Oral Argument Not Yet Scheduled

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

18-5353

MASSACHUSETTS LOBSTERMEN'S ASSOCIATION, et al.,

Plaintiffs-Appellants,

—v.—

WILBUR ROSS, et al.,

Defendants-Appellees,

—and—

NATURAL RESOURCES DEFENSE COUNCIL, et al.,

Intervenors for Defendant-Appellees.

ON APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA
NO. 1:17-CV-00406 (HON. JAMES E. BOASBERG)

BRIEF OF ACADEMIC SCIENTISTS AS *AMICI CURIAE* IN SUPPORT OF APPELLEES

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CERTIFICATE OF COUNSEL AS TO PARTIES, RULINGS, AND RELATED CASES

Pursuant to D.C. Circuit Rule 28(a)(1) and Federal Rule of Appellate Procedure 26.1, counsel for *Amici Curiae* Academic Scientists certifies as follows:

A. Parties and *Amici*

Except for proposed *amici* herein and other *amici* that may seek leave to participate before this Court, all parties, intervenors, and *amici* appearing before the district court and this Court are listed or referenced in the Appellants' opening brief and the Federal Appellee's Response Brief.

B. Rulings Under Review

References to the rulings at issue appear in the Appellants' opening brief.

C. Related Cases

There are no related cases within the meaning of D.C. Circuit Rule 28(a)(1)(C).

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

PRESIDENTIAL PROCLAMATIONS

STATUTES

ADMINISTRATIVE MATERIALS

ACADEMIC LITERATURE

OTHER AUTHORITIES

CERTIFICATE REGARDING CONSENT TO FILE AND SEPARATE BRIEFING

Federal Appellees and Intervenors-Appellees have consented to the filing of this brief so long as it conforms to D.C. Circuit Rules. Appellant has not consented to the filing of this brief.[1]

The Academic Scientists filed their motion to participate in this case as *amici curiae* on June 5, 2019. Pursuant to Circuit Rule 29(d), the Academic Scientists certify that it is necessary for them to file a separate brief because the expertise and perspective that the Academic Scientists offer the Court is distinct from the insights to be offered by the other four proposed amicus briefs. Three of those briefs speak to legal issues and will be submitted on behalf of (1) law school professors, (2) ocean experts and former State Department officials, and (3) United States Senators. The fourth proposed brief will be submitted on behalf of the National Audubon Society, an organization that both advocates for and engages in the scientific study of seabirds, and will explain why designation under the Antiquities Act is vital to the conservation of the ecosystems encompassed by the Monument that support seabirds.

[1] Counsel for *amici* certifies that no counsel for a party authored this brief in whole or in part and that no person, other than *amici* or their counsel, made a monetary contribution to the preparation or submission of this brief. *See* Fed. R. App. P. 29(a)(4)(E).

INTERESTS OF THE *AMICI CURIAE*[2]

Amici are a multidisciplinary group of academic scientists with expertise in marine biology, ecology, oceanography, genetics, conservation biology, and marine protected areas including national monuments and their design. The 30 *amici* listed in the Appendix include 17 members of the National Academy of Sciences. Many *amici* have authored definitive works on marine protected areas and contributed to scientific assessments of marine protected areas. A number of *amici* have expertise concerning the area comprising the Northeast Canyons and Seamounts Marine National Monument (the "Monument") based on research they have conducted within its bounds and the immediate vicinity.

Amici submit this brief to explain the importance of protecting the Monument area for the preservation of the distinctive, complex, interconnected ecosystems the Monument contains and of ongoing research conducted therein. Protecting the monument area preserves a haven for wildlife and a climate change reference area, and enhances resilience of species and ecosystems to climate change impacts. Research and study of the Monument area and its specific ecology and topography depend on the long-term robust protection provided by designation as a National Monument under the Antiquities Act.

[2] All *amici* join this brief as individuals and not as representatives of any institution or organization.

ARGUMENT

I. Marine Protected Areas Are Critical to the Conservation and Study of the World's Oceans

Over 95 percent of the living space available to life on earth is in the ocean.[3] The world's oceans produce half its oxygen,[4] absorb more than one-third of anthropogenic carbon emissions,[5] and absorb more than 90 percent of the excess heat trapped by greenhouse gases.[6] The oceans provide food for billions of people and support coastal economies worldwide. The oceans' ecosystems produce countless medical and scientific discoveries. The oceans are vast, but they are vulnerable.

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[3] Andrea Mustain, Mysteries of the Oceans Remain Vast and Deep, LiveScience (June 8, 2011), https://www.livescience.com/14493-ocean-exploration-deep-sea-diving.html.

[4] Russell Leonard Chapman, Algae: the world's most important "plants"—an introduction, 18 Mitigation and Adaption Strategies for Global Change 5 (2013), https://doi.org/10.1007/s11027-010-9255-9.

[5] Nicolas Gruber et al., *The oceanic sink for anthropogenic CO2 from 1994 to 2007*, 363 Science 1193 (2019).

[6] C. Le Quéré et al., *The global carbon budget 1959-2011*, 5 Earth Sys. Sci. Data Discussions 165 (2013), https://www.earth-syst-sci-data.net/5/165/2013/essd-5-165-2013.pdf; S. Levitus et al., *World ocean heat content and thermosteric sea level change (0–2000 m), 1955–2010*, Geophysical Research Letters (2012), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012GL051106; *see also* D. Laffoley & J.M. Baxter, *Explaining ocean warming: Causes, scale, effects and consequences*, IUCN (Sept. 2016), https://portals.iucn.org/library/sites/library/files/documents/2016-046_0.pdf.

Human activity has depleted, disrupted, and degraded the oceans. For most of human history, most of the ocean was too far from land or too deep to be substantially exploited by humans. Technological advancements have overcome these barriers and modern industries – particularly fishing, mining, and oil and gas exploration – have penetrated further and deeper in the last half century than ever before. In that time, industrial fishing has depleted the ocean's populations of large fishes by between 60 and 90 percent.[7] Marine mammals, sea turtles, seabirds, deep-sea corals, and other long-lived marine species have been significantly depleted, victim to collateral impacts of commercial fishing: food source depletion, bycatch (the catch of non-target species), and habitat destruction. Many are now endangered.

As modern industrial fishing has damaged habitats far from land and in deep waters, other human activities also have deleterious effects. Excess nutrients from wastewater, toxic chemicals, and plastics pollute the oceans.[8] Anthropogenic

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[7] Ransom A. Myers, Boris Worm, *Rapid worldwide depletion of predatory fish communities*, 423 Nature 280 (2003); John Sibert et al., *Biomass, size, and trophic status of top predators in the Pacific Ocean*, 314 Science 1773 (2006); Maria José Juan-Jordá et al., *Global population trajectories of tunas and their relatives*, PNAS (Dec. 20, 2011), https://www.pnas.org/content/pnas/108/51/20650.full.pdf.

[8] R.W. Bachmann et al., *Eutrophication of freshwater and marine ecosystems*, 51 Limnology & Oceanography 351 (2006); Andrés Cózar et al., *Plastic debris in the open ocean*, PNAS (July 15, 2014), https://www.pnas.org/content/pnas/111/28/10239.full.pdf; *see also* Melissa

climate change has made the oceans warmer, more acidic, and less oxygen-rich.[9] As a result of modern extractive industry and climate change, functional marine biodiversity is diminishing, populations are shrinking, and ecosystems are changing in ways scientists are only beginning to understand.[10] As stated unequivocally by the recent international scientific assessment on biodiversity, fishing is the biggest driver of loss of biodiversity in the ocean.[11]

Marine protected areas ("MPAs") offer a means to study and ultimately counter some of the impacts of human activity. MPAs provide a reference area to separate impacts of fishing from impacts of climate change. By excluding all or most extractive activities, MPAs can restore biodiversity, recover many depleted populations, and protect the genetic and species diversity that provide the potential for adaptation to environmental change.

