



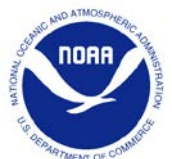
UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of National Marine Sanctuaries
1305 East-West Highway
Silver Spring, Maryland 20910

1/17/2017

MEMO FOR THE RECORD

This PDF document contains two documents submitted by the nominators related to the Mariana Trench National Marine Sanctuary nomination:

- 1) “NATIONAL MARINE SANCTUARY DESIGNATION FOR THE MARIANAS TRENCH MARINE NATIONAL MONUMENT Completing an Environmental Legacy” submitted on 12/5/17; and
- 2) “NOMINATION ADDENDUM” submitted on 1/17/17.



NATIONAL MARINE SANCTUARY DESIGNATION
FOR THE
MARIANAS TRENCH MARINE NATIONAL MONUMENT
Completing an Environmental Legacy

Authors:
Ignacio Cabrera
Diva Amon
Andrew Thaler
Laurie Peterka
Rick MacPherson
Joni Kerr



This snail photographed off the coast of Pagan is almost certainly a new species. *NOAA Office of Ocean Exploration and Research*

Contents

Executive Summary	4
Background.....	7
Cultures Connecting Across Oceans.....	10
A Culture of Conservation	12
Protect the Trench and Volcanic Units	16
Economic Benefits	19
Begin the Sanctuary Process Now	22
Seabirds.....	24
Whales.....	25
Sharks	29
Turtles.....	31
Tuna	32
Deep Ocean.....	34
Notable Deep-sea Species from the Marianas Trench	46
Current and Future Threats.....	49
Climate Change.....	49
Deep-sea Mining	53
Fishing.....	56
Conclusion	59
References	60

Executive Summary

- The Marianas Trench Marine National Monument was established by President Bush on January 6, 2009 and protects over 95,000 square miles of seafloor and waters in the Mariana Archipelago.
- The Monument consists of three units: the **Islands Unit** which protects the seafloor and waters around the three northernmost Mariana Islands, Farallon de Pajaros or Uracas, Maug, and Asuncion; the **Volcanic Unit**, which protects the seafloor surrounding 21 volcanic sites of exceptional scientific and conservation value; and the **Trench Unit**, which protects the seafloor east of the archipelago inside the US Exclusive Economic Zone from north of Uracus to south of Guam.
- Only the **Island Unit** includes the water column in its protective scope, protection within both the **Volcanic** and **Trench Units** is limited to the seafloor.
- The Bush Administration's proclamation included a mandate to create a management plan for the Marianas Trench National Monument following establishment. As of December 1, 2016, a management plan has neither been completed nor put forward for public review.
- There is an opportunity for the Obama Administration to use the National Marine Sanctuaries process to create a sanctuary in the Commonwealth of the Northern Mariana Islands (CNMI), building upon a cultural, scientific, and environmental legacy for future generations.
- CNMI Delegate Gregorio Camacho “Kilili” Sablan and Governor Ralph DeLeon Guerrero Torres wrote to President Obama in September 2016 asking to begin a sanctuary process in the Northern Mariana Islands, specifically to enhance the existing Marianas Trench Marine National Monument
- Since 2009, The Friends of the Marianas Trench have written several times to NOAA to ask for OMNS involvement in the management of the Marianas Trench Marine National Monument, and to enhance the protections afforded the Marianas Trench and the surrounding area, specifically asking to enhance the scope of the **Volcanic** and **Trench Units** to include the water column as well as the seafloor.
- Key ecosystems that would benefit from protection include blue water pelagic regions, shallow and deep-water coral reefs, seamounts, hydrothermal vents, mud volcanoes, cold seeps, and abyssal and hadal communities.

- The Mariana Trench is a region of significant historic value. It was first sounded by the Challenger Expedition and was the site of the Bathyscaph Trieste dive to the bottom of Challenger Deep, the deepest point in the ocean.
- Marine protected areas are most effective when they are large, remote, and comprehensively protected and managed. Expanding the monument to include the water column would enhance wildlife conservation, improve ecosystem health, and increase climate change resiliency.
- A scientific study published in November 2016 has identified the waters around the Marianas and Samoan Islands as the top marine conservation priorities within the United States Exclusive Economic Zone.
- The Office of National Marine Sanctuaries (OMNS) is one of the few federal programs that has, in their enabling legislation, a mandate to conduct educational and research programs, as well as resource protection. OMNS has the history and experience to operate the visitor centers and volunteer programs that were discussed when the monument was established.



NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas

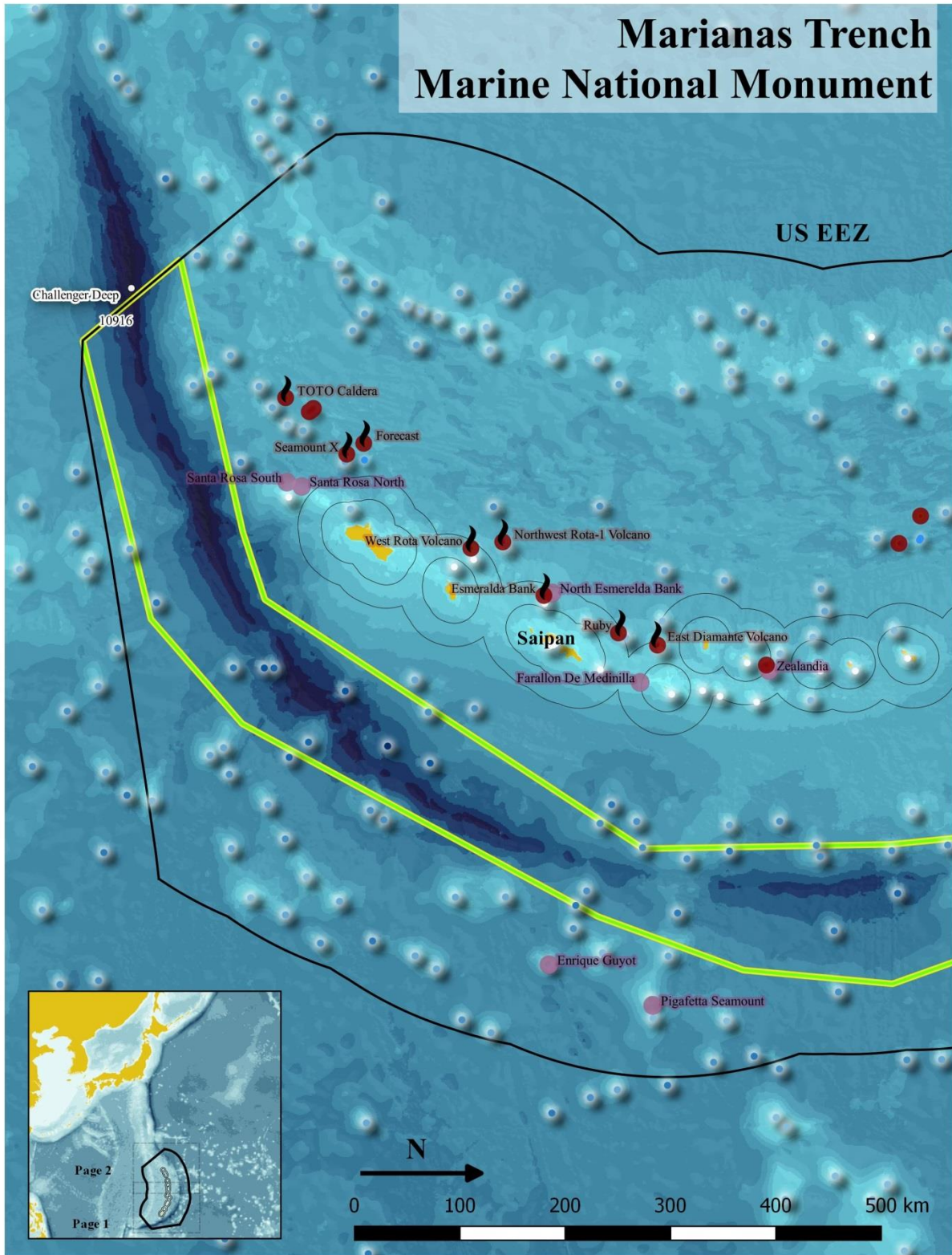
Background

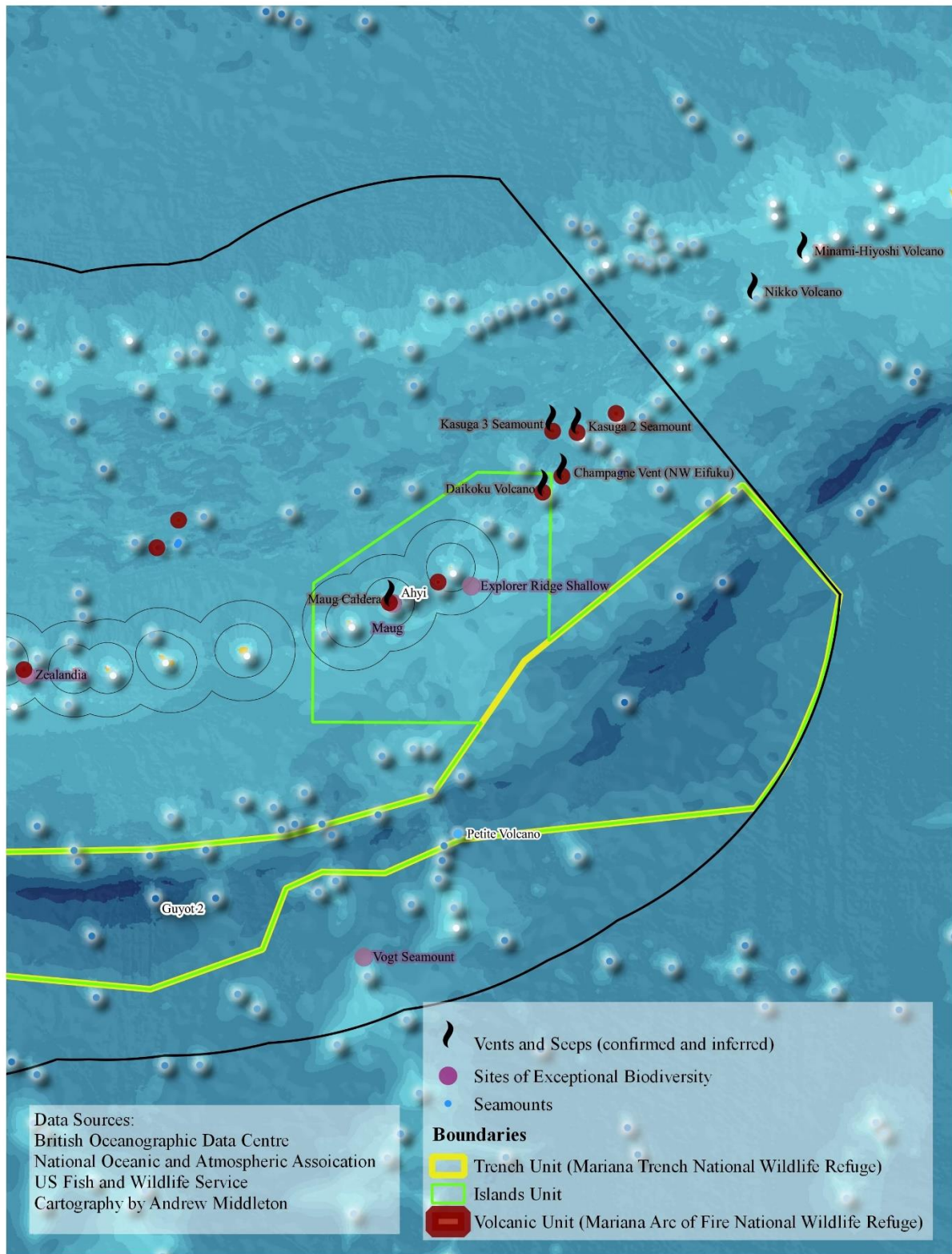
The Obama Administration built a legacy of ocean protection unrivaled by any president in American history. One of the first acts of his administration was to develop the National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes, implemented in 2013. This National Ocean Policy provided a broad framework for interagency cooperation to address critical ocean issues, promote state and community involvement in federal decisions, streamline federal operations, and promote economic growth¹.

