PART V: APPENDICES

Austinograea spp. crab (center), deep-sea anemone (center), Alvinocarididae shrimp (left), and *Ifremeria nautilei snails* (right) on Bathymodiolid mussels (in diffuse hydrothermal venting, at the Kilo Moana vent field).
Image courtesy of the Woods Hole Oceanographic Institute and Charles Fisher, Pennsylvania State University.

Appendix 1:

The Lost City Hydrothermal Field

Illustration of potential Outstanding Universal Value in the High Seas

Name of area:
The Lost City Hydrothermal Field

Location:
Mid-Atlantic Ridge, 30°07' N 42°07' W (750-900 m)

Description

The Lost City Hydrothermal Field is unlike any other ecosystem yet known on Earth. It is a remarkable geo-biological feature in the deep sea (700-800 m water depth), meaning that it was formed by a combination of geological and biological forces. The site is dominated by the *Poseidon* carbonate monolith, a 60-m tall edifice made of carbonate, the raw material of chalk and limestone. It was discovered serendipitously in 2000 during an *Alvin* submarine dive on the Mid-Atlantic Ridge range of underwater mountains, and it is still being explored. The Lost City Hydrothermal Field is an area of active hot spring venting that extends for more than 300 m along an east-west trending geological fault. Serpentinite cliffs here 'weep' hot fluids, producing delicate finger-like outgrowths and multi-pinnacle chimneys. Recent radioisotope dating reveals that fluid venting at the Lost City has been ongoing for 120,000 years. The Lost City is located on the *Atlantis Massif*, a broad dome-like feature of 1.5-million-year-old crust at the intersection of the Mid-Atlantic Ridge and the Atlantis Fracture Zone.[1]

In typical hydrothermal vents, or deep sea hot springs, of the mid-ocean ridge, venting fluids are heated by magma when seawater passes through cracks in hot crustal rock. In the Lost City, the fluid chemistry of vents seems to reflect lower-temperature (<150 ° C) weathering of ultramafic (upper mantle) rock (peridotite) exposed to seawater. This weathering process, known as serpentinization from the peridotite weathering to serpentinite, produces heat, hydrogen (H_2) and methane (CH_4) as reaction products.

1 this is not to be confused with the Atlantis Bank, in the south-west Indian Ocean

The highest temperature of venting fluids at the *Lost City* so far observed is in the order of 90° C and the fluid itself is calcium-rich and alkaline (pH 10 to 11), with very low metal concentrations. This system has been suggested as one of the chemical precursors for the origin of life, attracting the interest of NASA as a means of identifying the chemical signatures of life on other planets and moons.

The species that inhabit the Lost City Hydrothermal Field – both microorganisms and macrofauna – are different from those found at typical sulphide-rich hydrothermal vents on the Mid-Atlantic Ridge. Instead of dense swarms of shrimp or beds of mussels and clams that rely primarily on chemosynthesis for energy (from symbiotic, sulphide-oxidizing, chemoautotrophic microorganisms as are known for vent sites on the Mid-Atlantic Ridge), the Lost City invertebrate fauna, while relatively diverse, is visually understated as it has a very low biomass. But it is taxonomically distinct, presumably due to the unusual nature of the venting fluid at Lost City (high pH, low sulphide, high H_2 and CH_4). As a consequence, though poorly studied at present, the endemic invertebrate macrofauna that do exist at the Lost City (including gastropod snails, bivalves amphipods, stomatopods) are likely to exhibit unusual biochemical and physiological adaptations that have not yet been described in nature.

The microbial communities of the Lost City Hydrothermal Field are of particular interest because of the high concentrations of hydrogen and methane. Microbial densities are high, with up to 100 million cells in a gram of wet rock habitat in samples taken from actively venting carbonates. A particularly ancient type of microbe (archaeal phylotype) forms thick biofilms in the higher-temperature areas and is implicated in both methane generation and consumption. Bacteria, including sulphide oxidizers, are also found at the Lost City.

Jurisdiction – The Lost City Hydrothermal Field lies entirely in the High Seas.

Competent Authorities – includes the International Seabed Authority (ISA). For ongoing scientific evaluation and study: the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the Natural

Environment Research Council (NERC), the Centre national de la recherche scientifique (CNRS), among others.

Potential Outstanding Universal Value

Criterion vii – Superlative natural phenomena or natural beauty and aesthetic importance

While other sites in the world ocean with subsets of related geological features and processes are known to exist, the Lost City is globally singular among all known hydrothermal sites in the eerily lovely sculpture of its carbonate precipitates, its fluid chemistry and associated microbial and invertebrate community, and its longevity. Its magnificent shimmering carbonate edifices are reminiscent of Greek and Roman columns.

Criterion viii – Major stages in Earth's history and geological processes

The Lost City Hydrothermal Field is an extraordinary deep-sea site of significant, active (ongoing) serpentinization and hydrogen-, methane-, calcium-rich and alkaline fluid venting. The ultramafic nature of the system is chemically allied to lavas erupted into Earth's primordial ocean. Discoveries made at this site have fundamentally expanded our understanding of the diversity of hydrothermal processes on Earth. A comprehensive study of the structural and biochemical fossils harboured within the 120,000-year-old deposits remains to be undertaken.

Criterion ix – Significant ecological and biological processes in the evolution of ecosystems, communities of plant and animals

The Lost City Hydrothermal Field is postulated as a contemporary analogue for conditions where life on early Earth may have originated and for conditions that might support life within the oceans of extraterrestrial planetary bodies. The site is a locus for scientific study of prebiotic organic compounds such as formate and other low molecular weight organic acids produced by Fischer-Tropsch-type (FTT) reactions. These organic acids may have been critical building blocks for initiating life. Prebiotic compounds have since been studied in other serpentinite systems (e.g.the *Von Damm* site on the Cayman Rise), but *The Lost City* is the standard against which these other systems are compared.

Criterion x – Significant biological diversity and threatened species of OUV

Many of the taxa of the Lost City Hydrothermal Field – microbial and invertebrate – are so far known only from this site and represent 'living libraries', with biochemical and physiological adaptations to their extreme environment yet to be understood.