Denchak, *Ocean Pollution: The Dirty Facts*, NRDC (Jan. 22, 2018), https://www.nrdc.org/stories/ocean-pollution-dirty-facts.

[9] Scott C. Doney et al., *Ocean Acidification: The Other CO2 Problem*, 1 Ann. Rev. Marine Sci. 169 (2009); Ralph F. Keeling et al., *Ocean Deoxygenation in a Warming World*, 2 Ann. Rev. Marine Sci. 199 (2010); Ralph F. Keeling & Hernan E. Garcia, *The Change in Oceanic O2 Inventory Associated With Recent Global Warming*, PNAS (June 11, 2002), https://www.pnas.org/content/pnas/99/12/7848.full.pdf.

[10] Sandra Diaz et al., *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (May 6, 2019), https://www.ipbes.net/news/ipbes-global-assessment-summary-policymakers-pdf.

[11] *Id.*

The purpose of a protected area (whether on land or in the ocean) will determine the size it needs to be. If an MPA is intended to protect an ecosystem (rather than a few target species), it needs to be large enough to encompass the critical habitats of both juvenile and adult stages of most of the species in that system. The MPA size must also be relevant to the particular physical oceanography of the ecosystem, for example, to ensure adequate supply of nutrients, or juvenile stages. In many marine ecosystems, the different life history stages of a single species often live in different habitats, beginning life as a larva borne on an ocean current, then living in a different, specific habitat as a juvenile, and moving to yet another specific habitat more suited to the needs of its adult stage.[12]

MPAs come in several levels of protection: fully protected, highly protected, lightly protected, and minimally protected.[13] Fully and highly protected areas result in significantly greater conservation benefits than lightly or minimally protected areas.[14] Permanent protection is necessary for sustained conservation

[12] Brian A. Grantham et al., *Dispersal Potential of Marine Invertebrates in Diverse Habitats*, 13 Ecological Applications S108 (Supp. 2003).

[13] An Introduction to the MPA Guide, http://wcmc.io/8408.

[14] Enric Sala et al., *Assessing real progress towards effective ocean protection*, 91 Marine Pol'y 11 (May 2018), https://doi.org/10.1016/j.marpol.2018.02.004.

benefits.[15] The Monument, which permits recreational, but not commercial fishing, is a highly protected MPA. As such, it offers substantially more robust, and permanent, protection than would a protected area created under other authorities.

There are three principal statutory authorities that could be used to create an MPA, but only the Antiquities Act has preservation as its sole focus.[16] The second, the National Marine Sanctuaries Act, focuses on engaging the public and ensuring a mix of resource uses, usually by combining fishing, recreation and some conservation.[17] Only around four percent of the total area in the existing National Marine Sanctuaries is highly protected.[18] The third authority, the Magnuson-Stevens Fishery Conservation and Management Act, focuses on optimizing fisheries.[19] Although protected areas can be designated under this authority, that protection can be revoked at any time if the relevant Regional Fishery Management Council alters plans for the area.[20] Revocation of protection destroys any benefit accrued during the protected period. These three statutory authorities

[15] *Id.*; *see also* Enric Sala & Sylvaine Giakoumi, *No-take marine reserves are the most effective protected areas in the ocean*, 75 ICES J. Marine Sci. 1166 (2017).

[16] 16 U.S.C. § 431.

[17] 16 U.S.C. § 1811.

[18] Marine Conservation Institute, *Atlas of Marine Protection*, www.mpatlas.org (last visited May 31, 2019).

[19] 16 U.S.C. § 1431.

[20] *Id.*

are complementary; each serves a different purpose: (1) preservation; (2) multiple-use and education; and (3) fishery benefit.

In a highly protected MPA, all forms of commercial extractive industry are prohibited.[21] Highly protected areas with the full complement of top predators appear to be more ecologically resilient to environmental changes, such as climate change, than exploited areas.[22] As a highly protected area recovers from prior exposure to industrial fishing, fish and other previously targeted species such as lobsters and scallops become larger and denser. Biodiversity returns.[23] A highly protected MPA is more bountiful than unprotected areas and this bounty seeps into the surrounding waters, a phenomenon called "spillover" that is known to fishermen who "fish the line," concentrating their efforts along the margins of MPAs.[24]

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[21] Kristen Grorud-Colvert et al., *High-profile international commitments for ocean protection: Empty promises or meaningful progress?*, 105 Marine Pol'y 52 (July 2019), https://doi.org/10.1016/j.marpol.2019.04.003.

[22] Callum M. Roberts et al., *Marine reserves can mitigate and promote adaptation to climate change*, PNAS (June 13, 2017), www.pnas.org/cgi/doi/10.1073/pnas.1701262114; Sarah E. Lester & Benjamin S. Halpern, *Biological responses in marine no-take reserves versus partially protected areas*, 367 Marine Ecology Progress Series 49 (2008).

[23] *Id.*

[24] Benjamin S. Halpern et al., *Spillover from marine reserves and the replenishment of fished stocks*, 36 Envtl. Conservation 268 (2010).

Highly protected MPAs are necessary for two principal reasons. First, they protect biodiversity and fragile habitats and ecosystems. Second, they permit scientists to study the impacts of extractive human activities on the oceans by providing a "control" or "reference" area with which to compare impacted areas. For example, commercial fishing typically targets the largest individual fishes in an area. This practice exerts evolutionary pressure on fish populations to reproduce at smaller sizes. It also tends to remove the large-bodied individuals in a population, dubbed "BOFFFs" ("Big, Old, Fecund, Female Fish"), which are the highest producers of young and are critical for maintaining populations.[25] A highly protected MPA can counter the impacts of industrial fishing that would otherwise result in smaller and fewer fish and facilitate further study of its ecosystems.

II. The Monument Protects an Area of Great Scientific Interest

The canyons and seamounts, along with the adjacent shelf, intervening seafloor, and overhead water column, comprise a variety of depths, habitats, and topographical features. The relative proximity of these features creates ideal

[25] Mark A. Hixon et al., *BOFFFs: on the importance of conserving old-growth age structure in fishery populations*, 71 ICES J. Marine Sci. 2171 (Oct. 2014); *see also* Jane Lubchenco et al., *The Science of Marine Reserves*, Partnership for Interdisciplinary Studies of Coastal Oceans (2002). https://www.waterboards.ca.gov/centralcoast//board_info/agendas/2005/sept/item15/item15_attachment6.pdf.

conditions for flourishing ecosystems and dense profusions of life. These features, and the ecosystems they support, are of great scientific interest.

The varied habitats and complex currents created by the canyons and seamounts support significant and interconnected concentrations of marine life. The diversity of slopes, depths, and substrates (the seafloor material) provide homes to a variety of uncommon and understudied marine communities. As the Monument is further explored, new species are sure to be discovered. As recently as April 2019, researchers discovered two new species of cold-water bubblegum corals, which are notoriously slow-growing.[26]

The Monument hosts hotspots for deep-water corals, sponges, crustaceans, deep-sea fishes and other sea life.[27]

[26] Kendra Pierre-Louis, *'Dr. Seuss's Garden' Yields a Deep-Sea Discovery, but It Already Faces Threats*, N.Y. Times, Apr. 19, 2019, https://www.nytimes.com/2019/04/09/climate/coral-atlantic-warming.html.

[27] NOAA Fisheries, *Northeast Canyons and Seamounts Marine National Monument*, https://www.fisheries.noaa.gov/new-england-mid-atlantic/habitat-conservation/northeast-canyons-and-seamounts-marine-national (last visited May 31, 2019).

Octopus in Physalia Seamount. Credit: NOAA

Corals, sea pens, sponges, sea whips, anemones, and lace-forming animals called bryozoans inhabit harder substrates.[28] Brittle stars and a variety of worms, snails, clams, and sea cucumbers move across or plow through softer sediments.[29] Cat sharks, hake, flounder, rays, and other bottom-dwelling fishes variously use these invertebrates as shelter, or as food. Other species, like American lobsters and

[28] Thomas F. Hourigan et al., *The State of Deep-Sea Coral and Sponge Ecosystems of the United States*, NOAA Technical Memorandum (Dec. 2017) (citing Les Watling & Peter J. Auster, *Distribution of deep-water Alcyonacea off the Northeast coast of the United States*, Cold-Water Corals and Ecosystems (A. Freiwald & J.M. Roberts eds., 2005)).

