New England Coral Canyons and Seamounts

Prepared by Mystic Aquarium &
Natural Resources Defense Council

Front photo: Anemone in Heezen Canyon. Credit: NOAA OKEANOS Explorer Program, 2013 Northeast U.S. Canyons

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Introduction

Just 150 miles off the coast of Cape Cod lie some of our country's greatest marine treasures. Hidden beneath thousands of feet of ocean, where the continental shelf drops off to the pitch-black abyss of the deep Atlantic Ocean, five massive canyons plunge down, some deeper than the Grand Canyon. Just beyond these canyons, four extinct underwater volcanoes – called seamounts – rise as high as 7,700 feet above the ocean floor, higher than any mountain east of the Rockies and the only such seamounts in U.S. Atlantic waters.

The plunging walls and deep floors of the canyons – Oceanographer, Lydonia, Gilbert, Nygren and Heezen – and the towering slopes of the seamounts – Bear, Physalia, Mytilus, and Retriever – are alive with vivid coldwater corals of otherworldly beauty – some the size of small trees and centuries, if not thousands of years, old. These corals, together with other structure-forming fauna including sponges and anemones, form a foundation for vibrant deep-sea ecosystems, providing food, spawning habitat, and shelter for an array of fish and invertebrate species.

The varied habitats and strong and complex currents of the canyons and seamounts also support significant and diverse concentrations of marine life throughout the water column. Upwelling along steep walls and slopes bring nutrients to upper waters, supporting an abundance of plankton, squid, and forage fish. These, in turn, attract tunas, billfish, sharks, seabirds, and marine mammals, such as the endangered sperm whale, which eat up to a ton of squid and fish each day, and the North Atlantic right whale, the rarest of the North Atlantic's great baleen whales with only approximately 450 individuals remaining.[1]

These deep-sea biodiversity hotspots are sites of active scientific exploration, investigations and discovery. In recent years, research expeditions led by the National Oceanic and Atmospheric Administration (NOAA), in partnership with numerous academic and educational institutions, have confirmed the ecological significance of the canyons and seamounts, even while affirming how much remains to be discovered about these unique environments. The canyons and seamounts proposed for designation represent tremendous opportunities for further scientific exploration and education around deep-sea ecosystems. Importantly, these remote and relatively pristine areas function as a scientific reference site, giving researchers the chance to advance our understanding of undisturbed nature in a world otherwise transformed by humans. In recognition of this area's value, 141 eminent ocean scientists from 84 research institutions, along with the three major New England Aquaria and 226 accredited aquaria from around the world, have urged robust long-term protections for these "particularly outstanding examples" of New England's canyons and seamounts.

The window for securing protection is rapidly closing. Human activities, including commercial fishing, oil and gas exploration and drilling, deep-seabed mining, and cable-laying, as well as climate change and ocean acidification, put the New England Coral Canyons and Seamounts at risk. These deep-sea ecosystems, including the slow-growing and vulnerable corals, are extremely vulnerable to disturbance. This area where the deep sea intersects with the continental margin and the seamounts rise from the abyssal plain represents exceedingly rare habitats in an otherwise great expanse of deep ocean. The time has arrived to permanently protect one of the last truly wild, mysterious and scientifically-important places along the Atlantic seaboard, before the expanding footprint of industrial development reaches and forever changes it.

The New England Coral Canyons and Seamounts National Marine Monument

America has a long tradition of protecting our remarkable natural heritage and biological bounty. Yet, in contrast to our public lands and the Pacific Ocean, where very large areas have been protected by Presidential action, no monuments exist in our ocean waters off the lower 48 states, including in the U.S. Atlantic. The New England Coral Canyons and Seamounts, which constitute rare and highly vulnerable biological hotspots offshore of the nation's most populous coastline, deserve the permanent protection afforded by what would become America's first national marine monument in the Atlantic Ocean.

Location and Boundary Description

Oceanographer, Gilbert and Lydonia Canyons lie approximately 150 miles southeast of the southeastern tip of Cape Cod. Nygren and Heezen Canyons lie approximately forty and sixty miles respectively northeast of the other three canyons. Bear, Physalia, Mytilus and Retriever Seamounts are 25-75 miles southeast of Oceanographer, Gilbert and Lydonia canyons. The five canyons are each approximately 6500-7500 feet deep and up to 20-30 miles in length. The four seamounts are extinct volcanoes that rise as high as 7,700 feet above the ocean floor. Bear Seamount, the largest of the four, spans almost 20 miles across.

The proposed New England Coral Canyons and Seamounts National Monument is comprised of two units: a *southern unit*, which includes Oceanographer, Gilbert and Lydonia Canyons and the four seamounts, Bear, Retriever, Physalia, and Mytilus, and a *northern unit*, which includes Nygren and Heezen Canyons.

The two units together encompass 4329 square nautical miles (5734 square miles). Both units fall wholly within the U.S. Exclusive Economic Zone.

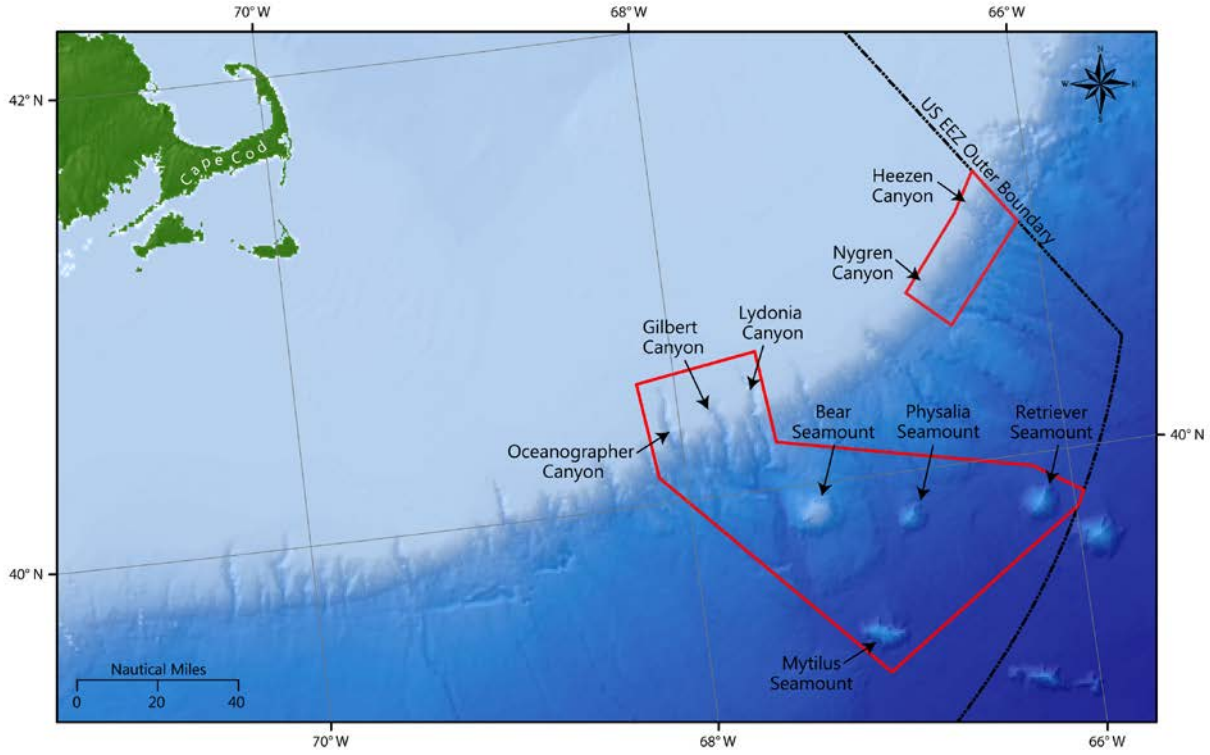
Southern unit: The proposed landward boundaries for the three canyons (Oceanographer, Gilbert, and Lydonia) are based on Habitat Area of Particular Concern (HAPC) designations recently approved by the New England Fishery Management Council. These HAPC designations were made for the broad ecological purpose of protecting habitat-forming deep sea coral communities for the benefit of managed fish species. See New England Fishery Management Council, Omnibus Essential Fish Habitat Amendment Volume 2: EFH and HAPC Designation Alternatives Environmental Impacts, Draft-Oct. 1, 2014, at 399-400. The NEFMC also took into account the canyons' general ecological importance, sensitivity to anthropogenic stresses, and rare habitats and organisms. Id. There is one HAPC designation for the Oceanographer, Gilbert and Lydonia canyons complex. We note that the boundaries of the existing tilefish gear restricted areas (GRAs) are less appropriate for use for this proposed unit because the GRAs are intended only to protect tilefish HAPC and encompass only Oceanographer and Lydonia Canyons, each separately.