Threats

The Lost City Hydrothermal Field is located off-axis of the Mid-Atlantic Ridge, which is a ridge axis that hosts metal-rich hydrothermal vent areas licensed for mineral exploration by the International Seabed Authority; the main threat would be from indirect impact from deep-sea mining for minerals. The rugged seabed topography in the region is such that fishing is unlikely to be an issue.

Protection and management

Deep-sea mining is licensed by the International Seabed Authority (ISA). The site would qualify as a Vulnerable Marine Ecosystem (VME) under the Food and Agriculture Organization of the United Nations (FAO) criteria and be subject to management by a Regional Marine Fisheries Organization (RMFO).

Public awareness

The discovery of the Lost City Hydrothermal Field was covered by a variety of media outlets, including *Scientific American* (13 December, 2000) and the *New York Times* (14 August, 2001). The *Lost City* was featured in James Cameron's *Aliens of the Deep: Voyages to the Strange World of the Deep Ocean* (Disney 3D IMAX and book, 2005)[2] and there are *Wikipedia* (https://en.wikipedia.org/wiki/Lost_City_Hydrothermal_Field) and *MicrobeWiki* (https://microbewiki.kenyon.edu/index.php/Lost_City_Hydrothermal_Field) pages devoted to the site. Youtube includes short video documentaries of the Lost City Hydrothermal Field, including one narrated by Dr Robert Ballard (https://www.youtube.com/watch?v=F7wnrE3_i8A) and a brief 'flyover' (https://www.youtube.com/watch?v=5Iv_HOTvuBQ). The NOAA *Ocean Explorer* programme featured a public 'telepresence' expedition to the Lost City Hydrothermal Field in 2005 (http://oceanexplorer.noaa.gov/explorations/05lostcity/welcome.html).

Geographic scale and site integrity

The Lost City Hydrothermal Field extends for at least 400 m across the terrace on top of the Atlantis Massif and is bound to the north by a small basin nicknamed Chaff Beach, and to the south by the Atlantis Transform Fault. A 20-km-wide buffer zone around the Lost City Hydrothermal Field would safeguard the integrity of this site.

2 Cameron, J. (Producer) and Cameron, J. (Director). 2005. *Aliens of the Deep* [Motion Picture]. United States: Walt Disney Pictures
Macinnis, J., Macinnis, J.,, Macinnis, J.B., Thomas, L. (Editor), Cameron, J. (Introduction). *James Cameron's Aliens of the Deep: Voyages to the Strange World of the Deep Ocean.* 2005. National Geographic

Other comparable sites

A number of hydrothermal vents occur north and south of the Lost City Hydrothermal Field (see http://vents-data.interridge.org/ventfields-geofield-map), but none are of the same geological, geochemical or biological type as the Lost City.

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Appendix 2

The Costa Rica Thermal Dome

Illustration of potential Outstanding Universal Value in the High Seas

Name of area:
The Costa Rica Thermal Dome

Location:
Northeast Tropical Pacific - mean position near 9° N 90° W

Description:

The Costa Rica Thermal Dome (CRTD) is an oceanic oasis in the Eastern Tropical Pacific whose high primary productivity attracts large ocean-going fish, marine mammals and marine mega-predators such as sharks, tuna, dolphins and whales. It is part of a migration corridor for critically endangered leatherback turtles. It is a highly productive thermal convection dome created through an interaction between wind and currents and covers a 300-500 km-wide area. It was first observed in 1948 (Wyrtki, 1964) and described by Cromwell (1958). Although mobile, as most oceanographic features are, its location and presence off the coast of Costa Rica and Central America is reliable and predictable.

Winds blowing through the gaps in the Central American mountain range, as well as ocean currents, push the warm water aside to allow for the rising of nutrient-rich cold water which is 0.5° C lower than the surrounding water (Hofmann et al., 1981; Fiedler, 2002; Xie et al., 2005; Ballestero, 2006). These colder surface waters are higher in nitrate and chlorophyll than surrounding areas, resulting in high levels of primary production (Broenkow, 1965; Chavez and Barber, 1987; Fiedler, 2002; Vilchis et al., 2006). The boundary between the warm surface water and cold deep water (called a thermocline) forms a dome-like feature, giving the area its name (Hofmann et al., 1981; Xie et al., 2005; Ballestero, 2006; Kahru et al., 2007). The Dome is located about 300 km off the Gulf of Papagayo, Costa Rica and at its maximum extent is about 30% in jurisdictional waters, and 70% in the High Seas. It is one of only six biodiversity-rich domes of this kind in the world, but the CRTD is unique because it is formed by a coastal wind jet.

The high productivity of the CRTD provides an outstanding year-round habitat for the endangered blue whale (*Balaenoptera musculus*), for mating, breeding, calving and raising calves (Mate et al., 1999; Hoyt, 2009; Hoyt and Tetley, 2011). It is the only known thermocline dome in the world where blue whales feed and breed. Blue whales migrate south from Baja California during the winter for breeding, calving, raising young and feeding. The blue whale is classified as an Endangered species on the IUCN Red List, but may in fact meet the criterion for Critically Endangered (Reilly et al., 2008). The Eastern North Pacific blue whale population, at approximately 3,000 individuals, represents the largest remaining blue whale population on Earth (Calambokidis and Barlow, 2004). For a portion of this blue whale population, the Dome is an important habitat for the survival and recovery (Matteson, 2009) and forms a key component in a network of blue whale habitat sites, several of which have already been partially protected off the California coast and in the Gulf of California, off Mexico.

The CRTD is also important for the short-beaked common dolphin (*Delphinus delphis*) and other dolphins of the Eastern Tropical Pacific. It is of special relevance for several other emblematic marine vertebrates, such as the critically endangered Eastern Pacific population of the leatherback sea turtle (*Dermochelys coriacea*), which nests on the beaches of Costa Rica and migrates through the area, as well as many species of mobulid rays (genera *Manta* and *Mobula*). The seasonal winds that form the CRTD and the resulting coastal eddies help move leatherback hatchlings from the coast to offshore habitats (Shillinger et al., 2012).

Jurisdiction – The Costa Rica Thermal Dome lies mainly in the High Seas but 30% crosses into EEZs of Central American countries. The core area is fully in the High Seas.