[29] *See* Andrea M. Quattrini et al., *Exploration of the Canyon-Incised Continental Margin of the Northeast United States Reveals Dynamic Habitats and Diverse Communities*, PLOS ONE, Oct. 28, 2015, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0139904.

tilefishes, create additional habitat by burrowing into canyon walls.[30] The Monument also hosts ecosystems associated with methane seeps – areas of the ocean floor where methane leaks from tectonic fissures and that often support communities of unusual organisms that convert chemicals, rather than sunlight, into energy.[31] Those chemosynthetic organisms in turn provide food for other sea life such as shrimps and crabs.

The steep sides of the canyons and seamounts divert ocean water moving along the bottom to cause strong and complex currents that move upward along the sides and into the water column above. These currents connect the deep sea and shallower waters. They transport (or "upwell") cold, nutrient-rich water upward into the water above the canyons and seamounts. This infusion of nutrients to the higher portions of the canyons and seamounts and the waters above them is a key feature of these ecosystems that produces ideal conditions for a profusion of life. The upper slopes and water above are like oases, supporting unusually lush populations of plankton, krill, and small fish. Those plants and animals, in turn,

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[30] *Id.*

[31] *See* Peter J. Auster & Scott D. Kraus, Comment Letter on Review of Certain National Monuments Established Since 1996, July 7, 2017, https://www.regulations.gov/document?D=DOI-2017-0002-619132 (citing A. Skarke et al., *Widespread methane leakage from the sea floor on the northern US Atlantic margin*, 7 Nature Geoscience 657 (2014)).

attract larger animals like fishes, marine mammals, and an unusually high density and diversity of seabirds.

The topographic and oceanographic features of the Monument area create interconnecting ecosystems that span from the seafloor to the surface and from the canyons and seamounts laterally to the continental shelf.[32] Dense swarms of krill migrate up and down the water column every day.[33] The krill rise toward the surface at dusk, providing prey to pelagic fishes and marine mammals. During their dawn downward migration, these swarms condense as they encounter "topographic blockage" in the canyon heads and are funneled by the topography of the canyons.[34] This combination of physical features condenses the krill into swarms exceeding 1000 individuals per cubic meter in density.[35] The density of this energy-rich prey is highly attractive to the fish and squid that prey on them at

[32] Auster & Kraus, *supra* note 31 (citing Karline Soetaert et al., *Ecosystem engineering creates a direct nutritional link between 600m deep cold-water coral mounds and surface productivity*, 6 Sci. Rep. 35057 (2016), https://www.nature.com/articles/srep35057).

[33] *See id.* (citing C.H. Greene et al., *Acoustical detection of high-density krill demersal layers in the submarine canyons off Georges Bank*, 241 Science 359 (1988)).

[34] *See id.* (citing E.S. Hobson et al., *Predation on ocean krill*, 243 Science 237 (1989)).

[35] Hobson, *supra* note 34.

depth. The resulting aggregations of fish and squid provide prime feeding grounds for the Monument's particularly diverse population of marine mammals.[36]

The accumulation of squid and fish appears to create ideal feeding grounds for a variety of poorly understood, deep-diving whales. The Monument is home to at least three species of beaked whales.[37] These whales, the world's champion divers, have been recorded diving to over 6000-foot depths and remaining submerged for over an hour.[38] Indeed, the tell-tale gouges left by beaked whales preying on deep-sea squid and other prey have been reported on the canyon floors in both Gilbert and Lydonia Canyons at a depth of 9,000 feet.[39] An unusual diversity of endangered whales, including blue, fin, sei, sperm, and right whales, also feed in the nutrient-rich waters upwelled by the canyon walls and seamount

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[36] *See* Auster & Kraus, *supra* note 31 (citing H.B. Moors-Murphy, *Submarine canyons as important habitat for cetaceans, with special reference to the Gully: A review*, 104 Deep Sea Research Part II: Topical Studies in Oceanography 6 (2014)).

[37] *See id.* (citing G.T. Waring et al., *Characterization of beaked whale (Ziphiidae) and sperm whale (Physeter macrocephalus) summer habitat in shelf-edge and deeper waters off the northeast U.S.*, 17 Marine Mammal Sci. 703 (2001)).

[38] Waring, *supra* note 37.

[39] *See* Auster & Kraus, *supra* note 31 (citing Peter J. Auster & Les Watling, *Beaked whale foraging areas inferred by gouges in the seafloor*, 26 Marine Mammal Sci. 226 (2010)).

slopes.[40] The same dense aggregations of prey that attract whales also support populations of large predatory fishes like swordfish, marlin, and tuna. The richness of the Monument area provides these wide-ranging large predators a network of critical feeding areas. A recent study tracking the movement of more than 30 short-finned pilot whales found submarine canyons to be their most heavily used habitat.[41] The whales stopped at each canyon for days, or even weeks, to feed.[42]

At least 23 species of whales, dolphins, and porpoises have been recorded in the Monument area. The area is so rich with life that it is common to see more than ten separate species in a day, including rare animals seldom seen elsewhere. A scientific survey crew aboard the NOAA ship *Henry Bigelow*, observing in the area during August of 2016, reported sightings of "sperm whales in deep waters near Oceanographer Canyon," along with thousands of common dolphins, dozens of fin whales, humpback whales, pilot whales, Risso's dolphins, bottlenose

[40] NOAA Fisheries, *Species Directory*, https://www.fisheries.noaa.gov/species-directory (last visited May 31, 2019).

[41] Lesley H. Throne et al., *Movement and foraging behavior of short-finned pilot whales in the Mid-Atlantic Bight: importance of bathymetric features and implications for management*, Marine Ecology Progress Series 246 (2017).