The Administration improved and expanded three of the four Pacific marine national monuments designated by former President George W. Bush. In 2012, the Administration expanded the 0.25 square miles Fagatele Bay National Marine Sanctuary into the 13,581 square miles National Marine Sanctuary of American Samoa, now the largest of the 13 national marine sanctuaries. In 2014, the president used his authority under the Antiquities Act of 1906 to expand three of the five marine protected areas managed collectively as the Pacific Remote Islands Marine National Monument, enlarging the area under protection from 225,000 square kilometers to 1.2 million square kilometers. More recently, in August 2016, after receiving nearly 1.4 million comments from constituents and stakeholders around the world, President Obama expanded the Papahānaumokuākea Marine National Monument, creating the world's largest highly-protected contiguous marine protected area. Within this executive order, President Obama also called upon the Secretary of Commerce to create a national marine sanctuary overlay to support education and research programs.

The president has the opportunity today to build upon these earlier decisions by enhancing the Marianas Trench Marine National Monument, the only marine monument in the Pacific he has yet to improve during his administration. Specifically, the president can begin the national marine sanctuary designation process in the Commonwealth of the Northern Mariana Islands (CNMI) consistent with the National Marine Sanctuaries Act². This will protect and preserve unique aspects of Chamorro and Carolinian culture, as well as internationally significant natural resources inside the US Exclusive Economic Zone. The Islands Unit is one area that has been identified by CNMI leaders for inclusion in the national marine sanctuary program, but there are others that should be explored during the designation process.

Marianas Trench Marine National Monument





Cultures Connecting Across Oceans

Archeological evidence indicates the Marianas may have been settled as early as 4,000 years ago by people from Southeast Asia (modern day Indonesia and the Philippines) arriving in seafaring canoes. These accounts establish that early Chamorros were in contact with one another across the archipelago and engaged in commerce with far reaching islands across Oceania. The modern historical records supports this, as well. In 1815, Refaluwasch settlers from the island of Satawal arrived in Saipan using traditional navigation and canoes. Later voyages between Saipan and Satawal, as well as the islands of Puluwat and Yap, kept this tradition alive until modern times.

A century and a half later, master navigator Pius “Mau” Pialug, who has strong familial ties to Saipan, shared his knowledge of traditional navigation with the Polynesian Voyaging Society and thus contributed to the second Hawaiian cultural renaissance and the revival of traditional navigation and canoe building across the entire Pacific³.

All of the Mariana Islanders share cultural and linguistic characteristics and archaeological findings show continuity in ceramic production on the different islands from 900-1700 CE. Similarity in early ceramic styles, decoration, and technique are indicative of areas with “strong inter-community and inter-island ties.”⁴ The Chamorro natives were expert seafarers and skilled craftspeople familiar with intricate weaving and detailed pottery-making.

It is likely that support from the larger, resource-rich islands to the south was needed to sustain intermittent settlements on the remote northern islands of Maug, Asuncion, and Farallon de Pajaros, the area that is now the Islands Unite of the monument. In return, the far northern islands provided the more populated southern islands with basalt and other volcanic rocks for use in mortars (lusong) and adzes⁵.

There is a strong tradition still practiced in the Northern Mariana Islands today that has helped maintain the richness of the Northern Islands. Natural resources, particularly coconut crabs (*ayuyu*) and fruit bats (*fanihi*) can be utilized while visiting the islands, but these resources must be consumed before returning to the south. This tradition often times conflicts with local and federal laws, but these laws are used to punish those who violate the tradition when poachers bring these resources back to Saipan or Guam. Being able to utilize these resources is a privilege afforded community members who have braved a visit to the Northern Islands, but along with this privilege comes the responsibility to protect the resource and ensure that future generations can benefit from them.

Celestial voyaging is another tradition that is practiced in the Northern Islands and the Marianas Trench Marine National Monument. Chamorro and Carolinian maritime skills evolved in local contexts over time and constitute what is now a rich navigational legacy in the Mariana Archipelago, as evidenced in chants still sung among the Refaluwasch people on Saipan today. Maintaining ancient maritime skill sets, including navigation by the stars, has become a source of pride amongst Pacific Islanders everywhere and has spurred Epeli Hau’ofa’s theories about

the great ocean networks that bridge the Pacific⁶. This is only possible today because the ancient routes between the Mariana Islands and Caroline Islands to the south were kept open.

Micronesian voyaging and wayfinding evolved from a system of non-instrument navigation to make long distant voyages across thousands of miles of open-ocean. This traditional practice and art of wayfinding relied upon observations of the natural environment such as the sun, moon and stars which rise and set in predictable star lines, cloud clusters and movement, wind direction and ocean swells or wave pilots.

Biological indicators such as migratory seabirds and/or sea marks provide distinctive natural occurrences at predictable places along sea routes, including regions where certain fish species leap above the water's surface, or zones of innumerable marine or avian life, all of which help to guide voyagers and expand island targets. The practice of traditional wayfinding requires protection of the entire marine environment, not just the target islands, because it then allows for the full use of biological signs and natural phenomena that help to expand the target island, and training navigators to use the full range of signs needed for the wayfinding.

Chamorro and Carolinian people living on Saipan have ambitions to reignite traditional voyaging and wayfinding in the archipelago. In June 2016, five navigators from the Federated States of Micronesia were named master navigators in a *pwo* traditional ceremony during the Festival of Pacific Arts in Guam. All five belong to the Werieng School of navigation. There is also a new NGO on Saipan called 500 Sails that hopes to train a new generation of indigenous sailors.

500 Sails has received a three-year, half million dollar grant from the Administration for Native Americans to create a resurgence of traditional navigating by constructing more than 500 Chamorro proas by 2030, a number that matches the size of the first fleet observed by European explorers. In addition, 500 Sails is in talks with The Okeanos Foundation for the Sea to fund the delivery of a double hulled voyaging canoe to Saipan and are planning a voyage to Maug. This effort will aid in reclaiming the traditional maritime heritage lost when locals were forbidden to access the reefs during the Spanish colonial era⁷.

A Culture of Conservation

The cultures of many Pacific islands have centuries, as opposed to decades, of experience in conserving the coral reefs and other natural resources on which their populations depend⁸. This is especially true in the Northern Mariana Islands, home of the Marianas Trench Marine National Monument. Over time, faced with a changing modern world and the threat of industrial fishing and other harmful activities, many of these ancient beliefs have experienced a cultural evolution, such that the framers of the Constitution of the Northern Mariana Islands guaranteed all citizens the right to a clean and healthful environment:

“Each person has the right to a clean and healthful public environment in all areas, including the land, air, and water. Harmful and unnecessary noise pollution, and the storage of nuclear or radioactive material and the dumping or storage of any type of nuclear waste within the surface or submerged lands and waters of the Northern Mariana Islands, are prohibited except as provided by law⁹.”

CNMI already has a locally-based system of marine protected areas. Preservation and protection were also enshrined in the founding documents of the Commonwealth, as several islands were set aside as uninhabited places in the Constitution:

“The islands of Maug, Uracas, Asuncion, Guguan, and other islands specified by law shall be maintained as uninhabited places and used only for the preservation and protection of natural resources, including but not limited to bird, wildlife, and plant species¹⁰.”

Generations of Chamorros and Carolinians have understood the need for wilderness areas in preserving the indigenous identity of the island community. Nearly a decade ago, The Friends of the Marianas Trench formed to express the voice of the local community and consists of a cross-section of indigenous and resident people of the CNMI who are dedicated to the conservation, preservation and protection of marine flora, fauna and geological features of the oceans; and the creation and proper management of a Marianas Trench Marine National Monument. Inspired by the Commonwealth’s founding fathers and the CNMI Constitution, they successfully petitioned former President George W. Bush to declare the Marianas Trench Marine Monument in 2009.

The vision for the Marine National Monument program, initiated in 2008, seeks to understand and protect the unique natural and cultural resources within the marine national monuments through the advancement of scientific research, exploration, and public education by building strong partnerships that promote healthy ecosystems through science based management. This vision included the explicit goals of developing collaborative, adapted management structures, scientific and exploration research programs, and to increase public awareness, engagement, and support for these monuments by 2016¹¹.

The existing monument covers almost 95,000 square miles of submerged lands and waters in the Mariana Archipelago and includes the Marianas Trench, the “Grand Canyon of the ocean” (though it is almost 120 times larger than the Grand Canyon). Comprised of three units, the Trench Unit, the Island Unit, and the Volcanic Unit, the Monument is jointly managed by NOAA and the US Fish and Wildlife Service in cooperation with the Government of the Commonwealth of the Northern Mariana Islands.

Despite the success in creating this monument, local people feel that a lot of conservation opportunities were missed with the declaration of the Marianas Trench Marine National Monument, and have been advocating for increased protections since 2009¹². Recently, the declaration of the Palau National Marine Sanctuary and the expansion of the Papahānaumokuākea Marine National Monument, has invigorated people living on the islands of Saipan and Guam to again call for expanding the Mariana Trench Monument, or to create a National Marine Sanctuary adjacent to the existing monument. Island leader and former lawmaker Cinta Kaipat wrote a letter to the editor in November 2015 outlining how the Marianas could follow Palau’s model of creating a large scale marine protected area¹³.

“With the amount of development our islands are expected to experience in the coming years, we need to start thinking like our brothers and sisters in Palau. So perhaps it is time to take another look at the Monument. This is a good thing. In many ways, the Monument we got was not the monument we asked for. The designation was opposed by some otherwise reasonable people for all the wrong reasons, and as a result not all of the many potential benefits were realized.”

Currently, protection of the Trench and Volcanic Units only extends to the immediate seafloor, not the water column above. Seafloor ecosystems are significantly and critically influenced by changes in the surrounding water column. Marine ecosystems, particularly deep-sea ecosystems, are vertically mediated, with food, oxygen, and other resources flowing downward into the deep sea. The deep-sea also functions as a buffer and sink for ocean impacts, absorbing and sequestering thermal energy, carbon dioxide, and organic matter. Thus, protecting the seafloor is necessary, but not sufficient in establishing full protection for deep-sea ecosystems, the connected water column up to the surface must also be protected.

Protecting the water column above the Trench Unit would make the monument the fourteenth largest highly protected area in the world, the deepest marine protected area in the world, and the only marine protected area which encompasses a complete cross-section of the ocean, from the surface and pelagic zones to the abyssal and hadal regions.

This document lays out the cultural and scientific justification for the president to begin the National Marine Sanctuary designation process in the Northern Mariana Islands. Additionally, this document highlights how the current levels of protection for the Trench and Volcanic Units do not allow for the proper care and management for populations of migratory birds, fish, mammals, and sea turtles, and newly discovered and little understood deep sea ecosystems found in the area, and explores areas that could be identified for further protections once the sanctuary designation process begins.



This coral and brittle star were seen at Farallon de Medinilla. The green filamentous material hanging off of the coral is hypothesized to be algae that has drifted down from the sea surface. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Protect the Trench and Volcanic Units

Currently only about 3% of the ocean is strongly (all commercial activity prohibited, only light recreational and subsistence fishing allowed) or fully protected (no extractive activities allowed)¹⁴. The International Union for Conservation of Nature recommends protecting 30 percent of the ocean, based on a recent scientific re-evaluation of coverage targets for marine protected areas showing that protection of at least 30 percent of each marine habitat globally is necessary to achieve conservation goals and broader management targets¹⁵. One leading scientist recommends as much as 50 percent¹⁶.

The Islands Unit of the Marianas Trench Marine National Monument is the smallest of the world's large scale marine protected areas. At 42,000 square kilometers (16,000 square miles), it encompasses only 4% of the United States EEZ surrounding Guam and the Northern Mariana Islands. The Volcanic and Trench Units of the monument are not marine protected areas as they protect only the submerged lands in the deepest part of the ocean and none of the water or marine life swimming above them.