Competent Authorities – In the High Seas, these include International Maritime Organization (IMO), Inter-American Tropical Tuna Commission (IATTC), the International Whaling Commission (IWC), the International Seabed Authority (ISA), the Convention on Biological Diversity Ecologically or Biologically Significant Area process (CBD EBSA), the Central American Integration System with specific Agencies: Central American Commission on Environment and Development (CCAD), the Central American Isthmus

Fishing and Aquaculture Organization (OSPESCA), and the Central American Commission on Maritime Transportation (COCATRAM).

Potential Outstanding Universal Value

Criterion viii – Major stages in Earth's history and geological processes

The Costa Rica Thermal Dome is an oceanographic feature in the Eastern Tropical Pacific formed by shoaling of the generally strong, shallow thermocline with upwelling of cool, nutrient-rich water, which promotes blooms of surface plankton. It differs from all other thermal domes elsewhere in the ocean by being a wind-driven (coastal jets) system. The upwelling at the Dome persists throughout the summer and early autumn, but diminishes by December-January.

Criterion ix – Significant ecological and biological processes in the evolution of ecosystems, communities of plant and animals

The upwelling of deep, nutrient-rich water at the Costa Rica Thermal Dome results in an area of high primary production detectable by remote sensing, forming a distinct biological habitat. The Dome's area is heavily used by highly migratory marine predators such as tuna, billfish, sharks, manta rays, dolphins and whales, in particular endangered blue whales. It is also part of the migratory corridor of a population of endangered leatherback turtles nesting in Costa Rica. The area is of vital importance for blue whales as habitat for feeding, breeding, calving and raising young. All life stages of blue whale can be found here. In addition, a population of blue whales moves seasonally between the Thermal Dome and Baja California. Leatherback turtles migrate through the dome and the region may be critical habitat for their newly-hatched offspring.

Criterion x – Significant biological diversity and threatened species of OUV

The Thermal Dome area in the Eastern Tropical Pacific provides an area for blue whale feeding, mating, breeding, calving and raising calves. The blue whale is classified as an Endangered species on the IUCN Red List, but may in fact meet the criterion for Critically Endangered. The Eastern North Pacific blue whale population, at approximately 3,000 individuals, represents the largest remaining blue whale population on Earth. The location is an EBSA and is being considered as an Important Marine Mammal Area (IMMA) by the IUCN Joint SSC-WCPA Task Force on Marine Mammal Protected Areas.

Threats

The highest threats to the Costa Rica Thermal Dome are shipping traffic (pollution, collision risk to cetaceans, noise), overfishing, IUU fishing, pollution from marine and land-based sources (agriculture, wastewater), and climate change (alteration of physical oceanographic processes, ocean acidification and modification in the distribution patterns of species) (Bailey et al., 2012; Rolland et al., 2012). The Costa Rica Thermal Dome ranks as an area of medium to high impact under a global analysis of human impacts on marine ecosystems (Halpern et al., 2008). There is concern that overfishing or other threats could cause the disappearance, displacement or marginalization of this population of blue whales currently known to be increasing (Hoyt, 2009).

The oceanographic feature itself may be impacted in the future by climate change, but is already impacted by El Niño events with an increment of 3° C to 4° C during the El Niño years compared with other years, and the inhibition of upwelling events (Alexander et al., 2012).

Protection and management

The Costa Rica Thermal Dome was described as an Ecologically or Biologically Significant Area (EBSA) in 2014. For the portion of the Dome within the jurisdictional waters of the Central American countries, the policy and regulatory framework from the Central American Integrated System and its Agencies on environment (CCAD), the Central American Isthmus Fishing and Aquaculture Organization (OSPESCA) and the Central American Commission on Maritime Transportation (COCATRAM) is applicable to address the conservation and sustainable use of the marine resources in the region.

Public awareness

Since 2012, the MarViva Foundation (http://www.marviva.net/) has led an international, participatory process to design and recommend a governance model for the High Seas portion of the CRTD. In partnership with Mission Blue, the Global Ocean Biodiversity Initiative (GOBI), Marine Conservation Biology Institute, Whale & Dolphin Conservation, IUCN, and the support of the JM Kaplan Fund, MarViva initiated a multi-sectoral analysis of the legal, technical and scientific data describing the Costa Rica Dome and the human activities dependent on the area and its resources. Within this process, meetings with regional and international competent authorities, and presentations of the initiative in international fora, have led to the steady consolidation of the initiative.

In addition, the Costa Rica Thermal Dome was also identified as a High Seas Gem by the Marine Conservation Biology

Institute. In 2014, the declaration of the area as an EBSA by the CBD raised scientific and public awareness about the Dome´s relevance as a critical habitat for multiple species.

Geographic scale and site integrity

The size and location of this area varies throughout the year but the mean position is near 9° N 90° W, between the westward North Equatorial Current and the Eastward North Equatorial Counter-current. The proposed boundary encapsulates the thermal dome, which is a distinct biological habitat 300–500 km across and provides the basis for securing its integrity.

Other comparable sites

Five other dome systems occur in the world's ocean, but the Costa Rica Thermal Dome is globally unique because it is also forced by a coastal wind jet (Fiedler, 2002). The CRTD creates a unique, highly productive area, making the oceanic habitat of the Eastern Tropical Pacific more heterogeneous and productive than other areas in the tropical ocean (Kessler 2006; Fiedler 2002; Ballestero and Coen, 2004; Vilchis et al., 2006).

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Appendix 3:

The White Shark Café

Illustration of potential Outstanding Universal Value in the High Seas

Name of area:
The White Shark Café

Location:
Eastern Tropical Pacific - approximately 23°22′ N 132°42′ W

Description:

Approximately halfway between North America and Hawaii, in the blank emptiness of the eastern Pacific, there is a place that to a human observer looks featureless and unremarkable. There are no landmarks here, no coasts to interrupt the endless cobalt blue. But this place is very special indeed to one of the ocean's largest hunters, the great white shark (*Carcharodon carcharias*). At one time, these sharks were known only in the eastern Pacific from their coastal haunts in California and Mexico where they appeared seasonally to hunt breeding elephant seals and sea lions. Satellite tracking tags have now revealed that after the coastal foraging bonanza, they migrate far offshore, congregating in this remote spot, probably to feed and mate. Researchers call it the White Shark Café. No other place like it is known anywhere else in the world.