Because the HAPC boundaries for the three canyons end at 1500 meters depth and do not encompass the seamounts, the HAPC boundaries are extended out seaward in straight lines to encompass Mytilus, Retriever, Physalia, and Bear Seamounts (without extending into international waters). Directly north of Bear Seamount, at the 1500 meter depth, the boundary rejoins the Oceanographer/Gilbert/Lydonia Canyons HAPC boundary.

Northern Unit: The landward boundary of the NEFMC-designated Heezen Canyon HAPC is utilized for the boundary of the landward side of the northern unit. On the west side of Heezen Canyon, the landward HAPC boundary is extended approximately following the same depth contour to form the landward boundary at the head of Nygren Canyon. We note that no HAPC was designated for Nygren Canyon because of the lack of exploratory activity in the canyon at the time that the NEFMC was initially developing its HAPC designations, which predated a 2013 NOAA expedition that found Nygren Canyon to be biologically-rich. For example, in the 2013 expedition, scientists identified over 27 different coral species in the canyon in a single dive, a high for all the canyons visited by the expedition. See infra at 8. During the same expedition, an ecologically-notable cold seep was also discovered in Nygren Canyon. See infra at 7.

On the east side of Heezen Canyon, the HAPC landward boundary is extended similarly following approximately the same depth contour to the U.S.-Canada boundary line. In order to encompass the entire canyon feature for both Heezen and Nygren Canyons, as well as observed and likely deep sea coral habitats, the oceanward boundary of the northern unit approximately follows the 2000 meter depth contour, rather than the oceanward boundary line of the HAPC, which is considerably shallower.

Map and Coordinates for New England Coral Canyons and Seamounts National Marine Monument



Coordinates of Proposed Monument:

Northern Unit	
Longitude	Latitude
-66.7970	40.7580
-66.4820	41.0660
-66.3593	41.2326
-66.1572	40.9945
-66.5804	40.5959

Southern Unit	
Longitude	Latitude
-66.0160	39.8280
-66.0580	39.7660
-67.1400	39.1810
-68.2120	40.1220
-68.2680	40.5270
-67.6280	40.6000
-67.5780	40.2070
-66.2650	39.9600

Management Goals

Designation of the New England Coral Canyons and Seamounts National Marine Monument would fully and permanently protect these natural treasures from harmful commercial uses, and recognize preservation, scientific study and education as the primary purposes of the area, with the following management goals:

1) Preserve and protect the extraordinary and vulnerable geological, biological and ecological resources of the canyons and seamounts.
2) Study, interpret and promote the outstanding geological, biological and ecological resources of the canyons and seamounts.
3) Advance America's understanding and appreciation of deep-sea ecosystems through development of educational materials and programs, research, and provision of educational opportunities to study the canyons and seamounts in their natural, undisturbed state.
4) Provide a reference area for scientific study of the effects of climate change and ocean acidification on deep ocean ecosystems
5) Enhance federal, state, local and private partnerships working to conserve and promote the natural resources of the area and to foster related educational and scientific opportunities.

The Case for Permanent Protection of the New England Coral Canyons and Seamounts

Ecological Qualities and Conservation Value

The New England coral canyons and seamounts represent biodiversity hotspots in the deep ocean.[2] The distinctive geomorphologic characteristics and oceanographic conditions found in the proposed national marine monument area result in a diversity of habitats uniquely suited to support significant and diverse concentrations of marine life. Steep and outcropped walls, glacially rafted fields of boulders, basalt escarpments and lava fields, cold seeps and a gradient of soft sediment environments together produce a landscape supporting diverse communities of marine organisms, including deep-sea coral communities and chemosynthetic ecosystems. Strong currents and circulation patterns, including upwellings, create turbulent waters that enhance mixing of surface and deep water, transport nutrients and concentrate food supply.[3] The increased production in and around these ocean features echoes up through the water column and food web.[4]

The Canyons: Oceanographer, Gilbert, and Lydonia Canyons are among the largest of the approximately 35 major submarine canyons that line the U.S. continental shelf edge from Cape Hatteras north to the Canadian boundary.[5] The three canyons are closely adjacent to each other, and form a canyon system. Each of these spectacular canyons ranges from a depth of approximately 500 feet at their heads to around 7700 feet at the point they intersect with the continental rise, deeper than the Grand Canyon. From canyon head to the continental rise, the three canyons extend approximately 22 to 30 miles in length; the full extension of the canyons down the continental rise, including their channels and fan valleys, can be more than twice as long.[6] To the north along the shelf edge, Heezen and Nygren Canyons are two extremely narrow and deeply incised canyons. Though not as extensive as their counterparts, these two canyons boast dramatic geologic features: Heezen Canyon has been described as a "winding gorge cut into sheer cliffs of massive chalk."[7]

The five canyons are subject to active erosion, which helps maintain the basis for their exceptional diversity of life.[8] The canyons have very high energy levels, due to the exceptionally strong currents that run through them.[9] As powerful currents traverse these canyons, they leave exposed rock and clay outcrops as well as eroded talus blocks behind. In many submarine canyons, exposed hard substrate is limited to the axes and lower walls, but in these five canyons, it is found throughout the canyon area.[10] These hard surfaces allow for settlement and attachment of sponges, corals and other invertebrate fauna that filter food from the water to flourish. Relative to the adjacent continental slope, the canyons are known to contain a high diversity of habitat types, ranging from a matrix of fine grain (soft) sediments to outcroppings of rock and layered clays as well as glacial erratic boulders deposited during the last ice age. The mixture of habitats creates a uniquely complex landscape supporting a wide diversity of species.[11]

Scientists have also recently documented the presence of cold seeps in Nygren Canyon as well as a potential cold seep between Nygren and Heezen Canyons. Cold seeps leak fluids, like hydrogen sulfide and methane, creating micro-habitats that support unique biological communities. These communities use chemosynthetic processes, rather than photosynthetic, processes to derive energy as the base of the food web.[12]

The Seamounts: Bear, Physalia, Mytilus, and Retriever seamounts, which are extinct underwater volcanoes, are the only seamounts in the U.S. Atlantic EEZ. They form the beginning of a chain of seamounts called the New England Seamount chain that stretches halfway across the western North Atlantic Ocean in international waters. The chain lies roughly perpendicular to two major currents, the Gulf Stream (which originates off the southern tip of Florida and transports warm water and marine organisms north along the east coast) and the Deep Western Boundary Current, and seamounts have been shown to significantly influence the Gulf Stream through the formation of quasi-stationary recirculation gyres and the frequent formation of transient warm-core rings.[13] The four seamounts in the proposed national marine monument rise as high as 7,700 feet above the ocean floor, higher than any mountain east of the Mississippi River. Bear Seamount is the largest of the four seamounts, spanning almost 20 miles across, and rises to the shallowest depth, approximately 3,500 feet below the surface. Formed about 100 million years ago, it is also the oldest seamount in the New England Seamount chain.