Should the water column above the Trench Unit be included a national marine sanctuary, in addition to protecting species and ecosystems that are known, such as tuna, sharks, and whales, protection will also be extended to those species which are yet to be discovered. The Marianas Trench is one of the least studied areas in the world, and recent scientific expeditions have found staggering amounts of biodiversity previously unknown to science. The potential for discovery is astounding, and protecting this unique habitat now would protect these species for future study.

“The deep sea is the last great unexplored wilderness. Every expedition yields new and surprising discoveries which often fundamentally challenge our understanding of life on Earth.”

It is estimated that ninety-one percent of all species in the ocean are unknown to science¹⁷. Globally, on both land and sea, scientists have identified barely 2 million species to date, but as many as 8.7 million are thought to exist, with as many as 2.2 million in the seas alone¹⁸. Many of these discoveries are likely to be found in unprotected areas within the US EEZ around the Mariana Islands.

Protecting the waters above the Trench Unit, or expanding the Islands Unit out to the extent of the US EEZ will also build resilience against the effects of climate change, which the President has identified as a major threat to national security¹⁹. Additionally, an enlarged protected area will serve as a refuge for species faced with warming and increasingly acidic seas^{20,21}

Furthermore, scientists have suggested that attempts to protect coral reefs from the impacts of climate change by solely reducing emissions have little impact unless protected areas are also established²².

A 2014 article published in *Nature* concluded that the effectiveness of marine protected areas (MPAs) yields the greatest conservation benefits when they are large, remote, strongly protected, protected for a long time, and enforced²³. The authors found that the conservation benefits of marine reserves “increase exponentially” with the accumulation of these features. The most effective reserves had twice as many large fish, five times as much fish biomass, and fourteen times more shark biomass than fished areas. By comparison, those with just one or two of the essential characteristics were ecologically indistinguishable from fished areas.

Beginning the sanctuary designation process in the Northern Mariana Islands is timely based on recent science. A 2016 survey of global ocean priorities for marine biodiversity identified the Marianas and Samoan Islands as the top marine conservation priorities within the United States EEZ²⁴.



Shallower moray eels like this one seen at a depth of 279 meters at Supply Reef are nocturnal and live in holes and crevices to avoid predators. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Economic Benefits

Marine protected areas (MPA) deliver substantial benefits to people and the global economy. It is widely established through numerous studies and peer-reviewed publications that the social and economic benefits of establishing and operating MPAs exceed their costs, from 3:1 for 10% protection, up to 20:1 for 30% protection²⁵.

For example, in Hawaii, a review of six marine protected areas showed that they generated benefit-cost ratios ranging from 3.8 to 41.5²⁶. Another example from Vanuatu showed a mean return on investment of 1.8 was achieved for five MPAs only five years after the initial investment²⁷. Another study demonstrated that economic benefits from establishing new MPAs can offset costs in as few as five years²⁸.

MPAs contribute to climate change adaptation and to some extent mitigation. Investing in MPAs can reduce community, national, and global vulnerability by increasing resilience and reducing risk²⁹. It can support adaptation efforts against climate-related impacts at various scales, and contribute somewhat to climate change mitigation via the maintenance of healthy oceans³⁰.

Investments in MPAs can provide direct benefits such as coastal protection, including the protection or restoration of mangroves and coral reefs. These investments will enhance resilience by protecting ecosystems, and thus improving food security and securing livelihoods options³¹. This will be increasingly important in helping communities adapt to climate change and in minimizing damages and losses.

MPAs can strengthen the provision of marine ecosystem services. As marine biodiversity loss disproportionately affects vulnerable populations, investments in MPAs, by helping to protect biodiversity, will help secure the long-term provisioning of key services and access to essential marine resources that support food security, economic opportunities, and human well-being of the world's poor populations³².

MPAs provide insurance and protection from risk. MPAs as the 'conservative' part of our ocean portfolio serve as insurance against our mistakes in management³³. Investments in MPAs can provide insurance against uncertain and accelerating future marine ecosystem change, and maintain and enhance future development options. Investments made now will reduce future costs and preserve opportunities for current and future generations.

MPAs are also a way to share ocean values with future generations. Effective MPAs are a powerful mechanism for delivering sustainable fisheries objectives for coastal marine ecosystems at varying scales, including sustainable food security, livelihoods, climate change, and disaster risk reduction, far into the future.

MPAs, especially those that connect to deep, relatively unexplored, portions of the ocean, can also contribute to fundamental scientific advancement, which often yields unexpected future economic gains as well as promoting international cooperation and collaboration. Currently American geologists are working aboard a Japanese research vessel exploring hydrothermal vent fields in the Trench Unit³⁴. Staging major research expeditions can also yield significant local economic gains in ports-of-call, such as Saipan.

Beginning the sanctuary process in the Northern Mariana Islands should also provide a level of federal spending, which is one of the major pillars of the CNMI economy. Once a sanctuary designation process is begun, it is assumed that the Office of National Marine Sanctuaries would hire local staff to open an office in Saipan and create an advisory council that is more inclusive than just federal oversight.



A Long-Tail Red Snapper spotted on Pagan. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Begin the Sanctuary Process Now

While the existing structure of the Marianas Trench Marine National Monument provides some structure for how the sanctuary designation process could proceed, there are areas and additional ecosystems in need of protection, beyond the Islands Unit. Some of these areas are both inside and outside of the Trench and Volcanic Units.

Expanding the protections during the sanctuary designation process offers an opportunity to conserve an unprecedented cross section of the most volcanically active region on Earth. The spectacular geology and associated rare ecology of the region arise from the subduction of the world's largest tectonic plate, the Pacific Plate, under the smaller, slower moving Philippine Plate. Protecting an expansive habitat like this on land would be nearly impossible to achieve, as it is the equivalent of protecting a cross section of the Rocky Mountains from Nebraska to Utah. The Volcanic and Trench Units of the existing monument only protect the substrate at the bottom of the ocean, but the President could extend protections to the diverse and mostly unknown life swimming in the waters above.



Masked Booby, *Sula dactylatra*, with chick on Tern Island, French Frigate Shoals. Duncan Wright, USFWS Hawaiian Islands NWR.

Seabirds

The Commonwealth of the Northern Mariana Islands is home to abundant populations of seabirds and shorebirds, including the Pacific Reef Heron, the Pacific Golden Plover, Whimbrel, Ruddy Turnstone, Wandering Tattlers, Cattle Egrets, Marianas Mallards, White Terns, Black Noddies, and Great Frigate Birds. Several species of Booby, including the common Brown Booby, Red-footed Booby, and Masked Booby, have major nesting colonies throughout the CNMI. There are past records of several species of albatross in the Marianas, but they have not been found on recent scientific surveys.

Seabirds are some of the most threatened species on the planet and taken as a whole have declined by approximately 70% since 1950³⁵. The largest declines were observed in families containing wide-ranging pelagic species, such as albatross, suggesting that pan-global populations may be more at risk than shorter-ranging coastal populations³⁶.

Many tropical seabird species are unable to dive to great depths. As a result, many species found in the Marianas such as noddies, terns, boobies, and frigatebirds are highly dependent on subsurface predators, particularly tunas and dolphins, to drive forage fish to the surface where they are then accessible to seabirds to take as food^{37,38}. In some parts of the Pacific, diet estimates from lethally sampled seabirds suggest that greater than 75% of prey consumed by some seabird species may be taken during facilitated foraging³⁹. Thus the maintenance of robust fish and dolphin populations is critical for the maintenance of many seabird populations.

Breeding seabirds are likely to forage near to colonies, though the distance they travel to feed varies depending on chick size and dependence. Furthermore, smaller seabird species have been shown to forage further from breeding colonies than larger birds (likely as a result of interspecies competition). Thus, many species are likely to be foraging in unprotected waters, including white-tailed tropicbirds, red-tailed tropic birds, masked boobies, great frigatebirds, sooty terns, and wedge-tailed shearwaters⁴⁰.

Whales

Very little is known about the whales and dolphins that live in the waters surrounding CNMI. As recently highlighted by Fulling et al. (2011)⁴¹, this is problematic for effective management under the Marine Mammal Protection Act, the Endangered Species Act, and the National Environmental Policy Act. As charismatic, yet understudied species, whale research in a National Marine Sanctuary would serve as a unique, collaborative target for future studies.

Common name	Scientific Name	Occurrence	IUCN status
North Pacific right whale*	<i>Eubalaena japonica</i>	Rare	Endangered
Humpback whale (Western North Pacific Distinct Population Segment)*	<i>Megaptera novaeangliae</i>	Regular	Least Concern
Minke whale	<i>Balaenoptera acutorostrata</i>	Rare	Least Concern
Sei whale*	<i>Balaenoptera borealis</i>	Extralimital	Endangered
Fin whale*	<i>Balaenoptera physalus</i>	Rare	Endangered
Blue whale*	<i>Balaenoptera musculus</i>	Rare	Endangered
Bryde's whale	<i>Balaenoptera edeni/brydei</i>	Regular	Data Deficient
Sperm whale*	<i>Physeter macrocephalus</i>	Regular	Vulnerable
Pygmy sperm whale	<i>Kogia breviceps</i>	Regular	Data Deficient
Dwarf sperm whale	<i>Kogia sima</i>	Regular	Data Deficient
Cuvier's beaked whale	<i>Ziphius cavirostris</i>	Regular	Least Concern
Blainville's beaked whale	<i>Mesoplodon densirostris</i>	Regular	Data Deficient
Ginkgo-toothed beaked whale	<i>Mesoplodon ginkgodens</i>	Rare	Data Deficient
Hubbs' beaked whale	<i>Mesoplodon carlhubbsi</i>	Extralimital	Data Deficient
Longman's [Indo-pacific] beaked whale	<i>Indopacetus pacificus</i>	Regular	Data Deficient
Rough-toothed dolphin	<i>Steno bredanensis</i>	Regular	Least Concern

Bottlenose dolphin	<i>Tursiops truncatus</i>	Regular	Least Concern
Indo-Pacific bottlenose dolphin	<i>Tursiops aduncus</i>	Extralimital	Data Deficient
Pantropical spotted dolphin	<i>Stenella attenuata</i>	Regular	Least Concern
Spinner dolphin	<i>Stenella longirostris</i>	Regular	Data Deficient
Striped dolphin	<i>Stenella coeruleoalba</i>	Regular	Least Concern
Short-beaked common dolphin	<i>Delphinus delphis</i>	Rare	Least Concern
Risso's dolphin	<i>Grampus griseus</i>	Regular	Least Concern
Melon-headed whale	<i>Peponocephala electra</i>	Regular	Least Concern
Fraser's dolphin	<i>Lagenodelphis hosei</i>	Regular	Least Concern
Pygmy killer whale	<i>Feresa attenuata</i>	Regular	Data Deficient
False killer whale	<i>Pseudorca crassidens</i>	Regular	Data Deficient
Killer whale	<i>Orcinus orca</i>	Regular	Data Deficient
*Listed as Endangered by the National Marine Fisheries Service.			

What little scientific data exist suggest high diversity for CNMI. A report for the Navy in 2005 included 29 cetacean species which potentially inhabit CNMI's waters. In 2007, an initial scientific survey of cetacean distribution and estimates was undertaken, covering 11,000 km², over depths ranging from 114 to 9,874 meters. Despite unfavorable survey conditions, this survey recorded 13 cetacean species, including sperm whales, baleen whales, four species of blackfish (false killer whales, short-finned pilot whales, melon-headed whales, and pygmy killer whales), and five species of dolphins. Of particular interest was the occurrence of sei whales, since they had not previously been confirmed south of 20°N in the Northern Pacific. An aerial survey later in 2007 detected several other more cryptic species, including dwarf/pygmy sperm whales (*Kogia* spp) and a Cuvier's beaked whale (*Ziphius cavirostris*)⁴². The complex bathymetry of this region, including the Mariana Ridge, the Mariana Trench, and multiple seamounts, seem to be very important to the diversity of cetaceans in the region, with different species associating with different habitats⁴³.

