect deep-sea coral communities in at least the canyons in the Mid-Atlantic region from fishing gear damage. This is the moment to act: Bottom trawling is not yet occurring in the hearts of the canyons themselves and at the depths where most of the corals are found. The Council intends to add this coral protection plan as the Deep Sea Corals Amendment to an existing fishery management plan (for squid, mackerel, and butterfish), which it will then submit to NOAA for approval; for more information on public hearings and how to submit written comments on the Deep Sea Corals Amendment, visit [www.mafmc.org/actions/msb/am16](http://www.mafmc.org/actions/msb/am16). The Deep Sea Corals Amendment represents a historic opportunity to protect the highly vulnerable, distinctive, and pristine ocean ecosystems in a significant number of Atlantic canyons.

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