The seamounts are considered "biological islands in the deep-sea," ideal incubators for new life because of their isolation, unique topography and current patterns.[14] As currents flow up and around the seamounts, eddies can form, trapping larvae and other small organisms in a closed loop over each seamount.[15] In addition to encouraging larval settlement, these currents also bring food to the filter-feeding corals and sponges that grow in abundance on the seamounts.[16] Like the canyons, the substrate on the New England seamounts varies widely, ranging from solid basalt crusts in many forms to finer pebbles and sand. Due to the variety of bottom types, many different species can be found in very close proximity, leading scientists to refer to the seamounts as "ocean oases."[17]

Deep-sea Corals, Sponges and Anemones: The proposed national marine monument area is exceptional for its diversity and abundance of deep-sea corals.[18] These deep-sea corals, and associated species including sponges and anemones, form the foundation of deep-sea ecosystems, providing food, shelter from predators, nursery habitat for juvenile organisms, and serving as hosts for a diversity of commensal species (those that live exclusively on and within coral hosts).[19] During a series of exploratory dives conducted by NOAA's *Okeanos Explorer* between 2012 and 2014, at least 58 species of coral (i.e. 58 coral taxa or putative species) were identified in the canyons and seamounts off the U.S. Atlantic coast.[20]

Oceanographer and Lydonia Canyons were among the first and best-explored of the Atlantic submarine canyons and have been long recognized for their spectacular assemblages of deep sea corals, including billowy white colonies of the soft coral *Capnella glomerata* in Lydonia Canyon.[21] During a 2013 *Okeanos Explorer* expedition, a rare white carnivorous sponge in Oceanographer Canyon was documented.[22] During this same expedition, deep in Heezen Canyon, scientists found what they described as a coral "forest," a wall of enormous branching corals approximately two meters tall and centuries old.[23] In Nygren Canyon, over 27 different coral species were identified in a single dive, an expedition high for all the Atlantic canyons.[24] In 2012, the first deep coral survey in Gilbert Canyon found significant coral diversity and abundance there as well.[25] Colonies of black corals have been found in all five canyons. Black corals, as well as the gorgonian corals also commonly found in the canyons, are often associated with a large number of other species, signifying their habitat importance.[26]

Like the canyons, the four seamounts in the proposed national marine monument area contain corals that are rarely found elsewhere along the continental slope and surrounding ocean floor.[27] Branching structure-forming stony corals like *Lophelia pertusa* that are uncommon in the region have been found on the seamounts, as well as the canyons, in the proposed national marine monument area.[28] A 2003 expedition to Bear Seamount observed *Vaughanella margaritata,* a solitary coral that had not been documented since its original description over 100 years ago.[29] Scientists also found a number of black corals in large, bush-like aggregations on Bear Seamount.[30] High sponge and coral diversity has been noted on Mytilus Seamount, including glass sponges with "tulip" and "rose" heads. On Retriever Seamount, scientists observed an astonishing collection of diverse corals - including stony corals, octocorals, precious corals, black corals, and bamboo corals - on a single outcrop.[31] And in 2014, a rarely-seen pompom anemone species was observed on Physalia Seamount.[32]

Researchers continue to find and describe new coral species in the area that includes the proposed national marine monument.[33] In 2013, scientists discovered what they believe to be two new coral species, a white octocoral and a soft coral, in an intercanyon area between Nygren and Heezen Canyons.[34] Of the approximately 45 octocoral species collected on the New England Seamounts during the 2003, 2004 and 2005 NOAA Mountains in the Sea Expeditions, only 11 had been previously identified.[35] To date, newly discovered species from the expeditions include two types of "precious" or red corals, one of which is the first to be reported from the western Atlantic.[36] Four new species of *Chrysogorgia* were also collected, characterized by a spiral form previously known only from Pacific species (with one exception).[37] Additionally, one new genus and three new species of primnoids have been described from the seamount samples.[38]

Importantly, recent work suggests that the seamount fauna is relatively distinct compared to the adjacent continental margin.[39] By including the canyons and seamounts as well as the intervening margin, the proposed national marine monument captures and represents different unique components of deep-sea biological diversity.

Other Fauna: A rich diversity of fish, crustaceans, marine mammals, seabirds, and other species, including invertebrates, use and inhabit the proposed national marine monument area. To date, the deep-sea region bordering the Gulf of Maine, inclusive of the proposed national marine monument area, harbors 1,671 documented species, with estimates of an additional 50% to be discovered.[40] A 2003 study identified 591 fish species living below 200 meters in the New England shelf region.[41] Expeditions to Bear Seamount between 2003 and 2006 revealed an additional 32 species of deep-sea fish, several of which were new to science.[42] Furthermore, several fish species found at Bear Seamount are rare in the northwest Atlantic, and some are only known from the eastern Atlantic.[43] In a 2013 expedition to Lydonia Canyon, researchers observed a pink flatworm and a spiny eel that had not been seen in dives to date, as well as a potential new species: a purple deep-sea nudibranch of the genus *Tritonia*.[44] Researchers also found a rare coral-eating aplacophoran mollusk on Physalia Seamount, and observed several kinds of sea stars that they believe could be new species.[45] In Nygren Canyon, researchers documented the presence of multiple patches of chemosynthetic mussels, as well as bacterial mats, scaleworms and gastropods, associated with the canyon's cold seep microhabitats.[46]

The canyons are also home to various species of flounders, squid, shrimp, octopus, hake, skates, ocean pout (a highly depleted species), cusk (a Species of Concern and Candidate species for

listing under the Endangered Species Act), grenadiers, and multiple species of eels.[47] Some species inhabit or travel through the canyons in dense aggregations. In Oceanographer, Lydonia and Gilbert canyons, crabs, lobsters and tilefish have constructed densely burrowed "pueblo villages" that provide habitat and nursery areas for them and other species.[48] Larger pelagic fish like swordfish, tuna and sharks also use the proposed national marine monument. Some of these species even begin life there. For example, species in the catshark family (Scyliorhinidae) routinely deposit egg cases on corals. Such egg cases were observed attached to deep-sea corals in Nygren Canyon in 2013.[49] Other noteworthy pelagic shark and ray species whose range includes the proposed national marine monument area include the giant manta ray, basking shark, blue shark, tiger shark, mako shark, hammerhead shark, thresher shark, porbeagle shark and great white shark.[50]

Endangered sperm whales come to the canyons to hunt for squid.[51] Large numbers of beaked whales have been sighted in the area; marks on the seafloor at deep sites off of Gilbert and Lydonia canyons were inferred to be beaked whale foraging tracks, extending the known depth range of this group of whales.[52] Critically-endangered North Atlantic right whales, whose migration track includes Gray's Reef and Stellwagen Bank National Marine Sanctuaries ending in a northern likely mating area in the vicinity of Cashes Ledge in the Gulf of Maine, have been observed in the vicinity of Oceanographer and Lydonia canyons. The proposed national marine

1. bamboo coral, Mytilus Seamount; **2.** spotted dolphin, Physalia Seamount; **3.** porcupine crab, Lydonia Canyon; **4.** lizard fish, Mytilus Seamount; **5.** sea spider, Oceanographer Canyon; **6.** chimera fish, Lydonia Canyon; **7.** sperm whales; **8.** corals, Oceanographer Canyon.
Images 1 – 6, 8 adapted from NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition. Image 7 copyright Footage Search.