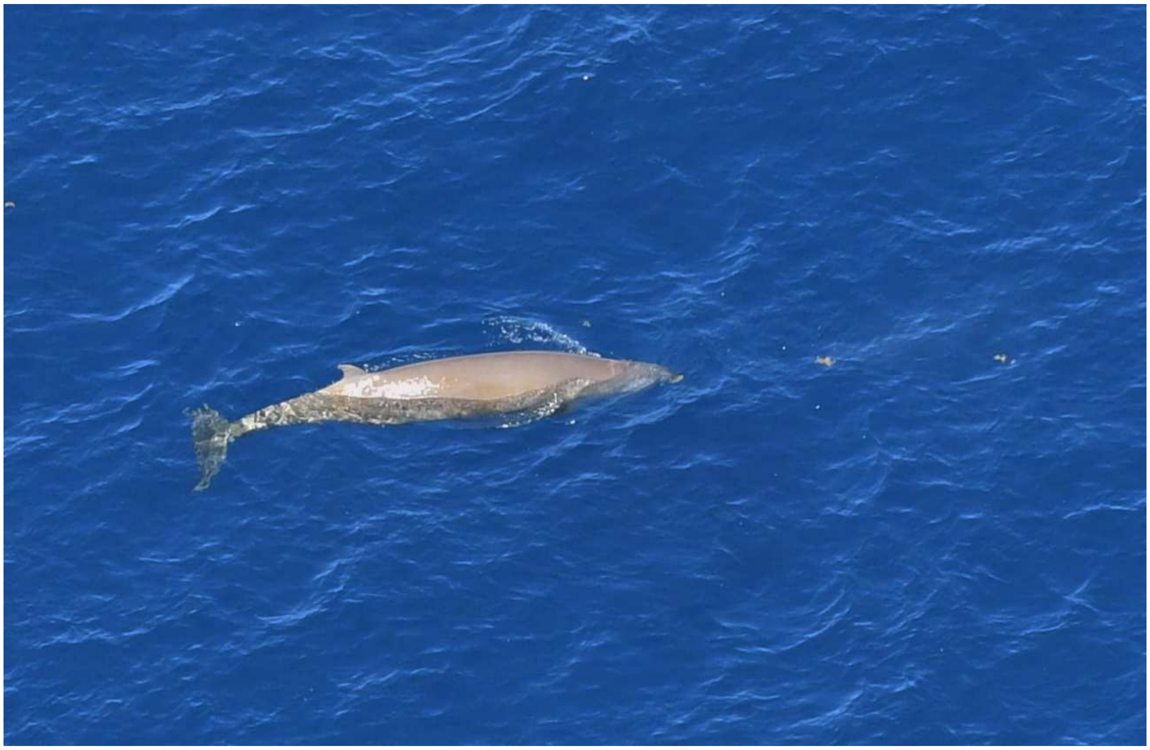
[42] *Id.*

dolphins, striped dolphins, and a few beaked whales and ocean sunfish.[43] An aerial survey of the Monument in April 2018 sighted hundreds of dolphins and dozens of whales, including thirteen rarely seen deep-diving Sowerby's beaked whales.[44] Another aerial survey in September 2018 recorded more than six hundred animals in just four hours, including hundreds of dolphins, two beaked whales, and a rare giant manta ray.[45] These large fish and marine mammals thrive at shallower depths because of the cycling of nutrients from the ocean floor within the Monument.

[43] *See* Auster & Kraus, *supra* note 31 (citing NEFSC, *A Record Day!*, Field Fresh: NEFSC Science in Motion (Aug. 12, 2016), https://nefsc.wordpress.com/category/amapps/).

[44] Emily Greenhalgh, *Aerial Survey Highlights Diversity at Northeast Canyons and Seamounts Marine National Monument*, Anderson Cabot Center for Ocean Life (May 10, 2018), https://www.andersoncabotcenterforoceanlife.org/blog/aerial-survey-highlights-diversity-at-northeast-canyons-and-seamounts-marine-national-monument/.

[45] Ester Quintana, *600+ Animals in 4 Hours: Biodiversity Abounds in the Monument*, Anderson Cabot Center for Ocean Life (Sept. 12, 2018), https://www.andersoncabotcenterforoceanlife.org/blog/september-aerial-survey-canyons-and-seamounts/.



Cuvier's beaked whale in Monument area. Credit: NEQ/ACCOL aerial survey team

Dolphin superpod in Monument area. Credit: NEQ/ACCOL aerial survey team

A. The Monument Area's Interconnected Ecosystems Provide Far-Reaching Benefits

The large-scale nutrient cycling and other processes that occur in the Monument area also provide a bulwark against some of the effects of climate change and ocean acidification, which is increasingly crucial as climate change and human impacts on ocean systems accelerate. The same nutrient cycle that connects the Monument's ecosystems also functions to sequester carbon. Billions of microscopic plants in the upper, sunlit waters of the Monument take in carbon dioxide to photosynthesize. They are eaten by herbivores of varying sizes; predators consume those herbivores, and in turn are eaten by their predators. Much of this organic carbon is cycled from the surface to the seafloor through defecation or the sinking of dead organisms.[46] On the seafloor, this surface carbon is locked into the bodies of deep-sea organisms like corals and benthic communities.[47]

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[46] *See* Auster & Kraus, *supra* note 31 (citing Joe Roman & James J. McCarthy, *The whale pump: marine mammals enhance primary productivity in a coastal basin*, PLOS ONE, Oct. 11, 2010, https://doi.org/10.1371/journal.pone.0013255); *id.* at 6 (citing Marsh J. Youngbluth et al., *Fecal pellet production and diel migratory behavior by the euphausiid effect benthic-pelagic coupling*, 36 Deep Sea Research Part A 1491 (1989); Barbara Hecker, *Photographic evidence for the rapid flux of particles to the sea floor and their transport down the continental slope*, 37 Deep Sea Res. 1773 (1990)).

[47] Auster & Kraus, *supra* note 31 (citing D. van Oevelen et al., *The cold-water coral community as hotspot of carbon cycling on continental margins: A food-web analysis from Rockall Bank (northeast Atlantic)*, 54 Limnology & Oceanography 1829 (2009)).

These processes are more robust in canyon and seamount topographies due to downwelling and upwelling along the canyon walls and seamounts, tidal influence and complex currents interacting with the topography, and the canyons and seamount slopes linking the shallows and the pelagic water column to the deep sea.

Mid-water fish that are abundant in the Monument also contribute to carbon sequestration and resilience to ocean acidification.[48] These fish embark on substantial daily vertical migrations, from deep water to shallow and back.[49] When they defecate at the surface, carbonate byproducts of their digestion absorb CO2 dissolved in the shallow water, and then sink to the seafloor.[50] Their daily migrations mean that the mid-water fish that accomplish this feat would be in danger were the Monument to exclude a portion of their ecosystem.

B. The Monument Area is Important to Conservation and to Understanding the Effects of Human Activities on Ocean Life

Protection of the Monument area in its current bounds also allows the Monument to serve scientific goals. Once commercial fishing has been phased out, the Monument will be the only highly protected area off the Atlantic Coast of

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[48] *Id.* (citing P.C. Davidson et al., *Carbon export mediated by mesopelagic fishes in the northeast Pacific Ocean*, 116 Progress in Oceanography 14 (2013)).

[49] *Id.*

[50] *Id.*

North America,[51] and will provide scientists with a functioning set of interconnected ecosystems to study with minimal human interference. The Monument will also provide a critical reference area to compare against other sites where commercial extractive activities are allowed, advancing scientific understanding and informing smart management in the future.

The Monument area serves as a crucial reference area to study the impact of commercial fishing. Commercial fishing equipment, from fixed gear like traps, gillnets, and fixed longlines to mobile gear like trawls, is known to have significant impacts on habitats, species and ecosystem dynamics. Fishing (even sustainable fishing) and bycatch of non-target species have cascading effects throughout an ecosystem. The Monument area is the only entanglement-free and bycatch-free zone off the east coast of the United States.[52]

The Monument, with its intact, fully functioning, protected ecosystems will also serve as a crucial reference against which to measure the impacts of seafloor mining, as new technology makes such mining more economically attractive. All along the Atlantic coast, the possibility of exploration for and exploitation of oil,

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[51] Marine Conservation Institute, *SeaStates US 2017*, https://marine-conservation.org/seastates/us/2017/ (last visited May 31, 2019).

[52] Auster & Kraus, *supra* note 31, at 9.

gas, methane hydrates, and manganese is growing, along with the concomitant environmental risks.[53]

Finally, the Monument area will serve as an important resource in the study of climate change. The Monument area provides a means for scientists to study the effects of climate change on marine ecosystems without interference from fishing or extractive industry. The effects of a warming planet, and rapidly warming oceans (studies show that the waters off the New England coast are warming faster than any other region in the Atlantic[54]), are not yet well understood. A reference region otherwise free from direct human interference is crucial to studying the changes in marine ecosystems wrought by climate change.

These features and ecosystems, the Monument's objects of scientific interest, are vital to recent, ongoing, and planned research. The Monument contains many ecological communities that are poorly understood and yet to be studied, including coral-sponge ecosystems and xenophyophore (aggregations of possibly unicellular

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[53] *Id.* (citing Nick Snow, *BOEM will resume evaluating requests to study Atlantic OCS potential*, Oil & Gas Journal, May 11, 2017, http://www.ogj.com/articles/2017/05/boem-will-resume-evaluating-requests-to-study-atlantic-ocs-potential.html).

[54] Auster & Kraus, *supra* note 31, at 7 (citing Katherine E. Mills et al., *Fisheries management in a changing climate: lessons from the 2012 ocean heat wave in the Northwest Atlantic*, 26 Oceanography 191 (June 2013)).

organisms that form shell-like structures out of minerals) communities.[55] Planned studies seek to measure the change in the Monument area's ecosystems over time. A series of studies in the 1980s exploring the Monument area via submersible resulted in a trove of data.[56] A new study to revisit the same sites as the 1980s study is being planned, and would use the prior study data as a baseline against which to measure changes in the Monument area ecosystems.[57] The Monument ecosystems will likely provide discoveries and insights across multiple disciplines from ecology to oceanography, genetics to natural products chemistry, microbial biology to marine mammalogy, and more.