Although no marine mammals were observed during the 2016 expedition 'Deepwater Exploration of the Marianas' by the NOAA Ship *Okeanos Explorer*, there may have been evidence of deep-diving cetaceans observed at approximately 3300 meters at a site known as Unnamed Forearc Seamount, located in the Trench Unit of the Marianas Trench Marine National Monument. There were a number of elongate furrows, most about 0.5 meter deep and 1-2 meters in length that were reminiscent of the gouges made by deep-diving whales observed

elsewhere in the world. If this were the case, this would indicate that there are marine mammals that utilize and likely influence the entire water column (from surface to benthos) in some deep-sea areas of the Marianas Trench Marine National Monument.

Whale falls are a further way that cetaceans may impact the deep ocean of the US EEZ surrounding the Commonwealth of the Northern Mariana Islands and Marianas Trench Marine National Monument. Once a cetacean dies, it may sink to the deep-sea floor where it is termed a 'whale fall', and can provide a resource to the deep-sea community for decades⁴⁴. Whale falls provide a large amount of organic enrichment, shelter and substrate to the deep-sea floor producing a distinct habitat⁴⁵. It is estimated that a 40-tonne whale carcass provides the equivalent organic carbon as that which would sink from the euphotic zone to a hectare of abyssal seafloor over 100-200 years, representing a very large transfer of nutrients from the ocean surface to its depths⁴⁶. The sediments directly under a carcass (which covers roughly 50m²) may experience an initial pulse of organic material equal to 2000 years of organic carbon flux. During the life of the carcass on the deep-sea floor, it transitions through three phases represented by distinct communities that are highly diverse and abundant. The communities are also comprised of both specialist (many species are endemic to whale falls) and opportunist organisms. Some of these species are also thought to use cetacean falls as stepping stones between other chemosynthetic communities such as wood falls, hydrothermal vents, and cold⁴⁷. Although no whale falls have been found within the US EEZ surrounding the Commonwealth of the Northern Mariana Islands so far, they are known from the eastern and central Pacific Ocean, and are thought to occur abundantly worldwide^{48,49}.



"A sixgill shark paid us a visit, and even stuck around for a minute. Note the high diversity of coral species in the foreground. Look closely, and you can see brittle starfish hiding in the corals." NOAA Office of Ocean Exploration and Research, 2016 *Deepwater Exploration of the Marianas*.

Sharks

Sharks are more than an order of magnitude denser around the uninhabited islands of the Marianas archipelago, and one site in the western arc—that is not currently under protection—has one of the highest densities of sharks in the Pacific. Seamounts within the expansion concentrate fish in a desert of deep ocean. Sharks and other apex predators drive smaller fish to the surface, creating the bait balls upon which many species of pelagic seabirds feed.

Ocean predators such as sharks are some of the most important species in the marine environment, and now, are among the most threatened. Globally, shark populations have declined, 100 million sharks are killed each year and half of all shark species assessed by scientists are now threatened or near threatened with extinction⁵⁰. Most sharks are unable to withstand pressures from commercial fishing because, like the great whales, they are grow slowly, take many years to reach sexual maturity, and produce few young⁵¹.

Sharks influence the abundance and diversity of the species below them in the food web, and their removal can have severe ecological consequences⁵². They are a keystone species in decline whose protection is required for a functioning reef system⁵³. As an area of intrinsic high shark diversity⁵⁴, the expansion of the monument would safeguard important priority areas for sharks.

In the Pacific, oceanic whitetip sharks (*Carcharhinus longimanus*) and silky sharks (*Carcharhinus falciformis*), highly migratory species that were once categorized as two of the most abundant species of large marine animals, have declined significantly⁵⁵. Populations of these species have dropped to such low levels that fishing vessels are now prohibited from retaining them^{56,57}. Despite this ban, both species are still incidentally caught and killed on longlines⁵⁸. Bycatch rates in Hawaii, for example, show one shark caught for every two tuna. Since the monument is within the core habitat for both oceanic whitetip and silky shark⁵⁹, an expanded protected area from fishing can ensure that populations of these vulnerable sharks are safeguarded.

During the 2016 *Okeanos Explorer* expedition, there were a number of sightings of a variety of large sharks. These included several smalltooth sandtiger sharks (*Odontaspis ferox*), including a pregnant female, and a sixgill shark (*Hexanchus griseus*) observed at depth, as well as a whale shark at the sea surface (*Rhincodon typus*).

The Western Central Pacific Regional Fisheries Management Council has proposed a directed shark fishery for the Northern Mariana Islands and Guam, despite local bans on the sale of shark fins⁶⁰. A National Marine Sanctuary could many species of sharks.



Sixgill shark seen while exploring Santa Rosa Reef, south of Guam, during the first dive of the Deepwater Exploration of the Marianas expedition. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Turtles

Four species of sea turtles have been recorded in the waters surrounding Guam and the Northern Mariana Islands: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and olive ridley (*Lepidochelys olivacea*)⁶¹. Green turtles are the only species known to currently nest on the islands, although hawksbill nesting has been recorded very rarely⁶². Non-nesting leatherbacks inhabit the pelagic environment.

All four are listed as threatened by the IUCN Red List of Threatened Species. Hawksbill sea turtles are Critically Endangered, green are Endangered, and leatherbacks and olive ridleys are Vulnerable. Globally, mortality from fisheries bycatch (including longlines) is a threat for green, leatherback, and olive ridley turtles⁶³.

Tuna

Skipjack are the most commonly landed commercial tuna in CNMI, followed by bigeye and yellowfin. Tuna landings in the Pacific have generally declined throughout the Pacific region of the US EEZ over the last 10 years. Lacking a sufficient fleet to exploit its own fishery, in recent years CNMI has sold a portion of its tuna fishing quota to the Hawaiian Longliners Association⁶⁴.

Tagging studies of individual yellowfin tuna in the western and central Pacific have found that most have lifetime movements on the order of hundreds, not thousands of miles, although some individuals do make some very long distance movements⁶⁵. Estimates of median lifetime displacements range from 411-471 nautical miles for skipjack (*Katsuwonus pelamis*) and 337-380 nautical miles for yellowfin (*Thunnus albacares*)⁶⁶. Another study, using stable isotopes, suggests that bigeye and yellowfin tuna are not 'highly migratory' and suggests a high degree of regional residency on the order of several months in the equatorial Pacific Ocean⁶⁷.

Most tuna species are assumed to be panmictic, mating randomly across entire ocean basins, but recent studies have shown evidence of site-specific discrete populations⁶⁸. Scientists have found genetically distinct subpopulations of yellowfin tuna in the Pacific Ocean. This result challenges the single stock paradigm for highly migratory species, and for fisheries management suggests that stocks should be assessed and managed at smaller scales.

These findings suggest that individual tuna from different species could spend their entire life history inside the borders of a marine reserve if the area is large enough. It has been shown that female fish that are older and of larger size produce a higher number and a higher quality of eggs⁶⁹. These tuna would grow large and produce exponentially more eggs than smaller, unprotected individuals swimming outside the area of protection. Spillover effects of the fish that do swim outside of the area of protection would benefit fishermen.



A small octopus made an appearance on the dive. You can see how small it is compared to the crinoid stalks it is next to. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

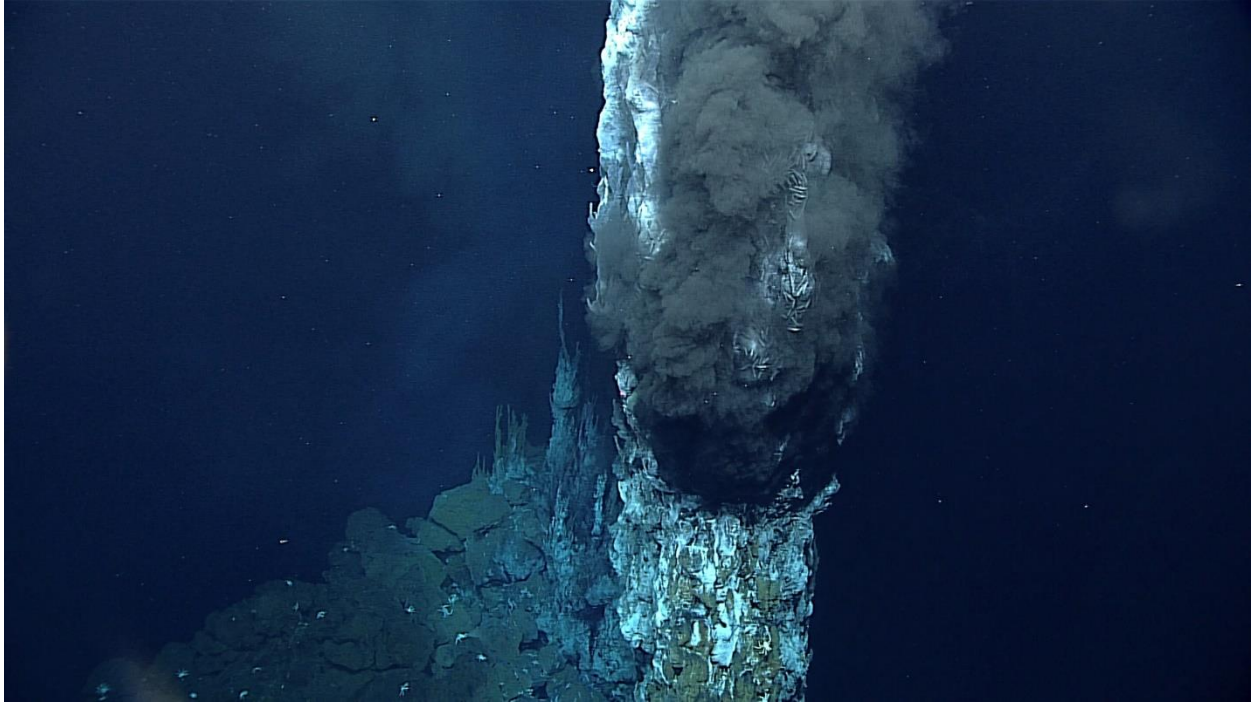
Deep Ocean

Undoubtedly, the most well-known area of the Marianas Trench region is Challenger Deep, the deepest point in our world's oceans at 10,989 meters. The vast majority of deep-sea research (>200 meters) within the Marianas Trench has been focused on this one region. This has meant that most of the deepwater of the US EEZ surrounding the Commonwealth of the Northern Mariana Islands and Marianas Trench Marine National Monument have remained relatively unexplored, especially the water column and its inhabitants. Since 2003, there has been an increase in research activity in this area. NOAA sponsored nine expeditions to the CNMI region; eight of those were focused on volcanic activity and the most recent, the 'Deepwater Exploration of the Marianas' expedition by the NOAA ship *Okeanos Explorer*, collected baseline biological and geological information from a variety of deepwater habitats. There have also been expeditions undertaken by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Schmidt Ocean Institute (SOI) and the DeepSea Challenge expedition of James Cameron. These expeditions have contributed to improved scientific knowledge and provided a small window into the amazing and unique geology that abounds here, as well as the fascinating biology that accompanies it.

The US EEZ surrounding the Commonwealth of the Northern Mariana Islands is one of most geologically-diverse places on Earth. Within this relatively small area, there are seamounts with and without ferromanganese crusts, hydrothermal vents, cold seeps, sedimented plains, active and extinct volcanoes, carbonate platforms and mountains, mud volcanoes, as well as the deepest trench on the planet. During a NOAA expedition in 2006, a number of volcanoes in the back-arc were confirmed to be hydrothermally active, many in ways never seen before and found nowhere else on the planet. A hydrothermally-active area is one where seawater percolates downward through oceanic crust becoming superheated and chemical-rich. It eventually becomes so hot and buoyant that it rises back to the seafloor surface. When this super-hot vent fluid meets the very cold water (2°C) of the deep sea, minerals that are carried in the fluid precipitate out of solution, forming spectacular vent chimneys that emanate clear, white or black fluid⁷⁰.