monument area is also one of the few areas in the U.S. Atlantic where blue whales can be encountered.[53] Additional baleen whale species (sei, fin humpback, minke) have been seen in the area.[54] Other marine mammals, such as pilot whales and multiple species of dolphins, have also been observed in high numbers along the shelf break in the Atlantic Ocean, and it is very likely that the animals use productive canyon and seamount zones as foraging or migration stops.[55]

Three species of protected sea turtles – leatherback, loggerhead and green – are known to forage in the pelagic waters around the canyons and seamounts as they ride the Gulf Stream. Endangered leatherback sea turtles are among the largest living reptiles in the world, and can dive deeper than 3,000 feet to feed on jellyfish. Threatened loggerhead feed on crustaceans and bottom-dwelling invertebrates while adult green turtles feed on seaweed. Research suggests that seamounts specifically may be important habitats for some sea turtle species.[56]

Marine birds are known to concentrate in upwelling areas, and large concentrations of birds have been noted in the vicinity of the Oceanographer, Lydonia, and Gilbert Canyon complex.[57] Several species of gulls, shearwaters, storm petrels, gannets, skuas, and terns, among others, regularly occur in the region, sometimes in large aggregations.[58] Avid bird watchers in the region voyage to some of these canyons for the opportunity to see birds that are not found anywhere else in New England.

Connectivity to other ecologically significant resources: The canyons and seamounts provide important biological connections both within and far beyond the region. Within the region, the canyons act as conduits for shelf-slope exchange of water, sediments, nutrients and organisms. High densities of krill that occur just over the seafloor in deep waters of the canyons can be transported by currents to Georges Bank, and scientists note this may be an important contribution to the elevated productivity of the canyon heads and southern portions of Georges Bank.[59] The canyons also act as refugia for migratory species during portions of their life cycles. For example, researchers found that juvenile lobster density was higher in offshore canyon habitat relative to non-canyon habitat, and that adult offshore American lobsters migrate from Oceanographer and Lydonia Canyons towards shore to lay eggs, molt and mate, before returning to the canyons.[60]

More broadly, recent research expeditions to the seamounts have yielded surprising discoveries of species distributions, revealing complex ecological and biological connections to other regions. For example, scientists note that at least 17 fish species appear to have arrived at Bear Seamount by using the New England seamount chain as a dispersal corridor or "stepping stones" from the eastern Atlantic, or by traveling on the Gulf Stream or Deep Western Boundary Current.[61] In another example, octocorals, black corals, invertebrate coral associates, and fish found on the seamounts have been described from dredge hauls taken in the 1950-60s in the Florida Straits and Gulf of Mexico and in the late 1800s off the Greater Antilles, further suggesting functional connectivity between southern biological communities and those of the seamounts.[62]

By providing food and habitat availability, the proposed national marine monument connects southern marine communities with those further north into Canada and into international waters. This is important for species resilience, providing a potential mechanism for long-distance

dispersal and thus adaptability in the face of changing environmental conditions. The proposed national marine monument also highlights the interconnectedness of underwater habitats across local, regional and basin-wide scales.

Socio-Economic Value

The proposed national marine monument's distance from shore precludes many traditional economic activities, although some whale-watching, fishing and seabird viewing occur in the proposed national marine monument. As described below, these deep-sea ecosystems do provide significant ecological goods and services, which can generate significant economic activity elsewhere, as well as scientific and educational value. The ecological goods and services described below are based on our limited knowledge of deep-sea ecosystems: as we learn more, the full value of these ecosystems' contribution is likely to become more apparent.

Ecosystem Services: The deep ocean and seafloor environment of this area provides public benefits through a variety of supporting, provisioning, regulating and cultural services.[63] The proposed national marine monument area includes spawning, foraging, and nursery areas for species of commercial, ecological, and/or cultural significance (supporting services). It contains important genetic diversity that supports biomedical research (provisioning services), and the deep-sea organisms it contains consume methane, keeping this potent greenhouse gas sequestered (regulating services). The proposed national marine monument area hosts tremendous species diversity and, as such diversity is positively correlated with ecosystem functioning in deep-sea ecosystems, the area likely sustains important ecological functions or level of function not present on the adjacent slope. Reduction of the area's biological diversity and productivity would likely diminish these essential services; as such, effective conservation of the proposed national marine monument's ecological attributes is paramount.[64]

The public also benefits from the proposed national marine monument's existence value. The intrigue and mystery, the strange life forms and the great unknown of the deep sea has acted as a muse for inspiration and imagination since the beginning of civilization.[65] Evidence for this is the large web-based audience (i.e., approximately 50,000 web viewers per day) that viewed live video-feed during the NOAA Ocean Exploration program dives in east coast submarine canyons and western North Atlantic Seamounts (2013-2014), including dives in these canyons and seamounts.[66] A national marine monument encompassing a portion of the North Atlantic's most dramatic and rich geologic and biological features likewise can build larger and more vocal constituencies for the conservation of our nation's deep seas, as well as ocean resources more generally.

Commercial Fisheries: Although the proposed national marine monument area as a whole is not a major commercial fishing grounds for demersal species, the canyon head and upper slope environments nurture a broad range of exploited species including white hake, silver hake and redfish. Scientists predict that the loss or destruction of habitat-forming species, including deep sea corals and sponges, could have significant impacts on such species.[67] According to a recent scientific review, "studies to date indicate that functional values in support of commercial fisheries probably represent the most important service provided by cold-water corals."[68] Studies have found that deep-sea corals provide: spawning habitat and shelter for developing larvae and juveniles; structure for shelter-seeking fishes; and enhanced rates of prey capture.[69] Correlative

studies and habitat models have shown that adult fish densities are often higher and average fish size larger around deep-sea corals compared to areas devoid of corals.[70] Further, research suggests that "fish larvae shelter around soft corals, [thus creating] a strong argument for classifying those [deep-sea corals] as essential fish habitat and as vulnerable marine ecosystems."[71] Protection of the structural function of these habitats would help support the productivity of commercially important species.[72] While the direct economic contribution of the proposed national marine monument to commercial fisheries has not been quantified, the overall commercial fishery sector is a vital economic engine to the New England region.

Biomedical and Biotechnology Research and Development: Deep-sea corals and sponges produce chemical compounds for defensive and other purposes that are unlike any found in shallow or warm water species.[73] Some of these compounds hold promise in pharmaceutical, industrial, engineering, and medical fields.[74] For example, certain deep-sea sponges are being tested for their use in treating cancer and Alzheimer's disease.[75] Sponges are prolific sources of diverse chemical compounds: an estimated 30% of all potential marine-derived medications and 75% of recently patented marine-derived anticancer compounds come from marine sponges.[76] A National Research Council report concluded that the exploration of deep-sea environments offered a high potential for continued discovery of new drugs.[77] Deep-sea organisms are also being tested and used to advance biotechnologies. For example, bamboo corals, which are found in Oceanographer Canyon, have a structure almost identical to bone and are currently being used to synthesize bone grafts.[78]

Protecting the corals and sponges of the five canyons and four seamounts ensures that the genetic diversity found there will be preserved, allowing these areas to function as "genetic reserves" and sustain the genetic diversity of surrounding areas.[79] The diversity of deep-sea organisms in the proposed national marine monument could also provide scientific research opportunities that could significantly contribute to public health.