White sharks are protected internationally under CITES (Appendix II) and are listed as Vulnerable under the IUCN Red List. The White Shark Café was completely unknown until animal borne tags, called pop-up satellite archival tags, were attached to sharks to track their movements, behaviours and the environmental conditions experienced (Weng et al. 2007, Domeier and Nasby-Lucas, 2008, Jorgensen et al. 2010). The tags record depth, temperature and light providing robust information on position and use of the open seas. In the past decade, over 100 white sharks have been satellite tagged in north-eastern Pacific waters, completely transforming our understanding both of the sharks and the High Seas environment they inhabit. Satellite tag data indicate that sub-adult and adult white sharks seasonally congregate in a distinct area of the warmer offshore waters of the subtropical gyre (a huge rotating current), called the White Shark Café, and later on return to the California Current where coastal feeding aggregations occur around elephant seal and sea lion rookeries in Central California and Guadalupe Island, Mexico (Boustany et al., 2002; Weng et al., 2007; Domeier and Nasby-Lucas, 2008; Jorgensen et al., 2012; Carlisle et al., 2012). Domeier and Nasby Lucas (2008) demonstrated that white sharks tagged off Guadalupe Island, Mexico also visited the same offshore locations, indicating that the two groups of sharks from North America overlap seasonally.

Electronic tagging data have shown that in addition to white sharks, other pelagic shark species including mako, salmon and blue sharks, tunas (albacore, bigeye and yellowfin tunas) and seabirds, also migrate to this distinct and enigmatic region of the subtropical gyre (Block et al., 2011). The satellite tagging data indicate that this is a seasonal aggregation site for the majority of the adult white shark population in the north-eastern Pacific. Jorgensen et al. (2012b) noted the Café was primarily defined by the presence of males converging during spring within a much smaller core area coincident with an increased rate of vertical diving movements, while females visited the Café centre only briefly. They suggested this region as a potential mating area although given the aggregation of many species in the region, foraging may also be on going here.

The extensive use by white sharks and other species underlines the great importance of the White Shark Café. Continued use of satellite tags has confirmed repeat visitation occurs annually.

Jurisdiction – The White Shark Café lies entirely in the High Seas.

Competent Authorities – include Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC)

Potential Outstanding Universal Value

Criterion vii – Superlative natural phenomena or natural beauty and aesthetic importance

Coastal waters are important habitat for many marine species, including white sharks. In the past decade, it has become apparent that pelagic environments also support aggregations, and coastal species often utilize offshore habitat during some phase of their life cycle. The California Current flows north to south along the continental shelf, and is a highly productive upwelling region that is retentive to a large number of top predators (Block et al., 2011). Photo identification of white shark individuals and acoustic and satellite tagging has shown that white sharks occupy predictable sites in the California Current, off North America. Shark usually forage around pinniped colonies for as much as six months of the year, from late August until early February. Sharks from both North American sites (Central California Islands and Guadalupe Island) have been observed with electronic tags to make seasonal migrations, remaining inshore in neritic waters foraging from late summer and autumn months to winter, and then travelling to the same general offshore aggregation area - the White Shark 'Café'. The white sharks remain offshore in the waters of the subtropical gyre (Café), with some individuals moving as far west as the Northwestern Hawaiian Islands. White sharks return back to the North American foraging zones, often showing site fidelity to the original regions where they were tagged (Weng et al., 2007; Domeier and Nasby-Lucas, 2008; Jorgensen et al., 2012b).

Criterion ix – Significant ecological and biological processes in the evolution of ecosystems, communities of plant and animals

Genetic studies demonstrate that global white shark populations have discrete subpopulation structure with unique demographics in South Africa, Australia, the Northeast Pacific Ocean, the Northwest Atlantic and the Mediterranean Sea (Pardini et al., 2000; Gubili et al., 2010, 2012; Jorgensen et al., 2010; Tanaka et al., 2011). Electronic tagging has shown that Northeast Pacific Ocean white sharks have a broad distribution extending from the North American continent to the Hawaiian Islands. These tagging data suggest sub-adult and adult white sharks seasonally inhabit warmer offshore waters of the subtropical gyre (the White Shark Café), and return to the California Current where coastal feeding aggregations occur in Central California and Guadalupe Island, Mexico (Boustany et al., 2002; Weng et al., 2007; Jorgensen et al., 2010). The majority of white shark observations of the NEP sharks occur near the North American coastline, usually at coastal islands that serve as pinniped rookeries such as the Farallon Islands, Año Nuevo and Guadalupe Island. Here, long-term studies, including photo identification and electronic tagging, have enabled individual tracking for several years to periods over two decades. (Jorgensen et al., 2010; Anderson et al., 2011).

Criterion x – Significant biological diversity and threatened species of OUV

White sharks (*Carcharodon carcharias*) are top predators in coastal and open ocean ecosystems that occur circumglobally. White sharks have warm bodied, or endothermic physiology. They are long-lived, late to mature and produce few young, making them vulnerable to overexploitation (Cailliet et al., 1985; Chapple and Botsford, 2013). Other than in unique offshore locations such as the White Shark Café, white sharks are most frequently observed in inshore temperate continental shelf waters, where they often forage on pinniped colonies close to shore. White sharks typically take up to 100 days to arrive at the Café, travelling around 1 m/s, during which they make periodic dives as deep as 900 m. While at the Café, they dive to depths of 300 m as often as once every ten minutes. The purpose of the dives, either along the journey or in the Café area, is unknown. White sharks are protected internationally under CITES (Appendix II) and listed as Vulnerable under the IUCN Red List. In the Northeast Pacific Ocean, the unique population of white sharks are of significant conservation concern (Chapple and Botsford, 2013).

Threats

The main threat is fishing and, in particular, the international longline fleet that covers the international waters that include the White Shark Café.

Understanding the role that oceanic habitats play in the life histories of these pelagic sharks is also important for conservation and management purposes. North American West Coast sharks are most vulnerable to capture by unregulated international fisheries in the High Seas. Given the sensitivity of these species to overexploitation, a more comprehensive understanding of the factors influencing offshore migrations is required for their effective conservation and management. By identifying the underlying life history function of these migrations and understanding the roles that oceanography and biology play in influencing their patterns of habitat use, we can develop environmental models that help to identify how and why California Current sharks utilize offshore habitats, create predictive frameworks to model their distribution based on oceanographic conditions, and help lay the foundation for protection and effective management of these regions and ecosystems.