The vent fluid is then used by chemoautotrophic bacteria as a source of energy to produce organic material and fuel much of the food web at these sites⁷¹. The process, called chemosynthesis, occurs in a similar way to which plants use sunlight via photosynthesis. Chemosynthetic bacteria are then grazed on by heterotrophs, which in turn are eaten by larger predators. Some of these bacteria even live inside vent fauna or grow on specialized appendages⁷². Hydrothermal-vent communities are extremely important for understanding how animals live in extreme conditions, the origin of life on Earth, and connectivity between these 'patchy' habitats.

There are numerous hydrothermally active, scientifically important sites within both the Trench and Volcanic Units.



A "black smoker". Where super-hot vent fluid meets very cold ambient sea water (2°C) of the deep sea, minerals that are carried in the fluid precipitate out of solution, forming spectacular vent chimneys. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

The black-smoker vent communities in the Mariana Arc are some of the most spectacular in the deep sea, as they feature very high abundances of a high diversity of animals, many of which are vent endemic⁷³. These include *Chorocaris* shrimp, *Gandalfus* crabs, actinarians, barnacles, *Bathymodiolus* mussels, *Paralvinella* tubeworms and many others⁷⁴. One of the most enigmatic animals observed at these vents is the deep-sea vent-endemic snail, *Alviniconcha hessleri*. Not only does it have blue blood due to the respiratory pigment hemocyanin and gets its food symbiotically from bacteria that live in its gills, but it also has hair-like projections on its shell, the purpose of which is unknown^{75,76}. During the 2016 *Okeanos Explorer* expedition, a new active vent field was visualized for the first time after discovery during an R/V *Falkor* expedition. This extraordinary site outside of the Marianas Trench Marine National Monument at 3292 meters included a 30-m (or ten-story tall) black-smoker chimney. The chimney is amongst the hottest vents in world at 339°C and hosted large communities of chemosynthetic animals similar to other high-temperature vent communities observed by the submersibles *Shinkai* and *Alvin* at vent fields between 1,500 and 4,000 meters in this area.



Close-up of “hairy snails;” these snails are known to live on hydrothermal vents in the Marianas. NOAA Office of Ocean Exploration and Research.

NW Eifuku Volcano, located within the Islands Unit of the Marianas Trench Marine National Monument at approximately 1600 meters, is characterized by large-scale venting of both gaseous and liquid carbon dioxide⁷⁷. This phenomenon is only known to exist at one other site in the world, in the Okinawa Trough. The white-smoker vents also found at this location provide hydrogen sulfide that supports a community of chemosynthetic organisms, despite acidic waters caused by the high levels of carbon dioxide. During the 2016 *Okeanos Explorer* expedition, new areas of hydrothermal activity were discovered here.

There have been liquid sulfur flows and lakes observed at Nikko Seamount, a site outside of the Marianas Trench Marine National Monument. This was first seen in 2005 during a JAMSTEC expedition. The chemosynthetic life in Nikko's crater and on its upper flanks is probably at the highest density observed to date on any seafloor volcano despite the very dynamic, unstable and acidic environment⁷⁸.

“Within the crater of Maug, found in the Volcanic Unit of the Marianas Trench Marine National Monument, shallow hydrothermal venting acidifies the surrounding coral reef. The location is now used as a proxy for our future oceans (given rising ocean temperatures due to global warming) to help scientists gain an understanding of the effects of ocean acidification on marine organisms⁷⁹.”

The first location deep-sea eruption to ever be observed directly was at NW Rota Seamount in 2006, also located in the Volcanic Unit of the Marianas Trench Marine National Monument. The eruption was observable as an effusion of lava issuing from a pit crater at the summit of the volcano⁸⁰.

Daikoku Seamount in the Islands Unit of the Marianas Trench Marine National Monument also hosts a remarkable high-sulfur hydrothermal system characterized by large numbers of a previously-unknown species of vent-dwelling flatfish. Nowhere else in the world other than in the US EEZ surrounding the Commonwealth of the Northern Mariana Islands and off Japan have flatfish been seen as part of the vent community⁸¹.

The first and only petite-spot volcano in U.S. waters is in the Trench Unit of the Marianas Trench Marine National Monument and was discovered during the 2016 *Okeanos Explorer* expedition. These volcanoes are found at stress cracks in tectonic plates rather than at plate boundaries. This is the only known record of this type of volcano outside of Japan (Hirano 2011) and Costa Rica⁸² and is the first evidence that the petite-spot phenomenon could be much more widespread than originally hypothesized.

One of the deepest cold seeps in the world is found at 5861 meters within the Trench Unit of the Marianas Trench Marine National Monument during a JAMSTEC expedition in 2010⁸³. This indicated that serpentinite-hosted low-temperature-fluid vents can sustain high-biomass chemosynthetic communities.

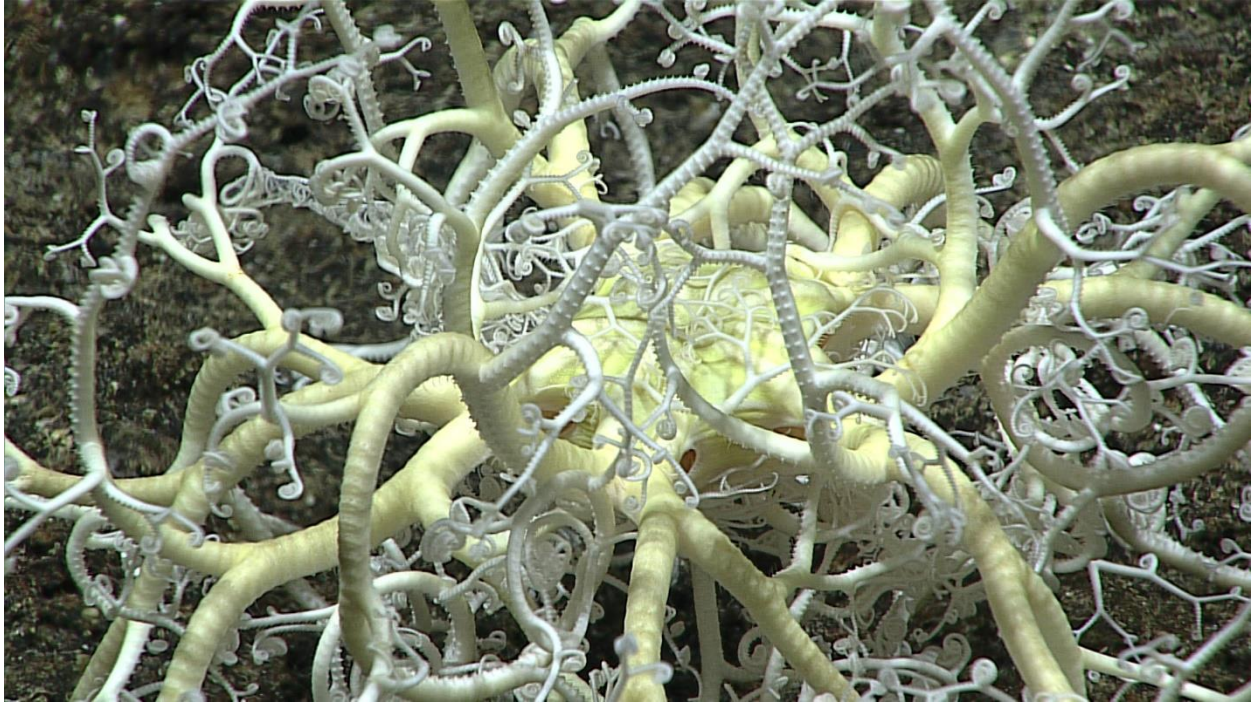
There are also many areas that are not of volcanic origin in the US EEZ surrounding the Commonwealth of the Northern Mariana Islands. Several carbonate areas were observed during the 2016 expedition by the *Okeanos Explorer*, many with numerous fossils. These included the first observations of Cretaceous rudist coral beds in the ocean at Subducting Guyot 1 and Hadal Ridge, two sites in the Trench Unit of the Marianas Trench Marine National Monument and carbonate platforms that may be Pleistocene reefs at Santa Rosa outside of the Marianas Trench Marine National Monument. The site at Hadal Ridge also featured never-before-seen white mountains that were reminiscent of the Alps whereas the site known as Subducting Guyot 1 was the first visited seamount that was being subducted and cracked open.

The US EEZ surrounding the Commonwealth of the Northern Mariana Islands and Marianas Trench Marine National Monument abound with seamounts, some of which are flat-topped, covered in thick ferromanganese crusts, and known as guyots. Seamounts are thought to be hotspots of biodiversity, both in the pelagic and benthic realms^{84,85}. The 2016 expedition by the *Okeanos Explorer* visited five guyots, Vogt, Pigafetta, Del Cano, Fryer and Enrique Guyots, all of which were outside of the Marianas Trench Marine National Monument. These will be used as a proxy for those guyots that may be mined east of US EEZ surrounding the Commonwealth of the Northern Mariana Islands (see section 'Deep-sea Mining').

The high geological diversity in the deepwater of the Mariana region lends itself to a large biological diversity. Prior to the 2016 *Okeanos Explorer* expedition, areas that were not volcanically-active had been poorly explored, many never, resulting in little known about the non-vent-endemic, deep-sea communities. As a result, there were hundreds of new species observed and many collected during the *Okeanos Explorer* expedition. These included several new species of jellyfish, nudibranch, slit-shell gastropod (an ancient type of snail), holothurians, carnivorous cladorhizid sponges of the most fascinating morphologies, an electric-blue tilefish and many more. There were also several new species of hexactinellid sponges including one that could not be identified past the taxonomic level of class! Additionally, there were many rarely-seen species and new records observed both within and outside of the Marianas Trench Marine National Monument. This included the first records for the region of the family, Ateleopodidae (jellynose eels), a slit-shell gastropod (cf. *Bayerotrochus teramachii*) and an anemone-like cnidarian (*Relicanthus* sp.) with 8-foot long tentacles. Another highlight of the *Okeanos Explorer* expedition was the first-ever live sighting of a fish from the family Aphyonidae (ghostfish). It was observed while exploring a ridge feature at a depth of approximately 2500 meters, and was about 10 cm in length with transparent gelatinous skin, which lacked scales, and highly reduced eyes that lacked pigment. But even if an organism was not a new species, new record or rare, many were still extremely strange; from the numerous walking fish to the candelabra-shaped sponges and the hermit crabs with actinarians that replaced their shells.

Ten high-density communities were documented during the 2016 *Okeanos Explorer* expedition, most of which were comprised of deep-sea corals and sponges. This was the first effort to document these communities in the US EEZ surrounding the Commonwealth of the Northern Mariana Islands. Many of these communities were also high diversity, comprised of high

abundances of many orders and families of corals and sponges, as well as commensal echinoderms and crustaceans. These high-density coral and sponge gardens are extremely important, as just like in shallow coral reefs, these habitats are homes to many different types of animals including commercial fish species⁸⁶. Many of these coral and sponges are new species and are also very slow growing, possibly hundreds to thousands of years old, making them vulnerable to fishing pressures⁸⁷. Some of the corals and sponges, especially at Vogt Seamount, were very large (over one meter across) indicating healthy and stable communities. Some of these were within the Marianas Trench Marine National Monument such as Maug and Explorer Ridge (Islands Unit), but several were outside (Vogt Seamount and Farallon De Medinilla). One of the most exciting observations was a community of thousands of individuals of gorgonocephalid basket stars (likely a new species) and crinoids at Zealandia Bank in the Volcanic Unit of the Marianas Trench Marine National Monument. Aggregations of this size have never been seen before.



Close up of a basket star, with commensal ophiuroids. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Some of the most exciting biology in the US EEZ surrounding the Commonwealth of the Northern Mariana Islands is in the Trench Unit of the Marianas Trench Marine National Monument, however it is important to remember that this is not only a trench but also contains many other habitat types, ranging from sedimented plains to cold seeps and seamounts⁸⁸. The deepest-dwelling fauna of the trench have been studied during expeditions by JAMSTEC and the SOI. The ocean floor at such depths consists of biogenous ooze composed of microscopic plankton shells⁸⁹. Xenophyophores (giant single-celled protists), jellyfish, amphipods, and holothurians have found a home in the harsh deepwater environment of Sirena Deep and Challenger Deep⁹⁰ but were also seen during the deepwater dives during the 2016 *Okeanos Explorer* expedition. Scientists on the R/V *Falkor* expedition in 2014 discovered 18 new species below 6400 meters. This included the world's deepest fish, a liparid or snailfish, at 8145 meters.