Whale-watching and seabird viewing: The canyons and seamounts are important forage and/or migration stops for a variety of whale and seabird species. Protecting the habitat resources important to whales and seabirds helps to conserve their populations throughout the region. Whale-watching in particular along the New England coast is big business, with nearly 1 million whale watchers and gross sales revenues of $35 million in 2008.[80] Whale-watching and seabird-watching trips to the canyons have been organized by non-profit organizations, including the Brookline Bird Club of Massachusetts, Massachusetts Audubon Society, Brian Patterson Pelagics, and the Coastal Research and Education Society of Long Island.[81] Several of these groups have submitted letters of support for protecting this area. Designation of the canyons and seamounts as a national marine monument could lead to the establishment of a more directed whale and seabird tourism economy. A NOAA study found that the capitalized economic value (that is, the total economic value of the industry) of whale-watching associated with the Stellwagen Bank National Marine Sanctuary was $440 million in a single year.[82]

Recreational Fishing: The canyons in the proposed national marine monument area are utilized less frequently by recreational fishermen than other canyons to the west and closer to shore. Nevertheless, recreational fishing, primarily targeting large pelagics, occurs around Oceanographer, Gilbert and Lydonia Canyons (less so around Nygren and Heezen, which are further from shore). These canyons lie within range of larger sport fishing vessels and party boats

sailing from Rhode Island, Connecticut, and Massachusetts ports. Several charter operations advertise "long range" or overnight fishing trips to the canyons, which give customers the opportunity to catch blue and white marlin, swordfish, yellowfin, albacore and bigeye tuna, mahi-mahi, and several species of sharks.[83]

Carbon and Methane Sequestration: Biological activity in the deep-sea, which is particularly high in biodiversity hotspots such as canyons and seamounts, helps to sequester atmospheric carbon, leading to these areas acting as climate sinks. Deep-sea organisms also consume methane, a potent greenhouse gas that can be released from deep-sea reservoirs, thus reducing the additional contribution of this warming agent to the atmosphere.[84] The regulating services provided by deep-sea communities are vital for mitigating the climatic changes caused by anthropogenic greenhouse emissions. Additionally, the deep-sea provides the ecological service of absorbing and detoxifying pollutants, including persistent organic pollutants, sewage, and oil.[85]

Scientific and Research Value

The proposed New England Coral Canyons and Seamounts National Marine Monument presents an exceptional opportunity to advance our understanding and knowledge of deep-sea ecosystems, the largest and least explored ecosystems on earth. There is a relative dearth of information on the natural history of these ecosystems when compared to shelf ecosystems, including species life history, habitat requirements, species associations, and population-community dynamics. Indeed, even the list of species occurring in these environments is incomplete, as range extensions and new species are routinely discovered in exploratory dives.

The seamounts and canyons in the proposed national marine monument area have been the subject of recent scientific exploration and research cruises (2001-2014). These cruises, funded and/or led by NOAA (NOAA Fisheries, National Undersea Research Program, Office of Ocean Exploration) have involved numerous partners, including the U.S. Geological Survey, University of Connecticut, University of Maine, University of Louisiana, Woods Hole Oceanographic Institution, and many other academic institutions and non-profit organizations.

The deep-sea explorations are ongoing. From 2013-2015, the Deep-Sea Coral Research and Technology Program (DSCRTP) and the National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center has been leading an intensive investigation in collaboration with the University of Maine, University of Connecticut, University of Louisiana Lafayette, and Woods Hole Oceanographic Institution into deep-sea coral distribution, biology, and ecology in New England waters. This investigation builds on a larger NOAA-wide partnership, the Atlantic Canyons Undersea Mapping Expeditions (ACUMEN), which commenced in 2012.[86]

A NOAA report on the state of deep coral ecosystems identified a number of research objectives for the Northeast region.[87] These objectives highlight the extensive nature of scientific inquiry that the proposed national marine monument could support:[88]

- Advance taxonomy and population connectivity of deep-sea communities; determine which species and clades (groups of species evolved from a common ancestor) are endemic to the region.

- Improve knowledge of the ecological processes driving patterns of diversity, and examine how species composition and interactions structure deep-sea communities.
- Explore fundamental questions regarding growth, physiology, reproduction, recruitment, larval connectivity, recolonization rates, feeding, and habitat requirements of deep-sea organisms.
- Determine the physical parameters that affect the distribution and extent of deep-sea biodiversity (e.g., oceanographic and geologic parameters).
- Assess deep coral habitat biodiversity.
- Define deep-sea ecosystem food web relationships.
- Enhance our knowledge about how deep-sea ecosystems serve as essential fish habitat for federally managed species.
- Quantify the vulnerability or resilience of deep-sea corals to various anthropogenic threats, and the recovery rates of corals and coral habitats that have been injured or destroyed.

Protection of the deep-sea coral communities within the proposed national marine monument also provides a living laboratory for retrospective studies. For example, given their distribution in all ocean basins, and the fact that they can live for centuries, deep-sea corals have been used to reconstruct past changes in global climate and oceanographic conditions.[89] Because of the importance of the ancient biological record provided by some of these extremely long-lived animals, scientists have referred to seamount hard corals as the "old-growth redwoods of the deep ocean."[90] As such, the proposed national marine monument area can serve as an important reference area for scientists studying the effects of human activity and climate change on deep ocean ecosystems.

While deep-sea corals are a primary focus, given the size and extent of these organisms and their fragility, many other elements of deep-sea communities found in the proposed national marine monument area are important targets for fundamental and conservation research. For example, other areas of inquiry important for natural resource management and conservation include the development and evolution of chemosynthetic seep communities, the patterns and dynamics of xenophyophore populations, the effects of slope fisheries on deep sea fish communities, and the extent and dynamics of infaunal communities in fine grained sediments.

Cultural and Historical Value

At the end of the Pleistocene, around 12,000 years ago, the retreat of Ice Age glaciers and the lower sea levels of the time allowed access to terrestrial mammals and their hunters to areas of the continental shelf, including Georges Bank, that are now submerged. Fossil remains of large and now extinct paleo-megafauna (e.g., mammoth) have been observed at the heads of submarine canyons to the west (Auster, unpublished data). The shallowest portions of the proposed national marine monument may hold remains of Paleo-Indian cultural sites or hunting grounds.[91] This offshore ancient history creates a powerful story of climatic change, and could be leveraged to discuss ongoing climatic changes and their implications. Indeed, the canyons themselves were carved as river valleys carrying torrents of water to sea as Ice Age glaciers melted.

More recently, the proposed national marine monument was well-traversed by vessels from multiple nations over the last several centuries. Of particular archeological interest, the proposed area is within shipping lanes used during the 17th and 18th centuries to conduct trade, and was an area of conflict during both World War I and II where allied shipping and military vessels were attacked by German U-boats.[92] This area was also a route for transatlantic immigration from the 18th through the 20th century, with a peak period being the 1830s through the 1920s. An unknown number of vessels were lost during this period, some without a trace, and could lie in this site.[93]

Educational Value

The proposed national marine monument area offers myriad opportunities for both formal and informal education, building on existing education products and program models developed during earlier exploration and research expeditions in the area, including outreach and education efforts from NOAA-funded and NOAA-led expeditions such as DeepEast in 2001, Mountains-In-The-Sea in 2003 and 2004, Deep Atlantic Stepping Stones in 2005, CanyBal in 2005, Northeast U.S. Canyons in 2013 and Exploring Atlantic Canyons and Seamounts in 2014. These programs were developed and implemented by a community of scientists and educators, including at NOAA, University of Connecticut, Mystic Aquarium, Woods Hole Oceanographic Institution, University of Rhode Island, University of Maine and Gulf of Maine Research Institute.[94]

The otherworldly beauty and novelty of the North Atlantic canyons and seamounts have captured the attention of the larger public, opening the door for continued informal education and engagement. In 2013, the live video feed from the NOAA Ship *Okeanos Explorer* went viral: it was initially featured on the White House blog and several media outlets, spread to the Associated Press, and then to exponentially more news stories, blogs, and websites and to the Twitter sphere and Facebook, with the live video web page ultimately receiving approximately 660,000 hits by the expedition's close.[95] The proposed national marine monument could act as an ambassador of the deep-sea to the general public, and the region's aquaria, including Mystic Aquarium, the Maritime Aquarium at Norwalk, and the New England Aquarium, who all enthusiastically support permanent protection of the area, will provide a key portal to this fascinating underwater world.