III. Commercial Fishing in the Monument Would Pose a Grave Threat to the Monument's Objects and to Scientific Study of Them

Of all extractive activities, fishing is the most immediate threat to biodiversity globally and the health of ecosystems in the Monument area.[58] Species depletion through fishing has far-reaching, lasting, and difficult to predict

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[55] *See id.* (citing Andrea M. Quattrini et al., *Exploration of the Canyon-Incised Continental Margin of the Northeast United States Reveals Dynamic Habitats and Diverse Communities*, PLOS ONE, Oct. 28, 2015, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0139904).

[56] *See id.* (citing R.A. Cooper et al., *Pre- and post-drilling benchmarks and monitoring data of ocean floor fauna, habitats, and contaminant loads on Georges Bank and its submarine canyons*, NOAA Symposium Series for Undersea Research 2, 17-48 (1987)).

[57] *Id.*

[58] *See* Diaz, *supra* note 10.

consequences. Species in an ecosystem are connected to one another, and depletion of one often has cascading consequences for others. The larger North Atlantic ecosystem has already been significantly altered by centuries of fishing. The depletion of baleen[59] and sperm whales,[60] Atlantic halibut,[61] northern cod,[62] and Bluefin tuna[63] are well-documented examples of fishing's significant impact on both target and non-target species. Bycatch, the capture of non-target species, which may include whales, sharks, sea turtles, seabirds, and non-commercially valuable fishes, as well as juveniles of commercially valuable fishes, remains a persistent problem in U.S. fisheries. More than one billion pounds of bycatch are hauled in each year in the U.S. alone.[64] Even light amounts of industrial fishing

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[59] Peter O. Thomas et al., *Status of the world's baleen whales*, Publications, Agencies and Staff of the U.S. Department of Commerce (2015).

[60] NOAA Fisheries, *Sperm Whale*, https://www.fisheries.noaa.gov/species/sperm-whale (last visited May 31, 2019).

[61] M. Kurtis Trzcinski & W. Don Bowen, *The recovery of Atlantic halibut: a large, long-lived, and exploited marine predator*, 73 ICES J. Marine Sci. 1104 (2016).

[62] Ransom A. Myers et al., *Why do Fish Stocks Collapse? The Example of Cod in Atlantic Canada*, 7 Ecological Applications 91 (Feb. 1997).

[63] Jean-Marc Fromentin & Joseph E. Powers, *Atlantic bluefin tuna: population dynamics, ecology, fisheries and management*, 6 Fish & Fisheries 281 (2005).

[64] Amanda Keledjian et al., *Wasted Catch*, Oceana (Mar. 2014), https://oceana.org/sites/default/files/reports/Bycatch_Report_FINAL.pdf.

can affect the distribution, abundance, body size, diversity, habitats, and ecological interactions of species within an ecosystem.[65]

Exposing the Monument to commercial fishing would pose a threat to many species and ecosystems, but two categories of species are particularly vulnerable: (1) deep-sea corals and other long-lived, bottom-dwelling, habitat-forming species damaged by fishing gear;[66] and (2) pelagic communities including whales,[67] dolphins,[68] turtles,[69] and seabirds[70] impacted as bycatch.

Threats to Bottom-Dwelling Communities. The Monument area is rich with cold-water corals and other habitat-forming invertebrates such as sponges and anemones. These creatures create habitats in which other species live, breed and give birth, or hide as juveniles and adults. They are fragile, long-lived, and slow-growing. For example, one species of coral that lives in the Monument area grows only 1/8th of an inch per year; others live and grow for hundreds, or even

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[65] *See* Lubchenco, *supra* note 25.

[66] Auster & Kraus, *supra* note 31, at 9.

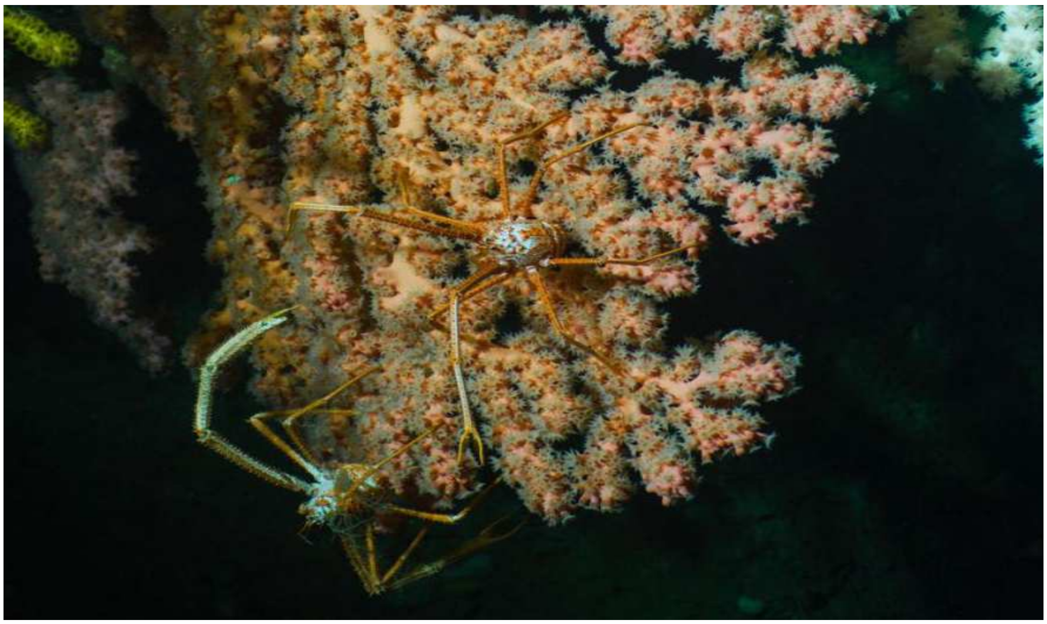
[67] *Id.* (citing Rebecca L. Lewison et al., *Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots*, PNAS (Apr. 8, 2014), https://www.pnas.org/content/111/14/5271).

[68] *Id.*

[69] *Id.* (citing Elena M. Finkbeiner et al., *Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007*, 144 Biological Conservation 2719 (2011)).

[70] *Id.* (citing A.I. Winter et al., *Modeling low rates of seabird bycatch in the U.S. Atlantic longline fishery*, 34 Waterbirds 289 (2011)).

thousands, of years.[71] Fishing gear is well-known to be severely destructive to such creatures which, due to their slow-growing longevity, may take centuries to recover from damage, if they are able to recover at all.[72] When these species perish, so too do the habitats they provide for countless others.



Bubblegum coral with crabs, Lydonia Canyon. Credit: Luis Lamar, Nat'l Geographic[73]

[71] *See* Mystic Aquarium, *Deep Sea Corals: Beautiful and Fragile*, http://www.mysticaquarium.org/northeast-canyons-and-seamounts-marine-national-monument/#Deep (last visited May 17, 2019).

[72] *See* Auster & Kraus, *supra* note 31, at 8 (citing M.R. Clark & J.A. Koslow, *Impacts of fisheries on seamounts*, Seamounts: Ecology, Conservation and Fisheries (Pitcher et al. eds., 2007).

[73] Sarah Gibbens, *Exclusive photos show deep-sea canyon in U.S. waters teeming with life*, National Geographic, Dec. 10, 2018, https://www.nationalgeographic.com/environment/2018/12/northeast-seamount-canyon-marine-monument-explored/.