The 2016 *Okeanos Explorer* expedition concentrated its exploration on the abyssal and abyssal-hadal-transition zone and found a low abundance but high diversity of species, many of which were potential new species or new records. Many species of white, pink and red holothurians (sea cucumbers), crinoids, swimming polychaete worms, acorn worms, long-legged isopods, carnivorous cladorhizid sponges, brisingid sea stars, and sea anemones were observed. Most fish observed in the Trench Unit were ophiidid cusk eels including a *Penopus* sp. seen over 1000 meters deeper than the previous deepest record of 3500 – 4000 meters for the genus. The deepest-known bamboo coral (Isididae) was observed at just over 4300 meters, expanding the known depth range for this family by approximately 100 meters.

The least-explored area of the US EEZ surrounding the Commonwealth of the Northern Mariana Islands is the water column. The 2016 *Okeanos Explorer* expedition conducted the first exploration of the water column by performing several midwater transects at depths ranging from 350 meters to 4000 meters to collect critical information in this vast biome. Transects at 4000 meters were also the deepest midwater exploration ever conducted. The majority of organisms identified during these transects were new records for the Mariana region, rare observations, or potential new species indicating an active but largely unknown pelagic community. Midwater transects at the site known as Subducting Guyot 1 within the Trench Unit of the Marianas Trench Marine National Monument yielded very little at 4000 meters but the number and diversity of plankton and organic particles increased at shallower depths. Mid-depth transects (2000 meters and 3000 meters) documented siphonophores and shrimp. During the transects at 800 meters, 1000 meters, and 1200 meters transects, fauna observed included fish, ctenophores, hydromedusae jellyfish, and siphonophores. Larvaceans (pelagic tunicates) were present throughout all depths surveyed. Midwater transects over the petite-spot volcano in the Trench Unit yielded many of the same taxa as seen at Subducting Guyot 1 but also included chaetognaths (arrow worms), foraminifera, radiolarians, siphonophores, and cephalopods.



This unidentified jellyfish was spotted during water column exploration at a petit-spot volcano.
NOAA Office of Ocean Exploration and Research.

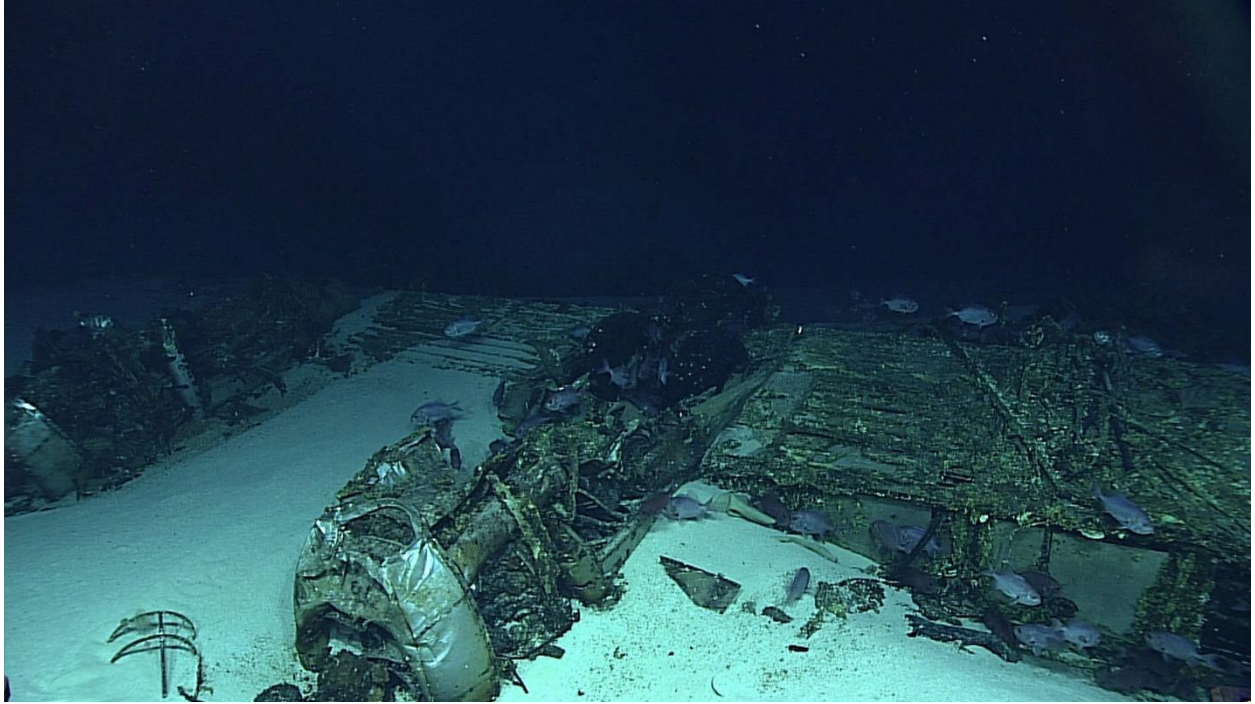
Although the trench and other deep ocean areas of the US EEZ surrounding the Commonwealth of the Northern Mariana Islands and Marianas Trench Marine National Monument are remote, they are connected to the atmosphere, sea surface and rest of the ocean in many ways. One of the most important of these is the biological pump, a key ecosystem service provided by the deep ocean, which is essential for sequestering carbon from the atmosphere. The biological pump has been one of the major buffers against climate change, transferring approximately $5\text{-}15 \text{ GT C yr}^{-1}$ from the surface ocean to the oceans interior worldwide⁹¹ and without it we believe that atmospheric CO_2 would be 200ppm higher⁹². The biological pump consists of the photosynthetic fixation of carbon in the upper ocean by phytoplankton, followed by the sinking of dead and waste material into the deep ocean due to gravitational settling⁹³. Any fixed carbon that makes it to the deep seafloor or are decomposed by bacteria during sinking are remineralized to be used again in primary production. The particles that escape these processes are sequestered in the deep sediment and may remain there for thousands of years.

It is this sequestered carbon that is responsible for ultimately lowering atmospheric carbon dioxide⁹⁴. This biological pump is also linked to the supply of most of the food to the deep seafloor. Nearly all of the food of deep-sea organisms, including those living in the depths of the Trench Unit, arrive from the sea surface via this biological pump⁹⁵. Occasionally, larger pieces of food, such as trees, and dead whales or fish sink from the ocean surface, feeding the deep-sea community for as much as 100 years⁹⁶. Ultimately however, the food supply to most of the deep ocean from the surface is low, decreasing with increasing depth, and therefore results in a low abundance of animals relative to much shallower areas⁹⁷. This connectivity of the sea surface with the deep seafloor has other implications also. This results in marine debris (especially plastics) ending up in the deep ocean where the decomposition process can be very slow⁹⁸. There were many pieces of trash observed during the 2016 *Okeanos Explorer* expedition, especially in the Trench Unit. Trenches, like canyons, can act as conduits, concentrating trash in certain areas.

The Marianas Trench Marine National Monument and US EEZ surrounding the Commonwealth of the Northern Mariana Islands are undoubtedly home to many cultural and historical sites. During the 2016 expedition of the *Okeanos Explorer*, a B-29 *Superfortress* bomber plane from World War II was located in the channel between Tinian and Saipan. These are likely quite common given the significance of the region during WWII. This site, and all as yet undiscovered, represent the final stages of the war, a historically significant time in American history, and are of interest to the Department of Defense POW/MIA Accounting Agency, Saipan Historic Preservation Office, National Park Service, U.S. Navy, U.S. Air Force, and several universities and foundations working to identify crash sites for the families of lost servicemen. This site was also biologically significant as it housed a large community of sessile and mobile animals, which included many commercially valuable fishes.

The discoveries from the limited deep-sea research expeditions in the US EEZ surrounding the Commonwealth of the Northern Mariana Islands have been numerous, scientifically captivating,

and often visually stunning. It is clear that the deep ocean of the CNMI and Marianas Trench Marine National Monument is extremely unique, with geology and biology found nowhere else on the planet, and still much more left to be discovered.



A B-29 Superfortress lost in the vicinity of Saipan. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Notable Deep-sea Species from the Marianas Trench

The deepest reaches of the Marianas Trench are almost completely unexplored. What few expeditions have probed the depths of the planet's deepest canyon have turned up new and surprising species, occasionally redefining our understanding of life on earth.

The hadal snailfish (*Pseudoliparis* sp.), observed at over 5 miles deep, is the deepest-living vertebrate. Prior to its discovery, it was thought the no fish could survive, at that depth, a limit which has since been revised⁹⁹.



This fish, of the family Aphyonidae, had never been seen alive before. *NOAA Office of Ocean Exploration and Research*.

During James Cameron's dive to the bottom of Challenger Deep, he observed an undescribed species of sea cucumber at almost 7 miles deep. These animals appear to rely on filter feeding, extending feeding tentacles into the water column to collect particulate organic matter. Currently undescribed, these sea cucumbers almost certainly represent a new species, if not a new genus.

Among some of the most surprising and enigmatic creatures of the deep Marianas Trench are Xenophyophores. These large, sponge-like creatures are actually single-celled protists, similar to amoebas. The size of softballs, they are the largest single-celled organism in the world.

Perhaps the most tantalizing prospect for scientific discovery in the Marianas Trench lies in its stunning microbial biodiversity. Studies of non-extremophilic sediment isolated thousands of microbes, including actinomycetes, fungi, non-extremophilic bacteria, and extremophilic bacteria like alkaliphiles, thermophiles, and psychrophiles¹⁰⁰. These microbial discoveries have the promise of new and novel pharmaceutical compounds which can only be revealed through fundamental research in protected marine regions.

Microbes aren't the only organisms that may reveal new medical compounds. Spoonworms, common throughout the trench, have been investigated as a potential source of new antibiotic and virucidal compounds as well as for anti-tumor drugs¹⁰¹. Meanwhile, the giant amphipods discovered in the nearby Great Britain Trench produce a compound called scyllo-inositol, which, in the ocean allows species to survive at tremendous pressure, but also inhibits the production of brain plaque, which makes it a promising treatment for Alzheimer's disease¹⁰².



This octopus was seen at Ahyi Seamount. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Current and Future Threats

Climate Change

The amount of carbon in the atmosphere is higher today than at any time in the last 400,000 years¹⁰³. The global concentration of carbon dioxide in the atmosphere surpassed 400 parts per million in 2013¹⁰⁴. Monthly average data from Mauna Loa over the past five years show the steadily increasing concentration of atmospheric carbon dioxide (figure from Mauna Loa, NOAA)¹⁰⁵. Further, the atmospheric partial pressure of carbon dioxide, or $p\text{CO}_2$ correlates with a decrease in pH, or increase in acidity of the ocean¹⁰⁶. Estimates vary, but the ocean absorbs between twenty six percent¹⁰⁷ to half¹⁰⁸ of all carbon dioxide released into the atmosphere.

The chemistry of carbon dioxide dissolving into the ocean is affected by local conditions of temperature, nutrients, ocean circulation and the surrounding biogeochemical community^{109,110}. Determining exactly what happens in a particular area is complicated and of course depends on species composition and resilience, however, both field and laboratory experiments point to acidification as responsible for reducing the availability of carbonate to organisms that produce calcium carbonate structures including corals, molluscs, coccolithophores, and calcareous seaweeds¹¹¹.

Ocean acidification is the insidious side effect of excess atmospheric carbon dioxide. It promises to disrupt formation of coral reefs and stability of food webs, resulting in ecosystem damage and food security issues¹¹². Immediately taking steps to decrease the concentration of atmospheric carbon dioxide is practically the only way to slow the effects of ocean acidification, however, protecting large expanses of reefs from fishing and other extraction activities would also help maintain the biodiversity needed to buffer or ameliorate the effects of ocean acidification¹¹³.