The exploration of the canyons and seamounts broke new ground for scientists as well. The 2013 and 2014 expeditions 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.

The need to train scientists with both taxonomic and technology skills to successfully explore deep-sea ecosystems has been widely noted.[96] For example, NOAA has identified a shortage in coral taxonomists that can properly identify and genetically distinguish deep-sea coral, and advocated that more students need to be trained in coral taxonomy at the graduate level.[97] The

proposed national marine monument has the potential to attract interest and investment in educational opportunities that will train the next generation of ocean researchers.

Furthermore, there is cultural significance associated with the proposed national marine monument area that can help to tell the broader story of ocean exploration and discovery. For example, Heezen Canyon was named after famed deep-sea explorer Bruce Heezen, who with his close collaborator Marie Tharp, produced the first physiographic map of the North Atlantic in 1957.[98] This work, which documented for the first time the mountains, ridges and canyons of the ocean floor, transformed our view of the planet, and helped to spur our modern understanding of plate tectonics.[99] Some of the first dives of the occupied submersible *Alvin* were made in the Georges Bank submarine canyons, including Oceanographer Canyon, and on Bear Seamount in the late 1960s.[100] These are but two of many stories that can be told and amplified through the narrative of the proposed national marine monument of humanity's quest for understanding the most unexplored part of our planet.

Threats to the New England Coral Canyons and Seamounts National Marine Monument

Deep-sea ecosystems are widely-recognized to be highly vulnerable to human disturbance. Compared to shallow-water counterparts, deep-water species tend to have a longer lifespan, later sexual maturity, slower growth rates and lower natural mortality, all of which generally make them slow to recover from harm.[101] Deep-sea corals are particularly vulnerable. Some coral species are estimated to be anywhere from hundreds to thousands of years old and grow at only 1.5-2.5 millimeters a year.[102] Thus, acute anthropogenic disturbance, such as the physical damage caused by bottom-contact fishing gear like trawls (which are dragged along the bottom, crushing or burying vulnerable organisms) or weighted traps (which can knock down or crush vulnerable organisms), can have devastating effects, eliminating these fragile deep-sea communities without recovery in any ecologically-relevant period of time.

To date, except for the shallowest parts, the highly vulnerable deep-sea coral communities in the proposed national marine monument area have been largely protected because of their depth and the ruggedness of the topography. These barriers, however, may not last. Ongoing advances in fishing technology, depletion of inshore fish populations, shellfish impacts associated with coastal acidification, possible new markets, and other factors is likely to make the canyons and seamounts more attractive targets for fisheries. In addition, as offshore drilling extends into deeper and deeper waters and deep seabed mining, especially for metals and methane hydrates, become more economically viable, these activities pose future threats. Activities related to installation of transmission cables on the seafloor are also sources of possible harm. Now is the time for conservation measures to protect the coral canyons and seamounts, while the areas are still nearly pristine.

Commercial fishing

Deep-sea corals are especially susceptible to damage by fishing gear because of their often fragile, complex branching form of growth that can be easily broken off or damaged when raked by trawls, hit by pots or traps, or ensnared by fishing line or nets. Fishing has been shown to have severe impacts on deep-sea corals in other regions, and of the 11 coral species identified as being particularly vulnerable to fishing gear based on their physical characteristics, 10 of the species occur within the proposed national marine monument.[103] Scientists participating in the

Okeanos expeditions observed traps and lines in contact with dead coral and proximate to coral communities.[104] Traps were also a common sight in recent expeditions, and one derelict trap was observed deep in Heezen Canyon atop corals and sponges.[105]

Deep-sea fish are highly vulnerable to exploitation, as they are long-lived, slow to mature and sustain high juvenile mortality. A study in the Canadian waters of the Northwest Atlantic where deep-sea fishing occurs documented a decline over a 17-year period of five species of deep-sea fish to such an extent that they met the IUCN criteria for being critically endangered.[106] Further, the impacts of fishing extend beyond the footprint where fishing actually occurs. A study in the Northeast Atlantic demonstrated the effects of fishing on multiple populations (target and bycatch species) with deeper depth distributions, impacting areas thought to be refugia from human activities.[107] Marine mammals and fish are also susceptible to becoming ensnared in derelict fishing gear or caught as bycatch in commercial fishing gear.

For now, the depth and complex topography of the canyons and seamounts has limited the extent and types of commercial fishing. Pelagic longlining, primarily targeting tuna and swordfish, is the main fishing activity in the area. Annual revenues from the area specifically, however, represent only between an estimated 0.08 and 1.5 percent of total annual revenues for the U.S. Atlantic pelagic longline fishery. Other types of fishing common in the region, in which bottom gear is used, generally does not occur in the area because of its depth and/or ruggedness. Limited bottom trawling occurs in the very shallowest portions of the area around the heads of the three canyons (Gilbert, Nygren and Heezen), constituting approximately 5% of the area; bottom trawling is prohibited in Oceanographer and Lydonia Canyons under multiple fishery management plans. The use of traps for lobsters and red crabs is similarly limited to the very shallowest portions of the area. No bottom fishing at all currently occurs on the seamounts.

The relatively low exploitation of fisheries in the proposed national marine monument area means that both the pelagic and benthic ecosystems are relatively well-preserved. The proposed national marine monument would partially protect populations of species that are subject to overexploitation or other threats elsewhere along their range.

Oil and gas exploration and development

The exploration for and production of oil and gas resources can damage deep-sea ecosystems in multiple ways. Drilling into or placing structures such as platforms, anchors, or pipelines on the seafloor can cause direct physical damage. Drilling and production operations typically generate very large quantities of drilling waste and produced water, which is usually dumped over the side of the rig. Such wastes contain toxic metals and organic pollutants and can smother or contaminate deep-sea organisms. A catastrophic oil spill could damage deep-sea coral communities and harm the flora and fauna in the spill area.

Additionally, the initial exploration for oil often employs high-decibel seismic surveys to detect oil and gas deposits. Seismic surveys have been shown to disrupt essential behavior in endangered whales and other marine mammals, and to cause catch rates of some commercial fish to significantly decline – in some cases over enormous areas of ocean.[108] Ship traffic, helicopter traffic, drilling noise and other disturbance can cause marine wildlife to avoid important feeding and other essential habitat.

Deep-sea mining

Deep-sea mining and mineral exploration is beginning in other countries and in the high seas. Deep-sea minerals of particular interest include cobalt-enriched crusts, which occur on seamounts at depths of 3,000-8,000 feet, precisely the depth of the four seamounts in the proposed national marine monument area.[109] Mining on the seamounts could lead to a number of severe detrimental impacts, including the destruction of benthic species and habitats due to strip mining, increased sedimentation or the release of metals, which could affect fauna in the adjacent areas, as well as water column processes like primary productivity.[110] Given the likelihood of endemic species residing on the seamounts, such impacts could lead to local extinctions.

Methane hydrates extraction

While not yet commercially viable, research into the extraction of deep sea methane hydrates as a source of natural gas is ongoing in several countries, including the U.S., Canada, and Japan. Three areas in the U.S. – Alaska's North Slope, the Gulf of Mexico, and waters offshore of South Carolina – have been under investigation by U.S. scientists and energy companies from as early as 1982.[111] The extraction of hydrate deposits, which exist in the proposed area, could result in disruption of and harm to sensitive sea-floor ecosystems that depend on these deposits.