Protection and management

Tuna fisheries in the region of the Pacific in which the White Shark Café is located are managed by the Inter-American Tropical Tuna Commission (IATTC).

During the coastal phase for many marine species, direct observation is possible, supporting extensive studies of the animals and systems and the development of management and protection regimes. However, when animals are in the offshore environment, direct observation becomes virtually impossible; as a result, we know very little about where, when or how pelagic environments are used by these animals. Consequently, very little protection is in place in pelagic zones. However, over the last several decades there has been rapid advancement in electronic tagging technologies, with tags becoming smaller, cheaper, more reliable and capable of collecting data on an increasing array of parameters. These advancements in tag technology have not only enabled description of the coastal aggregations and behaviours of many species, but have provided a whole new understanding of how pelagic predators utilize oceanic habitats. The unprecedented electronic tagging conducted by the Tagging of Pelagic Predators (Block et al., 2011), which encompassed 23 pelagic predators that as a group utilize the full extent of the North Pacific, identified a variety of important pelagic hotspots and migratory corridors that appear to be vital to the survival of many species.

The Café has been identified as a candidate Ecologically or Biologically Significant Area (EBSA).

Public awareness

Stanford University, Monterey Bay Aquarium and Marine Conservation Science Institute, Shark Stewards, Discovery, True Blue Films and the BBC have written science and public articles, created two films (for Shark Week, entitled 'Great White Highway' and 'Blue Sereneti') and presented the most concrete data that has established this region as a unique site worthy of protection.

Geographic scale and site integrity

The White Shark Café consists of a large and well-delineated oligotrophic area in the north east pacific sub-tropical gyre centered between the Baja peninsula and the big island of Hawaii. By using tagging data, it has been possible to delineate a predictable area critical for white sharks and as such this forms the basis for the integrity of the site proposed.

Other comparable sites

The White Shark Café forms one of several important pelagic hotspots and migratory corridors identified by Block et al. (2011), which also include the North Pacific Transition Zone, and Intertropical Convergence Zone, all of which attract and retain a variety of pelagic predators, but none in such aggregations for the white shark as the Café. These have been likened to the 'watering holes' of the African savannah.

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Appendix 4:

The Sargasso Sea

Illustration of potential Outstanding Universal Value in the High Seas

Name of area:
The Sargasso Sea

Location:
Wider Caribbean and western Mid-Atlantic. 30° N and 60° W.

Description

The 'Golden Floating Rainforest of the Ocean', the Sargasso Sea, is home to an iconic pelagic ecosystem built around the floating *Sargassum* seaweed, the world's only holopelagic algae. It was first viewed by Columbus on his first voyage in 1492 and has been a place of myth and legend ever since, it is located within the North Atlantic sub-tropical gyre bounded on all sides by the clockwise flow of major ocean currents. As such, it is the only sea without coasts, for only the islands of Bermuda lie within it. Its global importance derives from a combination of physical and oceanographic structure, its complex pelagic ecosystems and its role in global ocean and earth system processes (Freestone and Roe et al., 2015).

The floating *Sargassum* hosts a diverse community of associated organisms that include ten endemic species, and provides essential habitat for key life stages of a wide diversity of species, many of which are endangered or threatened or of economic worth. Young sea turtles spend their early – so called 'lost' - years in the *Sargassum* mats where they are protected and nurtured. The Sargasso Sea is the only breeding location for European and American eels, both endangered (the former critically), and is on the migration route of numerous other iconic and endangered species. A variety of oceanographic processes impact productivity and species diversity, and the area plays a disproportionately large role in global ocean processes of oxygen production and carbon sequestration.

The sea floor has two large seamount chains, home to specialized, fragile and endemic communities, and models predict the presence of numerous other isolated seamounts. Both pelagic and benthic ecosystems are impacted by a range of human activities, and the currents of the gyre act to concentrate pollutants.

The area has been of historic relevance and significance since the earliest days of ocean exploration and is the location of significant scientific discoveries that have expanded our understanding of how the global oceans function. Recent action to protect the Sargasso Sea and details of all aspects of an underlying comprehensive science case can be found in Laffoley and Roe et al. (2011).

Jurisdiction - The core area of the Sargasso Sea area featured here is in predominantly High Seas but also includes the Exclusive Economic Zone (EEZ) of Bermuda.

Competent Authorities – includes the International Seabed Authority (ISA), International Maritime Organization (IMO), Northwest Atlantic Fisheries Organization (NAFO), and The International Commission for the Conservation of Atlantic Tunas (ICCAT).

Potential Outstanding Universal Value

Criterion viii – Major stages in Earth's history and geological processes

The Sargasso Sea forms one of the world's five ocean gyres but is globally significant as the only one with a significant floating community based around *Sargassum* algae. It is surrounded by the Gulf Stream to the west, the North Atlantic Drift to the north, the more diffuse Canary Current to the east, and the North Equatorial Current and the Antilles Current to the south. Water retention within the Sargasso Sea is estimated to be up to 50 years and a variety of oceanographic features and processes influence the ecology and biology of the Sargasso Sea on different spatial and temporal scales. Cyclonic or anticyclonic rings and eddies spun off the Gulf Stream may persist as distinct entities for many months to years and these create localized

upwelling and downwelling which impact the upper layers of the Sargasso Sea by mixing surface and deeper waters. This affects nutrients, heat and salinity which together create localized areas of high or low productivity, which in turn impact biodiversity by 'capturing' and bringing 'foreign species' into the area, creating relic populations which may persist for months or, conversely, by spinning species out into the Gulf Stream. The Sargasso Sea plays a key role in both global oxygen production and ocean sequestration of carbon. It is one of the best-known areas of the world's ocean, studied since the 1870s and home to Hydrostation S, the longest-running time series of oceanographic measurements, begun in 1954. Data from the Sargasso Sea have proved critical to our understanding of global ocean processes and global change. The discovery of *Prochlorococcus* and the development of techniques able to evaluate the role of picoplankton in primary production measurements revolutionized perceptions of productivity in the Sargasso Sea and subsequently of the global ocean.