Along with warming, these increases in carbon dioxide are contributing to ocean acidification, deoxygenation, and sea level rise.

Large, strongly protected marine reserves have emerged as important policy solutions which carry the dual benefit of being both marine climate change mitigation and adaptation strategies. By increasing ocean health, marine reserves are one of the most efficient means to protect Earth and its climate. Fully-intact marine ecosystems, such as those protected by marine reserves, are healthy and resilient, better able to withstand the impacts of climate change. On the other hand, damaged ecosystems are weak and susceptible to further destruction and disease.

Scientists have suggested that attempts to spare coral reefs from the impacts of climate change by solely reducing emissions have little impact unless protected areas are also established in lockstep with policies that guard essential fish communities, and thus protect healthy reef functioning¹¹⁴. For example, in the large, fully-protected reserve in the Indian Ocean around the Chagos Islands, healthy lagoon habitat was critical to coral reef resilience to a large-scale warming event, enabling these ecosystems to recover from this unanticipated environmental shock¹¹⁵.

While the Marianas Archipelago coral habitats are relatively isolated, they are still threatened by the effects of climate change. The tropical Pacific has warmed substantially over the past 50 years and the intensified hydrological cycle has reduced the salinity of an area in the Central Pacific Ocean called the Pacific Warming Pool¹¹⁶, posing a considerable threat to the corals of the region¹¹⁷.

Additionally, as surface water temperatures and environmental conditions change, we tend to see the ranges of fish and fisheries shift toward cooler waters^{118,119,120,121,122} affecting fishery health¹²³, food security, and the economics of fishing¹²⁴. In a study conducted in 2012, scientists observed a northward range shift in various species of fish in the northeastern U.S. with increases in surface water temperature¹²⁵. In the Pacific, the expansion of the Pacific Warming Pool due to climate change is expected to push fish north and east¹²⁶. Given this observed relationship, climate change can pose a huge threat to species that need very specific environmental conditions (e.g. temperature, prey availability, mates) in order to survive, therefore shifting their ranges could prove disastrous if they are being heavily fished¹²⁷. With these temperature and environmental perturbations expected to intensify in the Pacific¹²⁸, creation of the Marianas Trench National Marine Sanctuary could provide a climate refuge for these marine species.

It is also important to note that it will take between 25-50 years for ocean chemistry to reach equilibrium with atmospheric carbon emissions, and that there will be a “stopping distance” between when we curb our carbon emissions and when coral reefs start getting healthier¹²⁹. If we wait until problems are visible and acute, they may become irreversible. We should protect the ecosystem now to the greatest extent possible.

Temperature anomalies present another significant threat to the marine environment. Elevated sea surface temperatures may be linked to coral bleaching events reported throughout the tropical Pacific in recent years. These bleaching events place stress on corals, making them more susceptible to disease.

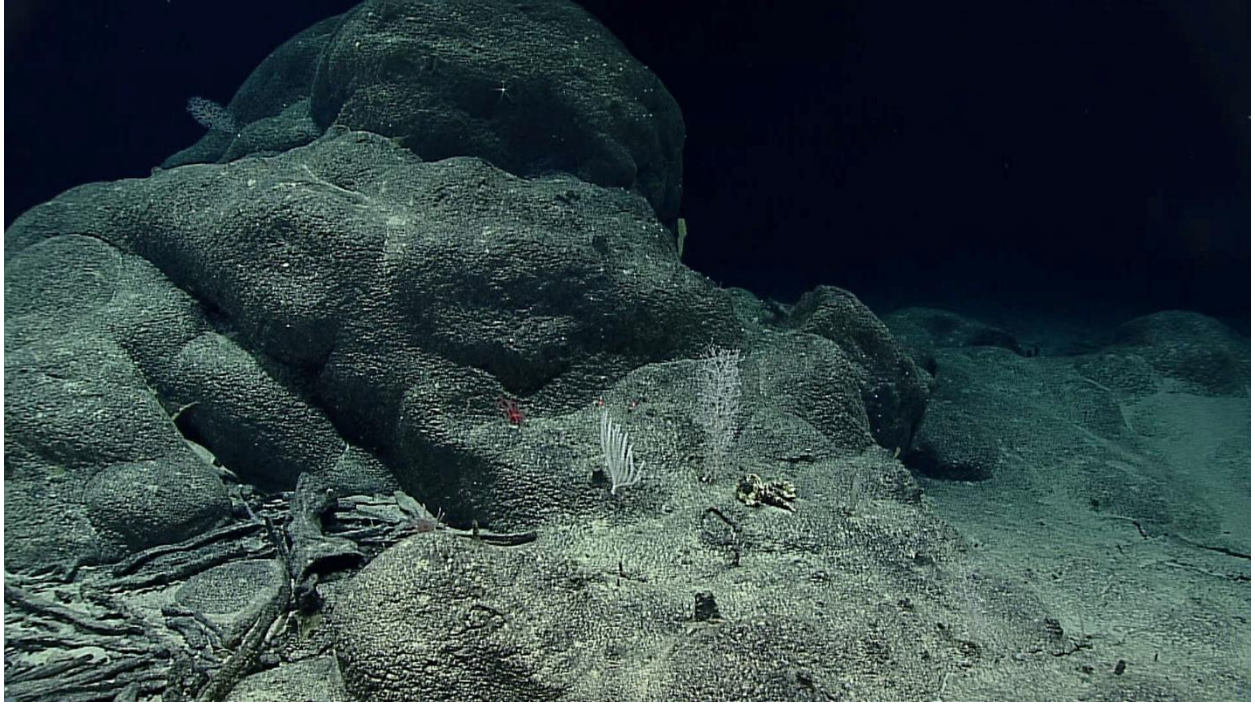
An additional concern is that the species that inhabit Pacific islands are particularly vulnerable to sea level rise. In a 2012 USGS report, models predicted a rise of approximately one meter in global sea level by 2100, which would result in a loss of 4% of the total island area. In an even more severe scenario, islands would lose up to 26% of land with a two meter increase in global sea level, land which various species of seabird depend on as breeding colonies¹³⁰. Additionally, neighboring coral reef archipelagos in the Pacific, such as the North Western Hawaiian Islands,

have on record experienced two episodes of coral bleaching¹³¹. Threats such as these are a major source of concern in maintaining biodiversity.

Seventy one percent of the Earth's surface is covered by ocean. It is the planet's largest ecosystem and plays a crucial role as a climate regulator. The ocean's role in the global carbon cycle is critical - it is by far the biggest carbon sink in the world; over the past 200 years the ocean has accumulated twenty six percent¹³² to half¹³³ of atmospheric carbon emissions. While it has suffered some damage as a result, the ocean has significantly reduced, and mitigated, the impacts of increasing concentrations of atmospheric carbon dioxide.

To an extent, the impacts of climate change have been set in motion, and will continue to affect the ocean and its ability to withstand environmental stress for years to come. However, scientists are discovering that marine life acts as the "biological pump" of the ocean – converting carbon dioxide into living matter – and could serve just as important of a role, if not more, as a carbon sink as the physical and chemical marine processes that drive the solubility of atmospheric carbon dioxide¹³⁴. In fact, this biological pump accounts for about two-thirds of the flux of carbon within the ocean¹³⁵ (see section on 'Deep Ocean').

A new study focuses specifically on the role of marine life in the carbon cycle. The study identifies eight key ways that life ranging from photosynthetic primary producers – that convert sunlight into essential building blocks – to the top predators of marine ecosystems act as carbon sinks. Most notably, this work highlights the role of food web dynamics and marine life biomass in carbon storage¹³⁶. In addition, this study and others have demonstrated that the ability of bony fish to metabolize carbon into calcium carbonate provides a much needed buffer against ocean acidification, accounting for as much as 45 percent of surface ocean carbonate¹³⁷. There is also evidence to suggest that intact predator populations are critical to maintaining or growing reserves of carbon stored in coastal or marine ecosystems, and policy and management need to be improved to reflect these realities¹³⁸. Therefore, using marine reserves as a tool to protect marine life appears to better support the ocean's ability to combat, and recover from, climate change. By keeping marine life in the water, marine reserves also support the ocean's continued role as a biological pump in the carbon cycle.



Ferromanganese crusts draping rocks (and even old sponge stalks) at Fryer Guyot. NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.

Deep-sea Mining

As the worldwide demand for metals increases, humans are seeking these resources in ever more remote places, such as the deep ocean¹³⁹. Although deep-sea mining is prohibited within the Marianas Trench Marine National Monument, the water column and benthos, as well as their inhabitants, are still vulnerable to the severe effects of mining in neighboring waters. Within the EEZ of the CNMI, as well as just outside, there are two sources of metals that could be mined in the future: ferromanganese crusts and seafloor massive sulfides.

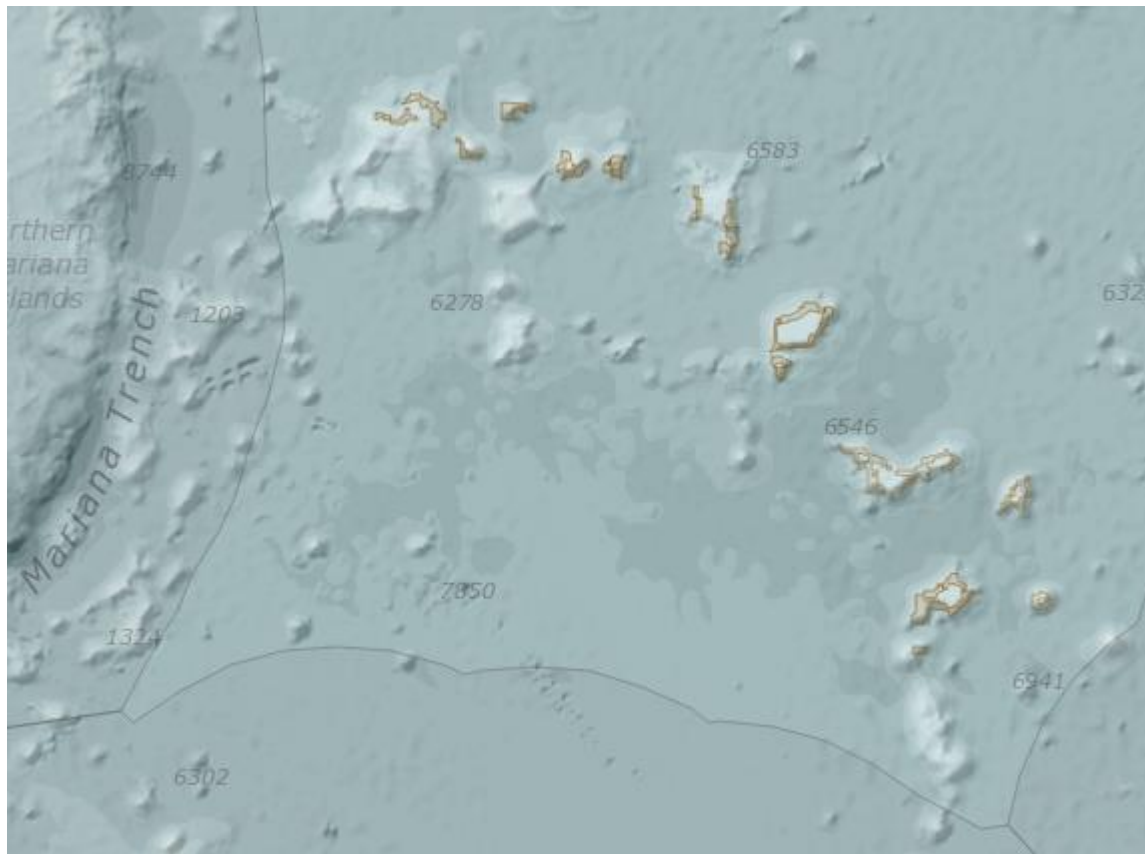
East of the Marianas Trench Marine National Monument, both within and outside of the EEZ, there are many deep-sea flat-topped seamounts, known as guyots, covered in thick ferromanganese crusts. These crusts are potential sources of cobalt, copper, manganese, platinum and other metals¹⁴⁰. These guyots, located in the Prime Crust Zone, are extremely vulnerable to deep-sea mining, as they are among the oldest and thickest in the Pacific Ocean, and therefore potentially some of the most valuable on the planet¹⁴¹. In international waters, just to the east of the CNMI, there have already been three exploratory licenses granted to Japan, Russia, and China¹⁴².