Invasive Species

Although little is known about invasive species in deep-sea environments, concern has been raised by scientists that the "sea squirt" (*Didemnum* sp. A), which is currently undergoing a massive population and range expansion in the Northeast, may pose a threat to deep-sea coral and sponge communities.[112] The invasive sea squirt is found on hard substrates, and its explosive growth smothers immobile or slow-moving organisms. Scientists believe that the species could contaminate new areas by inadvertent transportation on a ship hull, by the use of contaminated fishing gear (mobile or fixed), or by the washing of contaminated boat decks.

Climate change and ocean acidification

Climate change and ocean acidification together pose a serious threat to deep sea coral ecosystems. Deep-sea communities have evolved in relatively stable environmental conditions. Rapid climate change and ocean acidification are likely to alter environmental conditions, potentially outside of established thresholds for deep-sea organisms. Atmospheric climate change could be expected to lead to changes in temperature and current patterns in the deep-sea, which could lead to a reduction in oxygen levels and potentially a reduction in nutrient availability.[113] Another understudied but insidious potential threat is the impact of ocean acidification on deep-sea corals.[114] Ocean water made increasingly acidic due to the absorption of increasing levels of carbon dioxide is known to weaken coral skeletons and slow their growth, and may decrease food availability to corals.[115] On average, ocean waters have become 30% more acidic since the Industrial Revolution, and scientists' project the acidity of the ocean could double or triple by the end of the century.[116] A recent study examining the decline of pH (i.e., increasing acidity levels) suggests major pH reductions across 17% of the deep North Atlantic seafloor, including at some seamounts and canyons.[117] Another study suggests that the habitat suitability for cold-water stony corals is likely to be particularly reduced in the North Atlantic.[118]

By protecting an intact biodiversity hotspot, the proposed national marine monument will help to preserve important genetic diversity, increasing the possibility of successful organismal

adaptation and the maintenance of ecological function despite future environmental changes.[119] This protected area could also serve as a reference site for the study of the effects of climate change and ocean acidification on an ecosystem undisturbed by other human impacts.

Marine Debris and Plastic Pollution

A recent study off the U.S. west coast was the first to document the "surprisingly large amounts of discarded trash" that ends up in the deep ocean.[120] The scientists reported that trash – mainly plastics, metal objects, rope, fishing gear, glass bottles and aluminum cans – was not randomly distributed around the seafloor, but collected instead on the steep, rocky slopes of submarine canyons, and concentrated in the deeper parts of the canyon, suggesting that canyon currents can sweep coastal debris toward the deep sea.[121] The longevity of plastics in particular can be extremely long in the deep-sea environment as the anaerobic depths lack the bacteria and other organisms that can break down this type of debris. Plastics are known to smother or choke marine organisms that consume them. A separate study published in 2014 concluded, as a result of extensive sampling efforts, that "every square kilometer of deep ocean contains about four billion plastic fibers – most are two to three centimeters in length and as thin as a human hair. The fibers are four times more abundant in the deep sea than in surface and coastal waters."[122] No similar study has been done of marine debris and plastics in the Atlantic deep sea, although dive logs of the 2013-2014 *Okeanos Explorer* expeditions noted the presence of plastic, metal and fishing gear debris in the vast majority of the canyons visited.[123]

Submarine cables

The vast majority – 95% – of international communications are transferred through fiber optic cables that traverse the world's seafloors.[124] Ill sited and poorly laid cables can negatively impact the marine environment. For example, researchers from the Monterey Bay National Marine Sanctuary documented a cable on Pioneer Seamount that produced incisions into rocky habitat, presumably by abrasion with the armored cable jacket, and snagged drifting biological material such as kelp while static on the seafloor.[125] Researchers from NOAA and the U.S. Army Corps of Engineers also documented seafloor disturbance caused by unburied and suspended portions of cable that ran through the Olympic Coast National Marine Sanctuary.[126]

Need for Permanent Protection

The canyons and seamounts have been recognized by many management agencies as having significant ecological, scientific and educational value. However, the multiple management authorities that operate in the proposed national marine monument area are unable to provide the holistic and integrative framework for protection that these extraordinary ocean resources require. Designating the New England coral canyons and seamounts as a national marine monument with clear direction of how the area will be conserved and managed would ensure the protection of our deep-sea treasures for the long-term.

Existing management authorities

Currently, the regulatory and management authorities that exist for the proposed national marine monument include:

Deep-sea coral protection: The Magnuson-Stevens Fishery Conservation and Management Act (MSA) authorizes activities to better understand and conserve deep-sea coral communities. The law directed NOAA to establish a Deep Sea Research and Technology Program to help identify deep-sea coral communities. Regional fishery management councils were also provided the discretionary authority to designate deep-sea coral zones to protect deep-sea corals from the adverse effects of fishing. In 2010, NOAA developed a strategic plan related to deep-sea corals that included an objective to protect existing deep-sea coral and sponge communities from the impacts of bottom-tending fishing gear. Since 2009, the New England Fishery Management Council has been considering designation of the five canyons and the four seamounts as "Deep Sea Coral Protection Zones," which potentially would be accompanied by a prohibition on some or all bottom-tending fishing gear.[127] However, this process was put on hold in 2012. The Council announced its intent to restart development of deep-sea coral protections in the fall of 2015. However, the timing for completion of this process is unknown, as is the adequacy of any resulting protections. Moreover, assuming protections are implemented, they would not be permanent and would extend only to fishing impacts to deep-sea coral resources specifically. A national marine monument designation, on the other hand, would bring permanent, comprehensive and integrated protection to the area's deep-sea coral communities.

Fisheries Management: No less than five individual entities manage fish and marine mammal species in the proposed national marine monument area. Lobster is cooperatively managed by the states and the National Marine Fisheries Service (NMFS) through the Atlantic States Marine Fisheries Commission. Federal fisheries in the area are managed primarily by the New England Fishery Management Council (e.g., monkfish and hake) and the Mid-Atlantic Fishery Management Council (e.g., squid). Pelagic species like tuna, swordfish, and sharks are managed directly by the National Marine Fisheries Service (NMFS). Whale, dolphin and sea turtle species found in the national marine monument area are managed as protected species by NMFS.

The Mid-Atlantic Fishery Management Council has designated Lydonia and Oceanographer Canyons as "Habitat Areas of Particular Concern" pursuant to the essential fish habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act, and has prohibited the use of bottom trawls and dredges within these canyons. For its part, the New England Fishery Management Council has prohibited monkfish fishing in Oceanographer and Lydonia Canyons in order to prevent the expansion of bottom trawling in this fishery into the offshore canyons.[128] The New England Fishery Management Council recently approved the designation of Lydonia, Gilbert, Oceanographer and Heezen canyons and portions of Bear and Retriever seamounts as "Habitat Areas of Particular Concern"; while this designation emphasizes the habitat importance of these features, it does not offer any protections against fishing gear or other impacts.[129]

Submarine Cable Management: At least six entities have some authority over cable-laying in our oceans. Given the demonstrated impact of cables on rocky habitats and the potential for cables to ensnare marine wildlife, it is crucial that future cable-laying be conducted so as to preserve the special habitats and deep-sea organisms within the proposed national marine monument.

Oil and Gas Exploration and Development: The Bureau of Ocean Energy Management (BOEM) has authority for offshore oil and gas development in federal waters. In July of 2014, BOEM approved a framework for allowing seismic testing in the North Atlantic, the first of such surveys (which have been shown to disrupt essential behaviors in marine mammals and some fish species) in over 30 years.[130] While the proposed offshore oil and gas exploration management plans do not include the area of the proposed national marine monument, new seismic surveys could open the door to new drilling. The ecological, scientific and educational value of the proposed national marine monument could be irrevocably impaired as a result of seismic surveys, or subsequent energy exploitation (e.g., a catastrophic oil spill), and should be protected from these threats.