The primary threat posed by commercial fishing to bottom-dwelling communities is bottom trawling, a fishing technique in which a large net is dragged along the seafloor, clouding the water with sediment that smothers many bottom-dwellers and filter-feeding animals and scooping up target and non-target fish alike by the thousands.[74] This technique has been used at and around the shallower canyon heads, and technological advancements and economic forces will likely open more areas to this destructive practice. The United Nations Secretary General reported in 2006 that 95 percent of damage to seamount ecosystems worldwide was caused by deep-sea bottom trawling.[75]

Bottom-set traps also pose a serious threat to the fragile communities on the floor of the Monument. These traps, or "pots," which primarily fish for lobster and red crab, are set in a connected series; a vertical line at each end connects the set to surface buoys.[76] When sets of pots are lost due to storms or when a large animal like a whale becomes entangled in the buoy lines, an entire set of pots can be

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[74] Margo L. Stiles et al., *Impacts of Bottom Trawling on Fisheries, Tourism, and the Marine Environment*, Oceana (May 2010) https://oceana.org/sites/default/files/reports/Trawling_BZ_10may10_toAudrey.pdf.

[75] U.N. General Assembly, Report of the Secretary General, at 11 (July 14, 2006), https://www.un.org/Depts/los/general_assembly/documents/impact_of_fishing.pdf.

[76] *See* Elizabeth Brown, *Fishing Gear 101: Pots and Traps – The Ensnarers*, Safina Center (June 6, 2016), http://safinacenter.org/2016/02/fishing-gear-101-pots-and-traps-the-ensnarers/.

dragged along the seafloor, plowing through multiple habitats. Such lost traps, while gouging their way across the ecosystem, can continue to "ghost fish" for years after being lost, capturing and starving to death crustaceans and other species.[77]

Threats to Pelagic Communities. Many species not targeted by commercial fishing are nonetheless threatened by it. Due to the ecological richness of the Monument, pelagic species such as whales, dolphins, sea turtles, and seabirds frequent its waters and would be in danger of entanglement or bycatch were the Monument re-opened to commercial fishing.

The same bottom-set pots that threaten bottom-dwelling communities also pose a severe threat to pelagic species. The heavy-gauge lines connecting the pots to one another and to surface buoys pose entanglement risk to large whales. Of the 411 critically endangered North Atlantic right whales that remained in 2018,[78] roughly five are killed every year by fishing gear.[79] The Monument, without the

[77] Courtney Arthur et al., *Out of sight but not out of mind: Harmful effects of derelict traps in selected U.S. coastal waters*, 86 Marine Pollution Bulletin 19 (Sept. 15, 2014), https://doi.org/10.1016/j.marpolbul.2014.06.050.

[78] H.M. Pettis et al., *North Atlantic Right Whale Consortium: 2018 Annual Report Card*, https://www.narwc.org/uploads/1/1/6/6/116623219/2018report_cardfinal.pdf.

[79] Sean A. Hayes et al., *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments- 2017*, NOAA Technical Memorandum NMFS NE-245, at 4 (2017), https://www.nefsc.noaa.gov/publications/tm/tm245/.

threat of commercial fishing, offers protection from entanglement in the Monument area.

Pelagic species are also threatened by the use of longlines. Longlines, composed of a main line and hundreds of branch lines each terminating in a baited hook, can extend up to forty miles, and are used to fish for swordfish and tuna along the continental shelf. Non-target species like marine mammals, sea turtles, seabirds, and sharks can easily become entangled or hooked in the long, branching lines. Particularly threatened are endangered leatherback turtles,[80] which frequent the Monument area, and short-finned pilot whales.[81]

Industrial-scale fishing poses a grave threat to the marine ecology of fished areas. The Monument was designed to protect a specific and complex area from that threat. An area smaller than that settled upon for the Monument would be inadequate to protect the geographic and ecologic dynamics of the canyons and seamounts from the devastation of industrial fishing and other extractive activities.

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[80] Rebecca L. Lewison et al., *Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles*, 7 Ecology Letters 221 (2004).

[81] A.J. Read, *The Looming Crisis: Interactions Between Marine Mammals and Fisheries*, 89 J. Mammalogy 541 (2008).

IV. The Monument is the Smallest Area Compatible With the Proper Care and Management of the Monument's Objects

The Monument is composed of two separate units: the Canyons Unit and the Seamounts Unit. The Canyons Unit, encompassing just 941 square miles, protects three submarine canyons, some deeper than the Grand Canyon. The Seamounts Unit, encompassing 3,972 square miles, protects four extinct submarine volcanoes (seamounts). The Monument protects each of the canyons and seamounts in their entirety, the water column above, and the plants, animals, and ecosystems in and around the area.[82] By protecting the important ecologic linkages that connect the Monument's various topographies, the surrounding shelf, and the water column above them, the Monument protects connections that are critical to the functioning of the Monument's ecosystem.

The interdependence of species within the Monument's ecosystems makes them particularly vulnerable to damage from exploitation. It is well documented in many interconnected ecosystems around the world that depletion of one species often results in cascading consequences to other species. For example, overfishing of Atlantic cod in the Western Atlantic is thought to have resulted in increases in

[82] Northeast Canyons and Seamounts National Monument, Proclamation No. 9496, 81 Fed. Reg. 65,161 (Sept. 15, 2016) (APP42-51 at APP43) (designating as objects of scientific interest the "canyons and seamounts themselves, and the natural resources and ecosystems in and around them").

the population sizes of many of its prey species, including herbivorous sea urchins. More abundant urchins overgrazed their kelp forests, with serious consequences for a range of other species who depend upon kelp forests for their habitat. This effect, called a "trophic cascade," reflects the complex balance and interconnectedness within an ecosystem. Inside a highly protected area, where species are untouched by commercial fishing, the natural balance can be restored.[83]

Similar impacts have been demonstrated in other marine environments, reflecting the universal phenomenon of the interconnectedness of species within an ecosystem. Studies have shown that the effects of exploitation of specific deep-sea fish populations cascade throughout the water column, as unexploited species in different depth levels also declined.[84] This effect was demonstrated not only with respect to target species, but also with respect to bycatch.[85]

The size of a monument should be determined based on the scale of the processes required to protect the objects therein. The Monument is scaled to the physical oceanographic processes, locations of important habitats, and mobility of

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[83] Robert S. Steneck, *Apex Predators and Trophic Cascades in Large Marine Ecosystems: Learning from Serendipity*, PNAS (May 22, 2012), https://doi.org/10.1073/pnas.1205591109.

[84] Auster & Kraus, *supra* note 31 (citing D.M. Bailey et al., *Long-term changes in deep-water fish populations in the North East Atlantic: a deeper-reaching effect of fisheries?*, 275 Proceedings of the Royal Society B 1965 (2009).

[85] *Id.*; *see also* Kenneth T. Frank et al., *Trophic Cascades in a Formerly Cod-Dominated Ecosystem*, 308 Science 1621 (2005).

species that are being protected. The spatial scale of the ecological interactions and the flow of nutrients and species dictate the size of the monument, which is why the footprint of the Monument cannot simply be identical to the footprint of the canyons and seamounts themselves. The species living and feeding in the water column depend on the dynamics of upwelled nutrients and migrating species from the depths, and vice versa, connecting the Monument top-to-bottom and bottom-to-top. The Monument is also connected side-to-side, as other ocean currents transport species or highly mobile species swim in and around the canyons and seamounts.[86]

Commercial fishing activities disrupt these connections by removing or damaging key species and damaging habitats, sometimes substantially. The impact of these activities can cascade well beyond the target fish and bycatch – throughout the ecosystem, and up and down the water column. In the context of the Monument, this means that the entire set of nested ecosystems and the physical structures of the canyons and seamounts – from shelf edge, canyon head, and seamount summit to the abyss – must be protected if the ecosystems in and around the canyons and seamounts are to be protected. If the Monument were smaller, if any component of the canyon or seamount ecosystems were unprotected, it would

[86] Auster & Kraus, *supra* note 31, at 2.

be in danger of cascading impacts from fishing or other extractive activity. Depletion of species in and around the canyon heads would impact species in other parts of the Monument area as predator-prey relationships and nutrient cycling pathways are disrupted.[87] Commercial fishing could target the dense prey patch areas in the canyon heads, disrupting and dispersing the patches and endangering attracted predators. The Monument's designated size protects against these outcomes, protecting the objects of scientific interest that motivated its creation and preserving its ecological and scientific value.