Criterion ix – Significant ecological and biological processes in the evolution of ecosystems, communities of plant and animals

The Sargasso Sea is the ecological crossroads of the Atlantic Ocean. The two species of floating *Sargassum* found in the Sargasso Sea are the world's only holopelagic macroalgae, distinct from all other complex seaweeds in not having an attached benthic stage. Although these species occur in the Gulf of Mexico and Caribbean, the extent of their occurrence in the Sargasso Sea provides a unique and valuable structurally complex habitat in deep, open-ocean waters. The Sargasso Sea is home to numerous endemic species that are, by definition, rare. The floating *Sargassum* community hosts ten endemic species from a broad range of taxa. The mid-water fish community of the Sargasso Sea includes a suite of sub-tropical endemics from three genera in the family *Stomiidae*. On the sea floor, the New England seamount chain and the Corner Sea Rise seamounts are known to host endemic species and specialized communities, and models indicate that other isolated seamounts occur throughout the area.

Criterion x – Significant biological diversity and threatened species of OUV

Many of the species utilizing the Sargasso Sea are of global conservation significance, appearing on the IUCN Red List of Threatened Species, and/or under CITES, as well as in the annexes of the 1990 SPAW Protocol of the Cartagena Convention. Threatened and endangered species utilizing the Sargasso Sea include seabirds in the air above, turtles in the floating *Sargassum*, large pelagic fishes and cetaceans in the waters below, and a wide variety of deep water corals on seamounts rising from the seabed. It is the only spawning area for American and European eels, *Anguilla rostrata* and *Anguilla anguilla*. Porbeagle sharks (*Lamna nasus*) migrate from Canadian waters to the Sargasso Sea, where they may be pupping. The mats of *Sargassum* and their associated communities are essential as nursery habitats and feeding areas for many species of fish, seabirds and turtles. These include *Sargassum*-endemic species, such as the *Sargassum* anglerfish (*Histrio histrio*) and pipefish (*Syngnathus pelagicus*), as well as oceanic flying fish (Exocoetidae), white marlin (*Tetrapturus albidus*) and blue marlin (*Makaira nigricans*). Nearly all the large tunas and tuna-like species managed by ICCAT, including the bluefin tuna (*Thunnus thynnus*), migrate through the Sargasso Sea, while Albacore tuna are also believed to spawn in the Sargasso Sea. Green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricate*), loggerhead turtles (*Caretta caretta*), and Kemp's ridley turtles (*Lepidochelys kempii*), all of which are threatened or endangered, use *Sargassum* as a nursery habitat. Hatchlings swim hundreds of miles to the Sargasso Sea, where they hide in the *Sargassum* to feed and grow in relative safety, spending their so called 'lost years' among the weed. Below the floating *Sargassum*, the Corner Rise and New England Seamounts host abundant populations of deep-water fish and, despite heavy commercial exploitation, remain important as aggregating and spawning areas for the alfonsino (*Beryx splendens*). A variety of seabirds feed in association with *Sargassum* in the Sargasso Sea and its waters provide critical food and shelter for a variety of organisms on migratory routes between the tropical and temperate Atlantic, including basking sharks (*Cetorhinus maximus*), adult leatherback turtles (*Dermochelys coriacea*) and humpback whales (*Megaptera novaeangliae*), during their annual migrations between the Caribbean and the northern North Atlantic.

Threats

Despite its remote location, the Sargasso Sea does not remain totally natural. A recent global analysis of human impacts of marine ecosystems concluded that the area has sustained moderate to high impacts over time. Fisheries landings for many species in the North Central Atlantic have declined significantly in the last 50 years, indicative of impacts on those populations. Bottom trawling between 1976 and 1995 on the Corner Rise seamounts caused extensive destruction of the benthic fauna. Floating plastic particles were reported in the Sargasso Sea as early as 1972, and today the currents of the North Atlantic gyre have trapped floating debris on a scale similar to the more infamous North Pacific garbage patch with concentrations of plastic particles reaching in excess of 100,000 pieces/km^2 in some places. This clearly impacts the naturalness of the area, and the negative impacts of plastic debris on organisms such as turtles and seabirds are well-documented.

There are also some 11 submarine communications cables that have a minor effect on the naturalness of the seabed, and this is likely to be an ongoing issue. The Sargasso Sea lies within one of the world's busiest international shipping areas and is crossed by a large number of vessels each year. This affects the naturalness of the area, but impacts on

conditions are unclear as appropriate research is lacking. Areas of concern include the possible introduction of invasive species via ballast water, the potential impact of underwater noise generated by ships on marine mammals, and the risk of collision with whales, dolphins and turtles. Shipping transiting the Sargasso Sea may also have a direct physical impact on the *Sargassum* mats, destroying the integrity of the floating community. Research is clearly needed to quantify the degree of pressure that shipping exerts on the Sargasso Sea. Despite these concerns regarding the condition of the Sargasso Sea, the ecological and biological functionality of the ecosystem remain intact, allowing this unique area to still fulfil its role as a home and an essential resource for a great diversity of species, many of which are of considerable conservation interest.

Protection and management

In March 2014, representatives from 11 governments met in Bermuda to express concern for the conservation of the Sargasso Sea and five (Azores, Bermuda, Monaco, United Kingdom of Great Britain and Northern Ireland and United States of America) signed the *Hamilton Declaration on Collaboration for the Conservation of the Sargasso Sea* (Freestone and Morrison, 2014). Pursuant to the Declaration, Bermuda established the Sargasso Sea Commission (Freestone and Bulger, 2016) composed of scientists and others of international repute, serving in their personal capacity, to exercise a stewardship role and to assist the signatory governments in developing proposals for conservation measures to be presented to international and regional bodies with sectoral responsibilities for this High Seas area.

The Commission has sponsored the listing, proposed successfully by Monaco in 2014, of the European eel (*Anguilla anguilla*) under Appendix II of the Convention on Migratory Species. It has engaged productively with the cable industry in discussion of best practices in the laying and maintenance of submarine communication cables through the Sargasso Sea (de Juvigny et al., 2015). It is also sponsoring scientific work through the International Commission for the Conservation of Atlantic Tunas (ICCAT) aimed at regulatory actions by ICCAT. In September 2015, after proposals by the Hamilton Declaration, signatories to the North-west Atlantic Fisheries Organization banned the use of attachments to gear used in mid-water trawling that might impact the seabed and banned all fishing, including exploratory fishing on all the seamounts under the Sargasso Sea until the end of 2020. The recovery of these habitats in the coming years will be monitored.