International Significance

Designation of the New England Coral Canyons and Seamounts National Marine Monument would complement and reinforce the international recognition that has been given to the portion of the New England Seamounts chain that is in international waters. An international scientific meeting held under the auspices of the Convention on Biological Diversity (CBD) determined that the New England Seamounts extending into international waters meet the CBD criteria for designation as Ecologically and Biologically Significant Areas (EBSAs).[131] Additionally, in recognition of the vulnerability of deep sea corals and other benthic habitats on the New England seamounts and in the canyons in the area beyond the U.S. EEZ, the Northwest Atlantic Fisheries Organization (NAFO) has established multiple closed areas, which include a number of canyons, as well as the New England Seamounts closed area that currently protects 112,000 square miles in international waters from bottom fishing.[132] The NAFO Scientific Council has recommended the extension of the New England Seamounts closed area to the boundary of the U.S. EEZ, which would protect seamounts just outside U.S. waters from bottom fishing.[133] The United States has strongly supported both the existing and the proposed closures.[134] Designating the New England Coral Canyons and Seamounts National Marine Monument would create the opportunity to highlight the connectivity between, and thus the global significance of, the New England canyons and seamounts, and the international cooperation underway to conserve important ecological resources of the high seas. National marine monument designation would also amplify the credibility of the U.S. positions taken in these international waters to protect the international seamounts in the New England Seamount chain.

The proposed national marine monument, by protecting canyons, cold seeps and deep-water organisms of Georges Bank, mirrors efforts underway in Canada, where the coldwater corals, sponge-dominated communities, hydrothermal vents and seamounts in the Gulf of Maine bioregion have been identified by scientists as a national priority for protection.[135] In particular, since 2002 Canada has protected several areas known for high concentration of corals from the impacts of destructive fishing practices. These areas include the Northeast Channel Coral Protection Area, the Gully Marine Protected Area, the Stone Fence Lophelia Conservation Area, the Southern Grand Banks Coral Protection Area, and the Sponge Conservation Areas. Elsewhere, such as in the Waterton Glacier International Peace Park, Canada and the U.S. work together to manage, study and interpret the extraordinary natural resources that span our common border. Perhaps even more so than on land, our underwater environments are connected, and a significant opportunity exists for a US/Canadian partnership to highlight this marine

interconnectedness and build upon an existing legacy of sharing natural resources and common conservation goals.

The threats to the canyons and seamounts in the proposed national marine monument are many and varied, ranging from acute harm resulting from destructive fishing practices and potential energy and mining development to the pernicious impacts of pollution, climate change and ocean acidification. As a national marine monument, managed activities would be guided by a single vision unified around protecting the invaluable deep-sea ecosystems and associated species present in the national marine monument area.

Support for the Designation and Management of the New England Coral Canyons and Seamounts National Marine Monument

Potential Collaborations and Partnerships to Support Monument Management

There are many opportunities for collaborations and partnerships that would assist the development of a vibrant and thriving New England Coral Canyons and Seamounts National Marine Monument. The following, based on broad topical areas of engagement, are elements of such collaborations and partnerships:

Interpretation and Education: The Association of Zoos and Aquariums (AZA) has multiple members in the region, including Mystic Aquarium, New England Aquarium, and Maritime Aquarium at Norwalk. AZA and its members, hosting 181 million visitors annually, have ocean conservation as a major element of their portfolio and national marine monuments can provide an important focus. In addition, the AZA's Save Animals From Extinction (SAFE) Initiative, with its focus on conservation, can help to highlight shark conservation issues, as multiple recent expeditions noted pelagic and deep-sea sharks within the proposed national marine monument area.

Mystic Aquarium, with 700,000 visitors, is the largest science and natural history attraction outside of the Boston area in the New England region. Mystic Aquarium is eager to become the public's portal for the New England Coral Canyons and Seamounts National Marine Monument. In particular, Mystic Aquarium stands ready to collaborate on development of interpretive materials, exhibit display and public outreach through website design and materials, social media networks and public events. New England Aquarium, with over 1.3 million visitors per year, and Maritime Aquarium in Norwalk have also expressed strong interest in potential collaborations around a permanently protected New England Coral Canyons and Seamounts area.

Educational and interpretive materials have been developed for K-12 curriculum as a result of recent expeditions to the canyons and seamounts, and Mystic Aquarium is ready to explore ways to adapt these materials and to expand their use in schools in Connecticut, the region and beyond. The Aquarium is the largest informal science education provider in Connecticut, reaching 100,000 students annually. Further, the University of Connecticut, a long-time partner with Mystic Aquarium in both research and education, was a principal collaborator with NOAA and others in developing the education programs associated with the initial Ocean Exploration expeditions to these canyons and seamounts. Faculty involved in those efforts also stand ready to partner on developing education programs for primary, secondary and college level programs.

Research and Monitoring: Research in this region has involved many investigators and institutions from across the country, focused on a diversity of subject areas and taxa, ranging in size from marine microbes to the great whales. The potential for ongoing research and monitoring partnerships and collaborations abound, and such activities – particularly research that requires a commitment to longitudinal data sets - would be given a renewed focus by designation of the proposed area.

Collections: Studies to date relating to the proposed national marine monument area have been using internationally-known collections as reference materials and as depositories for new materials: Smithsonian Institution, Yale Peabody Museum, Harvard Museum of Comparative Zoology. These institutions already have significant material (including holotypes and paratypes) of specimens collected from trawl-dredge and submersible collections since 2001 (Ocean Explorations and Census of Marine Life activities) and active curators and associated scientists with interests in this region. These institutions stand ready to accept new material in support of taxonomic survey and research needs of the national marine monument and associated research community. Managers of data collections (e.g., geophysical data such as multibeam, biological sampling data from imagery) can utilize existing national and international databases and repositories to enhance access and collaborations. For example, multibeam survey data has been archived and available from the Federal Geophysical Data Center (FGDC). Data on deep sea corals should be archived with the NOAA Deep Sea Coral Database. Linkages to other data bases, such as Ocean Biogeographic Information System (OBIS) can be done through existing databases (nodes) or receive contributions in a prescribed format from individuals. A plan for linking data and samples to particular repositories and keeping track of where such data are accessible will be a key element for management of this National marine monument. Mystic Aquarium and UConn stand ready to collaborate to organize a planning group to address this issue.

Operations: The proposed national marine monument is a significant distance from shore and natural resources extend from the surface and continental shelf seafloor to deep slope depths. The region hosts a large number of institutions and organizations that own and operate facilities that can provide access to the proposed national marine monument and would be able to work with federal managers, given available resources, to provide access to the national marine monument. These include capabilities in direct underwater observation and sampling using such tools as: University of Connecticut Northeast Undersea Research, Technology & Education Center's (NURTEC) ROVs Kraken 2 and Hela as well as the ISIS2 camera platform that can operate to 1000 m; Woods Hole Oceanographic Institution's National Deep Submergence Facility (NDSF; operating DSV Alvin, ROV Jason/Medea, AUV Sentry) and associated laboratories (e.g., Deep Submergence Laboratory, MISO) that operate and develop tools for working in the deep ocean (e.g., Towcam 2). NOAA's Ocean Exploration and Research facility in Narragansett operates the NOAA Ship *Okeanos Explorer* with the ROV Deep Discoverer/Seirios. In addition, multiple NOAA, University National Oceanographic Laboratory System (UNOLS), and other university and private vessels can support deep submergence and standard oceanographic sampling systems (e.g., NOAA Ship Henry B. Bigelow, UNOLS vessels operated by WHOI RVs Atlantis, and the soon to be launched Neil Armstrong, RV Endeavor operated by University of Rhode Island, RV Connecticut owned and operated by University of Connecticut).

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