V. Conclusion

The Northeast Canyons and Seamounts National Monument is critical to the protection and understanding of a special marine geography and its interconnected set of highly threatened and little-understood species, habitats, and ecosystems. The Monument includes the only seamounts in U.S. Atlantic waters and three of the submarine canyons that connect the shallow waters on the continental shelf to the floor of the deep sea. The Monument's geography supports communities of ancient deep-sea corals and other bottom-dwelling communities. Marine mammals, including dolphins, porpoises, and endangered whales, marine reptiles, and

[87] *Id.* at 8.

seabirds depend on the Monument as a critical feeding ground, a sanctuary, and a home.

This dynamic and interconnected set of ecosystems requires the high level of protection that designation as a national monument provides. Its boundaries were drawn to ensure the smallest possible size. The current size of the monument is necessary to protect its entire nested set of ecosystems and the scientific benefits that flow from that ecosystem's flourishing.

Dated: June 5, 2019

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CERTIFICATE OF COMPLIANCE

I certify that this brief complies with the type-volume limitations of Fed. R. App. P. 29(a)(5) because it consists of 6,401 words, excluding the parts of the brief exempted by Fed. R. App. P. 32(a)(7)(B)(iii) and D.C. Cir. Rule 32(e)(1), as determined by the word-counting feature of Microsoft Word.

This brief complies with the typeface requirement of Fed. R. App. P. 32(a)(5) and the type style requirements of Fed. R. App. P. 32(a)(6) because it has been prepared in a proportionally spaced typeface, including serifs, using Microsoft Word 2010 in Times New Roman, 14-point font.

Dated: June 5, 2019

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CERTIFICATE OF SERVICE

I hereby certify that on June 5, 2019, I caused to be electronically filed the foregoing with the Clerk of the Court for the United States Court of Appeals for the District of Columbia Circuit by using the appellate CM/ECF system. The participants in this case are registered CM/ECF users and service will be accomplished by the appellate CM/ECF system.

Dated: June 5, 2019

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APPENDIX: LIST OF *AMICI CURIAE*

Dr. Jane Lubchenco is a Distinguished Professor at Oregon State University. She is a marine ecologist with expertise in the ocean and interactions between the environment and human well-being. She served as the U.S. Under Secretary of Commerce for Oceans and Atmosphere and Administrator of NOAA (2009-2013) where she was deeply immersed in fishery management, ocean policy and practice, marine protected areas, and ocean exploration, among other topics, both in the Atlantic Ocean and other geographies. She later served with the State Department as the first U.S. Science Envoy for the Ocean (2014-2016). Dr. Lubchenco is one of the "most highly cited" ecologists in the world with eight publications as "Science Citation Classics." She is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and others. Her awards include 22 honorary doctorates and the highest honors given by the National Academy of Sciences (the Public Welfare Medal) and the National Science Foundation (the Vannevar Bush Award). She received her Ph.D. in ecology from Harvard University where she developed her expertise on the ecology of the North Atlantic Ocean off the shores of New England. She is an expert in the design and evaluation of marine protected areas, relationships between protected areas and fisheries, and impacts of climate change on ocean ecosystems and the benefits they provide to people.

Dr. Andrew J. Read is the Stephen A. Toth Professor of Marine Biology at Duke University and the Director of the Duke Marine Lab. His research focuses on the conservation biology of long-lived marine vertebrates, particularly marine mammals, seabirds, and sea turtles. Much of his current research documents the effects of human activities on populations of these species and attempts to find solutions through field work, experimentation, and modeling.

Dr. Gorka Sancho is a Professor of Biology at the College of Charleston and the Grice Marine Laboratory. His research focuses on the behavioral ecology and conservation of marine fishes, working with fishes in coral reef, estuarine, hydrothermal vent and open-ocean habitats.

Dr. John C. Avise is a Distinguished Professor of Ecology and Evolution at the University of California, Irvine. He is the author or editor of 32 books and more than 360 research articles in the areas of molecular ecology, molecular evolution, conservation biology, and genetics. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society.

Dr. Mark Carr is a marine ecologist and Professor in the Department of Ecology and Evolutionary Biology at the University of California, Santa Cruz. Dr. Carr has studied and published broadly on the applications, design, and evaluation of marine protected areas. He was the co-Chair of the Science Advisory Team to

California's Marine Life Protection Act, which culminated in California's state-wide network of 124 protected areas. He was the science representative to NOAA's Marine Protected Areas Federal Advisory Committee (2014-2018), and a member of the US-China Joint Scientific Experts Group on Marine Protected Areas and Fisheries sponsored by NOAA and the US State Department (2017-2019). He is a member of the Science Advisory Committee to the Northern Shelf Bioregion Network of Marine Protected Areas, in British Columbia, Canada.

Dr. Colleen M. Cavanaugh is the Edward C. Jeffrey Professor of Biology in the Department of Organismic and Evolutionary Biology and Co-Director and founder of the Microbial Sciences Initiative at Harvard University. Her research interests focus on the ecology and evolution of marine invertebrate–bacterial symbioses, including deep-sea microbial interactions. She has participated in research expeditions worldwide with numerous deep-sea dives in the submersible *R/V Alvin*. Dr. Cavanaugh is also a Visiting Investigator at the Woods Hole Oceanographic Institution, an adjunct Senior Research Scientist at the Marine Biological Laboratory, and an elected Fellow of the American Association for the Advancement of Science and the American Academy of Microbiology.

Dr. Gretchen C. Daily is Bing Professor of Environmental Science in the Department of Biology and the Woods Institute for the Environment at Stanford University. Her work focuses on understanding the dynamics of change in the biosphere, their implications for human well-being, and the deep societal transformations needed to secure people and nature. She has won international honors for her work and is a fellow of the National Academy of Sciences, the American Philosophical Society, and the American Academy of Arts and Sciences.

Dr. Scott V. Edwards is a Professor of Organismic and Evolutionary Biology at Harvard University. Dr. Edwards studies the evolutionary biology and genetics of birds. He has received numerous awards for his research and is a member of the National Academy of Sciences and the American Academy of Arts & Sciences.

Dr. James A. Estes is Professor Emeritus in the Department of Ecology and Evolutionary Biology at the University of California, Santa Cruz. Dr. Estes is an ecologist with expertise in marine vertebrate and ecosystem dynamics and has conducted field research in those fields in Alaska, California, Canada, Mexico, New Zealand, and Russia. He has published more than 200 scientific articles, several books and monographs, and has served on the editorial boards of a variety of professional societies. Dr. Estes is a Pew Fellow in marine conservation, a Fellow of the California Academy of Sciences, and member of the National Academy of Sciences. He received the Western Society of Naturalist's Lifetime Achievement Award in 2011 and the American Society of Mammalogists' C. Hart Merriam Award for excellence in research in 2012.

Dr. Ron Etter is a Professor of Biology at the University of Massachusetts Boston and in The Inter-Campus School of Marine Science. His research explores the ecology and evolution of marine organisms in coastal and deep ocean ecosystems, specifically focused on understanding the forces that influence the origin and maintenance of biodiversity.

Dr. Alan Friedlander is director of the Fisheries Ecology Research Laboratory at the University of Hawai'i and Chief Scientist and Acting Director of Research for the National Geographic Society's program, Last Wild Places. He leads the research efforts to help understand and conserve iconic, special places in the ocean. Dr. Friedlander is an expert in marine ecology, fisheries, and conservation. He works on marine protected areas from small to large – from small places managed by local communities to some of the largest protected areas on the planet.

Dr. Steven D. Gaines is Dean and Distinguished Professor at the Bren School of Environmental Science & Management, University of California, Santa Barbara. His science seeks solutions to diverse challenges in ocean conservation and the sustainable production of food from the sea. His work has helped design marine protected areas and fisheries innovations in many settings across the globe. He has received numerous awards for his research and is a fellow of the American Academy of Arts & Sciences.