Actions to address some of these concerns can only serve to improve the future outlook for the area. Concerns for the future include the potential for commercial extraction of *Sargassum* seaweed and seabed mining activities. Application of the precautionary approach is vital to ensure the continued ecological and biological importance of this area into the future.

Public awareness

The Sargasso Sea was first reported by Christopher Columbus aboard the 'Santa Maria' on his first voyage in 1492. His sailors, afraid of becoming entangled in the weed and being dragged down to the ocean floor, started the first myths and legends. In the late 19th century, Jules Verne wrote in *Twenty Thousand Leagues under the Sea* (Verne and Miller, 1966) 'Captain Nemo, not wishing to entangle his crew in this herbaceous mass, kept some yards beneath the surface of the waves'. Further notoriety followed by association with the infamous Bermuda Triangle, the south-west area of the Sargasso Sea between Bermuda, Florida and Puerto Rico, where planes and ships apparently suddenly disappeared for no obvious reason. Disney somewhat redressed these fears with his adventures of Donald Duck in the *Secrets of the Sargasso Sea* in the 1960s.[3]

Geographic scale and site integrity

The Sargasso Sea represents an entire ocean gyre system, surrounded by the Gulf Stream to the west, the North Atlantic Drift to the north, the more diffuse Canary Current to the east, and the North Equatorial Current and the Antilles Current to the south. The area thus acts as a functional unit and accordingly displays high site integrity.

Other comparable sites

Whilst floating algal communities exist in other regions of the world ocean, it is the areal extent of the *Sargassum* and the thickness of the mats it forms, along with their persistence, which attract and retain a great density and diversity of associated organisms, which distinguish the Sargasso Sea in significance from ecosystem from other drift algal habitats. The Sargasso Sea is also the northerly limit of persistent *Sargassum* presence.

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Appendix 5:

The Atlantis Bank

Illustration of potential Outstanding Universal Value in the High Seas

Name of area:
The Atlantis Bank

Location:
Southern Indian Ocean, extends from latitudes 32°38' S to 32°48' S, and longitudes 57°12' E to 57°20' E

Description

Deep in the sub-tropical waters of the Indian Ocean, there is an island. But this island's beaches, cliffs and headlands can only be visited by submarine, remote cameras or fish, for it lies at the bottom of the sea. The Atlantis Bank is a sunken tectonic fossil island, the first ever studied. The Bank rises 3,300 m from the bottom of the abyss, peaking 700 m below sea level. It is located at latitude 32° S and flanks the Atlantis II transform fracture zone on the Southwest Indian Ridge. It has a unique paleontological record and due to its research history is a seabed bank of great scientific significance. It was pivotal to understanding the geology of 'ultraslow' spreading seabed ridges. It is also of global value as it is a tectonic bank (rather than the more common volcanic type – hence a bank and not a seamount), consisting of a sunken fossil island (guyot) of crustal origin. The summit is capped by marine carbonate deposits and is largely flat where it was levelled off by sea level erosion during subsidence. The top of the bank covers at least 25 km^2 and because of its remarkable preservation of ancient island features, was named after the mythical island of Atlantis.

The bank was studied in depth during the Ocean Drilling Programme in 1999, and remains a major focus of research activity (such as a widely publicized 2016 attempt to drill down towards the mantle, deep beneath the ocean crust). Baines et al. (2003) and Palmiotto et al. (2013) report on the mechanisms that have given rise to the 120 km-long ridge of which Atlantis Bank is part. As a result of once being an island, the Atlantis Bank has two fossil beaches, lagoons and a submerged headland. About two-thirds of the bank is covered by limestone, with ripple marks identical to those in the sand on exposed beaches. These were 'frozen' or lithified as rock millions of years ago, as the island sank. There are little pot holes ground into gabbro rock from wave erosion.

The complex geomorphology of old headlands, precipitous cliffs, stacks, beaches and lagoons (FAO, 2006; Rogers et al., 2012) harbours a very diverse deep-sea fauna at depths from 700 to 4,000 m (Rogers et al., 2012), characterized by large anemones, armchair-sized sponges and octocorals. Large and very ancient *Paragorgia* colonies are particularly notable. On a recent research cruise visiting several different seamounts on the Southwest Indian Ridge, it was the only bank on which large concentrations of pelagic armourhead fish (*Pseudopentaceros wheeleri*) were observed. It also hosts populations of alfonsino (*Beryx splendens*). Both have seen widespread depletion by fishing in other parts of the deep sea.

The Southwest Indian Ridge has attracted interest as a rich habitat for deep-water commercial fish species. It falls under the jurisdiction of the SIODFA. Partly due to its varied topography resulting in diverse habitats and diversity of species, the Atlantis Bank attracted additional scientific attention and was declared a BPA by SIODFA (FAO, 2006).

Jurisdiction – The Atlantis Bank lies entirely in the High Seas.

Competent Authorities – include Southwest Indian Ocean Fisheries Commission (SWIOFC), the Southern Indian Ocean Deepwater Fisheries Association (SIODFA) and the International Seabed Authority (ISA).

Potential Outstanding Universal Value

Criterion viii – Major stages in Earth's history and geological processes

The Atlantis Bank is a remarkable, tectonic feature created by uplift at the Southwest Indian Ridge and subsequent subsidence. The Bank has an age of about 11 million years shown by its crustal core, was sub-aerially exposed to about

1,000 m altitude about 7 million years, and is capped by a carbonate platform dated between 4.5 and 2.3 million years, deposited when the island was subsiding and about 100-200 m below sea level. It now peaks at 700 meter below sea level. Its location at about 200 km from the spreading ridge, demonstrates slow movement characteristic of an ultra-slow spreading ridge. The Bank has a complex geomorphology of old headlands, precipitous cliffs, stacks, beaches and lagoons. While other examples may occur elsewhere, the Atlantis Bank is the best-documented and studied example of this type of 'cold' or tectonically-formed feature.