Dr. Alan Hastings is a Distinguished Professor in the Department of Environmental Science and Policy at the University of California, Davis. He has published over 300 papers on aspects of theoretical ecology including many focusing on the theory behind the design and function of marine protected areas. He is an elected member of the National Academy of Sciences, and a fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science.

Dr. Mark Hixon is the Erica and Sidney Hsiao Endowed Professor of Marine Biology at the University of Hawai‘i. His expertise is coastal marine ecology and conservation biology, emphasizing undersea experiments. His research experience includes deep rocky reefs, which he has explored in dozens of deep submersible dives, and marine protected areas (MPAs), including the first study documenting that successful MPAs seed unfished areas with fish larvae spawned within the protected areas. His policy experience includes MPA planning in the Bahamas, Oregon, and Hawai‘i, as well as serving on the MPA Federal Advisory Committee for the Departments of Commerce and the Interior from 2003 to 2009, including service as chair for the latter 3 years.

Dr. Jeremy Jackson is emeritus professor of oceanography at the Scripps Institution of Oceanography, where he led the Center for Marine Biodiversity and Conservation, and research paleobiologist at the American Museum of Natural

History. He studies threats and solutions to human impacts on the oceans and the ecology and evolution of tropical seas. He is a member of the National Academy of Sciences and has won numerous international prizes and awards. He is the author of more than 160 scientific publications and eleven books, most recently *Breakpoint: Reckoning with America's Environmental Crises* and *Shifting Baselines in Fisheries: Using the Past to Manage the Future.*

Dr. Peter Kareiva is the director of the Institute of the Environment and Sustainability at UCLA and the Pritzker Distinguished Professor in Environment & Sustainability. His expertise is in conservation science broadly, as well as marine conservation in particular. In addition to writing two conservation science textbooks and leading the Conservation Biology Division at NOAA's Northwest Fisheries Science Center, he served as the Vice President of Science for The Nature Conservancy, where he oversaw their designation of which lands and waters warranted the highest priority for protected area status. Dr. Kareiva is a fellow of the American Academy of Arts and Sciences and a member of the National Academy of Sciences.

Dr. Les Kaufman is a Professor of Biology at Boston University and Faculty Fellow with the Pardee Center for the Study of the Longer-Range Future. Dr. Kaufman is a marine ecologist who focuses on relationships between society and ecosystems, especially coastal communities and their adjacent oceans. He conducts research in the Gulf of Maine on seabirds, fishes, marine mammals, and fisheries in the Monument area. More specifically, he investigates forage species and their predators, especially critical habitat on the northeast continental shelf. He has also worked extensively in other habitats including coral reefs. His research encompasses modeling for marine policy scenario analysis, field research on response and recovery of marine ecosystems to climate change and other human impacts, and development of ecosystem-based management policies. He has been recognized with numerous honors and awards including as a Pew Fellow in Conservation and the Parker/Gentry Award in Conservation Biology.

Dr. Nancy Knowlton is a marine ecologist and emeritus scientist at the Smithsonian Tropical Research Institute and the National Museum of Natural History. She was formerly a professor at Yale University and at the University of California in San Diego, where she founded the Center for Marine Biodiversity and Conservation at the Scripps Institution of Oceanography. She is an elected member of the American Academy of Arts and Sciences and the U.S. National Academy of Sciences.

Dr. Lisa Levin is a Distinguished Professor at the Scripps Institution of Oceanography, University of California, San Diego, and former director of the Center for Marine Biodiversity and Conservation at Scripps. She has conducted extensive research on deep-sea ecosystems and their vulnerability to climate change and human impacts. Dr. Levin is a fellow of the American Geophysical Union and the American Association for the Advancement of Science, and was awarded the Redfield Lifetime Achievement Award by the American Society of Limnology and Oceanography.

Dr. Simon Levin is the Distinguished University Professor in Ecology and Evolutionary Biology at Princeton University, and was founding Director of the Princeton Environmental Institute. His research focuses on the dynamics of ecological systems, and their interrelatedness with socio-economic systems. He is a member of the National Academy of Sciences and the American Philosophical Society; Fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science; and awardee of the National Medal of Science, Tyler Prize, Kyoto Prize, Heineken Prize and Margalef Prize.

Dr. Thomas E. Lovejoy is a professor in the Department of Environmental Science and Policy at George Mason University and a senior fellow at the United Nations Foundation. Lovejoy has served on science and environmental councils under the Reagan, Bush and Clinton administrations and was also the World Bank's chief biodiversity advisor and lead specialist for environment for Latin America and the Caribbean. Lovejoy holds a Bachelor of Science and PhD in biology from Yale University.

Dr. Fiorenza Micheli is a marine ecologist at Stanford University, where she is the David and Lucile Packard Professor of Marine Science and the co-director of the Center for Ocean Solutions. Her research focuses on the processes shaping marine communities and coastal social-ecological systems, and the implications for marine management and conservation. She investigates impacts of climate change and ocean acidification on marine species and ecosystems. Her work on marine predators and trophic cascades is relevant to small-scale fisheries and the design and functioning of Marine Protected Areas. She is fellow of the California Academy of Sciences, research advisor to the Monterey Bay National Marine Sanctuary and Seafood Watch, and senior fellow at Stanford's Woods Institute for the Environment.

Dr. Harold A. Mooney holds the Paul S. Achilles Professorship in Environmental Biology, Emeritus at Stanford University. He pioneered the incorporation of physiological understanding into studies of ecosystem processes and studies the convergent properties of ecosystems, plant-animal interactions, and the impacts of global change on ecosystems, especially on productivity and biodiversity. Mooney served as Secretary General of the International Council for Science (ICSU) and as a Scientific Panel co-Chair for the Millennium Ecosystem Assessment. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society. He has received the Eminent Ecologist Award of the Ecological Society of America, Honorary Member of the British Ecological Society, Humboldt Senior Distinguished U.S. Scientist Award, the Max Planck Research Award, the Ecology Institute Prize, and the Blue Planet Prize.

Dr. Stephen W. Pacala is the Frederick D. Petrie Professor of Ecology and Evolutionary Biology at Princeton University. His work focuses on problems of global change with an emphasis on interactions among the biosphere, greenhouse gases and climate. He also researches solutions to the climate problem, the dynamics of forests, and the relationship between biodiversity and ecosystem function. He is a member of the National Academy of Sciences.

Dr. Stephen R. Palumbi is a marine population and evolutionary biologist and the Jane and Marshall Steele Jr. Chair of Marine Biology at Stanford University. He has received numerous awards for his pioneering scientific findings and is a member of the National Academy of Sciences. He uses genetic detective work to understand past and current dynamics of marine species, most recently how they are impacted by climate change and what might be done to save them. He has authored three books about evolution and ocean science for non-scientists, most recently, *The Extreme Life of the Sea*, written with his son and novelist Anthony.

Dr. Mary E. Power is Professor in the Department of Integrative Biology at the University of California, Berkeley. Dr. Power is an ecologist who studies ecological interactions, especially food-webs within ecosystems and the ecological connections across habitat boundaries that link adjacent ecosystems. She is a member of the National Academy of Sciences.

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Dr. Edward O. Wilson is recognized as one of the creators of two scientific disciplines (island biogeography and sociobiology), three unifying concepts for science and the humanities jointly (biophilia, biodiversity studies, and consilience), and one major technological advance in the study of global biodiversity (the Encyclopedia of Life). He is a member of the National Academy of Science. Among more than one hundred awards he has received worldwide are the U.S National Medal of Science, the Crafoord Prize (equivalent of the Nobel, for ecology) of the Royal Swedish Academy of Sciences, the International Prize of Biology of Japan; and in letters, two Pulitzer prizes in nonfiction, the Nonino and Serono Prizes of Italy, and the COSMOS Prize of Japan. He is currently Honorary Curator in Entomology and University Research Professor Emeritus, Harvard University.