Criterion ix – Significant ecological and biological processes in the evolution of ecosystems, communities of plant and animals

The Atlantis Bank harbours a very diverse deep-sea fauna at depths from 700 to 4,000 m (Rogers et al., 2012). The Bank hosts diverse coral gardens and complex sea-cliff deep-sea communities characterized by large anemones, large sponges and octocorals. Large *Paragorgia* colonies are particularly notable. Rock outcrops, particularly along the edges of the summit host large stylasterid colonies, with the echinoid *Dermechinus horridus*. Spines of these urchins form the substratum for infauna around the outcroppings.

Small sharks occur on the Bank summit, including one as yet unidentified species. Solitary corals, also unidentified, occur on the summit. The eastern side of the Bank comprises rocky/boulder slopes with glass sponges and octocorals. The western side has rock buttresses flanking rock-slide features hosting rich benthic communities of large, armchair-sized sponges, glass sponges, anemones and predatory sea spiders.

Observations during JAMSTEC[4] cruises on near-bottom and/or mesopelagic communities at depths from 750 to over 5,000 m show vertical stratification of Crow Shark (*Etmopterus pusillus*), Gilchrist's Orange Roughy (*Hoplostethus gilchristi*) and the Big-eye Dory (*Allocytus verrucosus*). Initial surveys of mid-water biomass by echosounding are not yet conclusive on how the Bank/ridge system affects pelagic fish abundance, though it is clear that the broader region provides significant prey species biomass that supports higher predators, notably macaroni penguin (*Eudyptes chrsolophus*, the largest consumer among seabird species) and southern elephant seal (Boersch-Supan et al., 2015).

Criterion x – Significant biological diversity and threatened species of OUV

The geology and oceanography of the Atlantis Bank has led to a highly unusual confluence of different habitats due to its unusual geological past. In 2012 it was considered of high significance under the CBD EBSA process as an area that contains either (i) unique ('the only one of its kind'), rare ('occurs only in few locations') or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems, and/or (iii) unique or unusual geomorphological or oceanographic features.[5] It was also considered highly significant as an area containing habitat for the survival and recovery of endangered, threatened or declining species, or an area with significant assemblages of such species.

The Bank is a hotspot for biodiversity and is also rated as of high significance for a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery. It is of particular ecological and scientific value and is of importance for the preservation of pelagic armourhead on the Southwest Indian Ridge.

The deep sea south-west Indian Ocean fauna is relatively poorly known compared to the better-studied north Pacific and Atlantic. This is shown by species discoveries from recent expeditions covering primnoid octocorals (Taylor et al., 2013), lobsters (Ahyong, 2014), hyppolytid shrimp (Komai, 2013; Nye, 2013) and sea cucumbers (O'Loughlin et al., 2013), as well as of species assemblages on 'organic fall' habitats (e.g. wood, carcasses) (Amon et al., 2015). However, it is not currently known whether this is indicative of endemism at the regional level or just low historical sampling. These studies have demonstrated isolation among seamounts in the region, and thus of uniqueness of the Atlantis Bank.

Threats

The area appears to be important for pelagic armourhead, a valuable fishery species, and hosts vulnerable marine ecosystems, such as deep coral garden communities. Other seamounts on the Southwest Indian Ridge have experienced high fishing pressure, and it is known that deepwater species, of targeted fish and invertebrate species, have low reproductive rates and slow growth, thus take decades and maybe hundreds of years to recover from fishing. The complex topography of the Atlantis Seamount has protected it from past bottom-trawling activities, thus it may serve as a refuge for resource species targeted elsewhere.

The Atlantis Bank also has intact coral communities which are known to have been impacted significantly by bottom trawling on Southwest Indian Ridge seamounts (Rogers, 2012). Growth rates of structural stony coral species are known to be slow in the deep sea, thus they are highly vulnerable to damage from fishing, particularly bottom trawling. Areas physically damaged by human activities are likely to take hundreds of years to recover. This Bank is thus particularly important in preserving diverse seabed

4 Japan Agency for Marine-Earth Science and Technology. See http://www.jamstec.go.jp/e/about/equipment/ships/shinkai2000.html

5 See https://chm.cbd.int/database/record?documentID=204015

communities on the Southwest Indian Ridge in sub-tropical waters.

Protection and management

The feature has been declared a Benthic Protection Area (BPA) by the Southern Indian Ocean Deepwater Fishers Association (SIODFA). However, there is evidence of fishing on the Bank in the form of trawling scars on landslide areas on the north-western side of the Bank. It is proposed as an Ecologically or Biologically Significant Area (EBSA) because it lies in sub-tropical waters and hosts high densities of pelagic armourhead and vulnerable marine ecosystems (coral garden and cliff communities).

Public awareness

Due to its uniqueness and scientific attention to it, the Atlantis Bank has featured in campaigns raising awareness about the vulnerability of seamounts, with expeditions writing articles (in *Oceanus* magazine in 1998 (http://www.whoi.edu/services/communications/oceanusmag.050826/v41n1/dick.html), in expedition blogs and media content (e.g. on the BBC, http://news.bbc.co.uk/earth/hi/earth_news/newsid_8363000/8363108.stm). Given its recognition as an EBSA, the Atlantis Bank also features in outreach materials on deep sea and seamount conservation, and is among the signature sites in the UNDP/IUCN GEF-funded project on seamounts in the south-west Indian Ocean (http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Water%20and%20Ocean%20Governance/Seamounts_Project.pdf).

Geographic scale and site integrity

The Atlantis Bank is a significant feature – rising up from over 5,000 m deep, it has a top at 700 m that occupies some 25 km^2. Whilst there has been limited impact already from fishing, it nevertheless represents a complete system of sufficient dimensions to safeguard its complex and rich diversity of habitats, ecosystems and species, but nevertheless of reasonable size that the whole system could be designated as a World Heritage site. It is also a distinct Bank from the surrounding seabed areas that are targeted for potential seabed mining concessions.

Other comparable sites

There are estimated to be over 100,000 seamounts one kilometre or larger globally,[6] with an unclear number in the south-west Indian Ocean. The Atlantis Bank is unique for its combination of sub-tropical ocean setting, unusual geological history and ecological and species diversity. It also has a more extensive research history than other banks or seamounts, increasing its value as a reference site.

This Bank is not to be mistaken with the similarly-named Atlantis-Great Meteor Seamount Chain and the Atlantis-Plato-Cruiser-Great Meteor Seamount Group, which is a string of extinct submarine volcanoes (i.e. 'hot' seamounts) in the northern Atlantic Ocean.

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