“Because of the great expense involved in exploring the deep sea, industrial exploitation is primed to get there first. Without comprehensive protection for sites of exceptional biological diversity, we may never know the value of what we lost.”

West of the Marianas Trench Marine National Monument within the US EEZ surrounding the Commonwealth of the Northern Mariana Islands, there are numerous massive polymetallic-sulphide deposits at sites of hydrothermal venting, another potentially valuable metal resource. These deposits are known to have high concentrations of zinc, copper, cadmium, gold, silver and other metals¹⁴³. A number of both hydrothermal and ferromanganese-encrusted sites within the Marianas Trench Marine National Monument and US EEZ surrounding the Commonwealth of the Northern Mariana Islands were investigated by the NOAA Ship *Okeanos Explorer* in 2016, highlighting the high diversity of animals that live at these unique deep-sea habitats. The guyots appeared to host unique communities which is interesting from a management perspective, however only a small area of each was investigated.

Given the close proximity of the Marianas Trench Marine National Monument to areas that may be mined in the future, adverse ecological impacts are still possible. Deep-sea mining will be extremely destructive; the process involves the removal of the top mineral-rich layer of the

substrate along with all of the benthic animals that may be living on it¹⁴⁴. Sediment and rock particles will be suspended by machinery, forming sediment plumes that travel with currents in the water column and are then deposited on the benthos across wider areas, potentially within the Marianas Trench Marine National Monument¹⁴⁵. After the processing of mined material on surface support vessels, tailings will likely be deposited at depth in the water column, again creating further large sediment plumes¹⁴⁶. If done in close proximity to the Marianas Trench Marine National Monument, this could smother both animals in the water column, as well as on the seafloor. The mining machinery will also result in high levels of noise and light pollution in the deep ocean^{147,148}. Furthermore, the strategic location of the CNMI may result in some of the islands serving as bases for the mining operations, leading to a large increase in ship traffic within and near to the Marianas Trench Marine National Monument, compounding the issue of noise pollution and possibly resulting in an increase in marine debris and the possibility of accidents. These impacts could impact fisheries, marine mammals, turtles, sharks and other pelagics in the water column.



Current ISA issued lease blocks for deep-sea mining in international waters near the Marianas Trench Marine National Monument. Via <https://deepseaminingwatch.msi.ucsb.edu>

Fishing

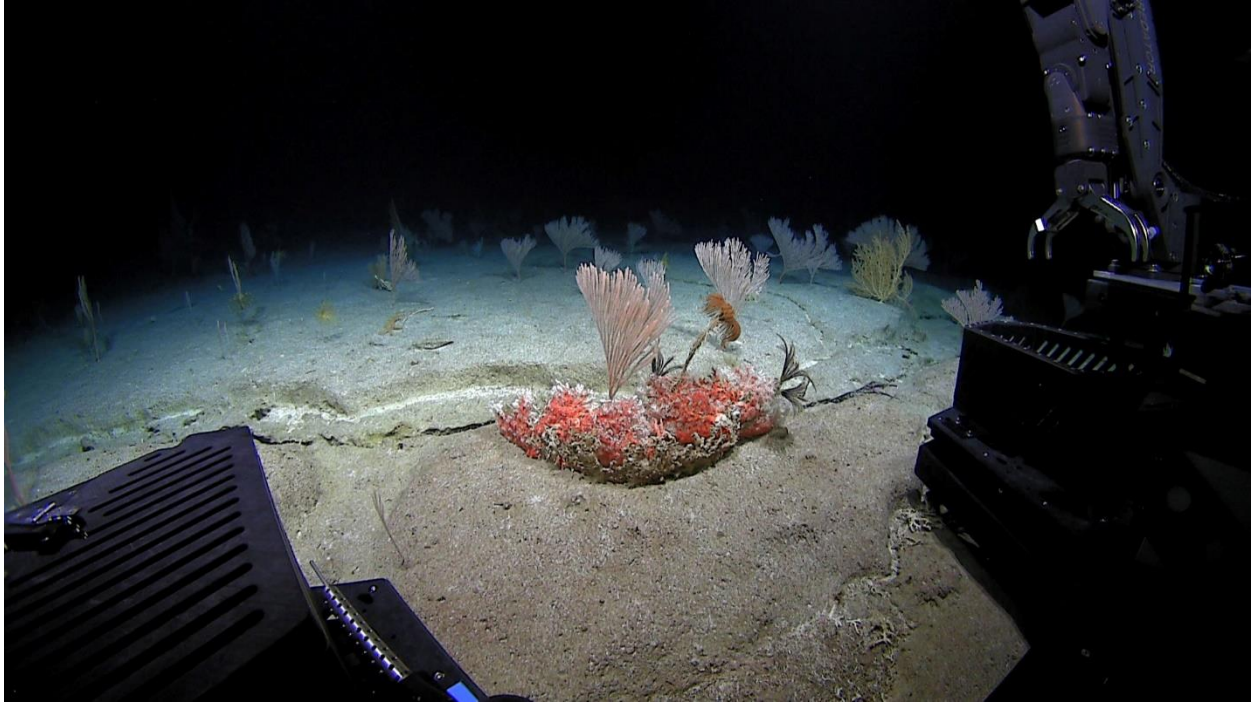
Currently, there is no longline fishing taking place in the CNMI or Guam. Small scale commercial and recreational boats are not active in waters above the trench unit.

Ancient Chamorros [and Carolinians both] relied heavily on the resources of the seas for their subsistence. They had a great variety of fishing equipment and many methods of catching fish. Some of the fishing methods are unique to the aborigines of the Mariana Islands. Juan Pobre de Zamora (1602), Spanish priest, described the Chamorros as “the most skilled fishermen ever to have been discovered¹⁴⁹.”

While the majority of the fishing was coastal, fishing for subsistence while traveling was a necessity. There were restrictions on catches and types of fishing allowed during certain times of year. Any excess catch would be shared with, not sold to, the village and/or salt cured. Different areas were off limits during different times of year and fishing was organized by a caste system with the lowest element forbidden to even touch the sea. Other people were allowed only in the shallows, while yet others (those highest in the system) were granted access rights to the deep sea. Men fished the waters while women would collect sea life from the shallow reefs. Of those granted rights to fish, fishing areas were owned by clans or matrilineages¹⁵⁰.

Today, fishing is still very much a part of Chamorro and Carolinian cultures as with all Pacific island nations. There are fishing derbies and family outings. Fishing for the purposes of subsistence living is inter-mixed with a reliance on store bought canned and boxed foods. There are small scale commercial fisheries focused on catching fish to sell to local restaurants, but they rarely venture to the monument waters. Most fish are caught and sold locally within a confined radius around the southern Mariana Islands. While a couple of attempts have been made at creating a local commercial fishery post WWII, these have not been successful¹⁵¹.

During the 2016 expedition by the NOAA ship *Okeanos Explorer*, a number of commercially-viable fish species were seen inside and outside the Marianas Trench Marine National Monument. These included the pale snapper (*Etelis radiosus*), deepwater longtail red snapper (*E. coruscans*), deepwater red snapper (*E. carbunculus*), eightbar grouper (*Hyporthodus octofasciatus*), amberjack (*Seriola* sp.), dogtooth tuna (*Gymnosarda unicolor*), monchong or sickle pomfret (*Taractichthys steindachneri*), roughy (*Hoplostethus* sp.), oblique-banded snapper (*Pristipomoides zonatus*), ornate jobfish (*Pristipomoides argyrogrammicus*), goldflag jobfish (*Pristipomoides auricilla*), and golden grouper (*Saloptia powelli*). There were also a number of precious corals observed (including pink, red, black, gold and bamboo coral), although fewer than expected. Precious corals are extremely long lived (some species have been known to live over 2,000 years) and slow growing. Although the precious-coral fishery is listed as a managed fishery in Guam and the CNMI, no known harvesting in this region of the Pacific is known to occur.



The low, wide coral toward the bottom of the photo is a precious red coral (*Corallium* sp.). These corals are prized as jewelry and vulnerable to overexploitation. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*



This shrimp is a species in the family Stylodactylidae. The strange setose appendages and the long-toothed rostrum are characteristic of the species. *NOAA Office of Ocean Exploration and Research, 2016 Deepwater Exploration of the Marianas.*

Conclusion

President Barack Obama has a unique opportunity to create the only marine protected area in the world that encompasses the full range of vertical regions in the ocean, from the surface to the abyss. Expanding the Trench and Volcanic Units or the Marianas Trench Marine National Monument will meet the United States' commitment to the Micronesia Challenge for the Commonwealth of the Northern Mariana Islands and Guam. The waters around the Northern Marianas Islands are one of the preeminent biodiversity targets for protection within the United States' EEZ.

The proposed expansion contains assets of considerable cultural, historic, and scientific value, from traditional navigational routes to as-yet unexplored deep-sea resources. The area contains essential habitat for resident and migratory birds, whales, sharks, and threatened sea turtles. The seabed, which, though it has direct protection, is still vulnerable to any impact to the overriding water column, contains some of the rarest deep-sea creatures in the world and holds a staggering amount of undiscovered biodiversity. An uncounted number of seamounts, hydrothermal vents, and geologic formations are still waiting to be explored.

These protections can be put in place with almost no disruption to the commercial fishing industry, which has minimal presence in the area. There is no evidence that a marine protected area above the current Monument would reduce fish catches, as longlining efforts are distributed across the Pacific to target migratory species. NOAA data from the Pacific Remote Islands Marine National Monument strongly supports this claim. Upon creation of that monument, fishing effort simply shifted to the 98% of the ocean still open to fishing.

Decades of scientific evidence point to solutions to better manage our ocean fisheries, and that message is clear: large, remote marine reserves work and prove to be beneficial, not a hardship, to fishermen. No negative impacts on US fisheries landings has resulted from previous designations of fully-protected marine reserves throughout Pacific States and Territories. The creation and expansion of the Papahānaumokuākea Marine National Monument as well as the creation of the Pacific Remote Islands Marine National Monument have demonstrated no adverse effects to fisheries bottom line. Rather, these no-take zones serve as insurance policies for commercial fishing viability into the future.

There is rigorous scientific, as well as historic and cultural reasons to expand the Trench and Volcano Units of the Marianas Trench Marine National Monument. The arguments against expansion are unconvincing and driven by the politics and financial incentives of a few who would seek to exploit the scientific and cultural resource of the Commonwealth of the Northern Mariana Islands for short term gains. It is time to finish the work of protecting this precious resource and complete an environmental legacy for the people of the Mariana Islands, the United States, and the world.

References

- ¹ National Ocean Policy Implementation Plan (<https://www.whitehouse.gov/administration/eop/oceans/implementationplan>)
- ² National Marine Sanctuaries Act (<http://sanctuaries.noaa.gov/library/national/nmsa.pdf>)
- ³ Cunningham, Lawrence J. *Ancient Chamorro Society*. Honolulu: The Bess Press, 1992.
- ⁴ Rainbird Paul, *Archeaology of Micronesia*. 2004: Cambridge University Press. p. 106.
- ⁵ Cunningham, Lawrence J. *Ancient Chamorro Society*. Honolulu: The Bess Press, 1992.
- ⁶ D'Arcy, P., *Connected by the Sea: Towards a Regional History of the Western Caroline Islands*. The Journal of Pacific History, 2001. p. 163-182.
- ⁷ 500 Sails aims to revive maritime sailing tradition in the NMI (<http://www.mvariety.com/cnmi/cnmi-news/local/87876-500-sails-aims-to-revive-maritime-sailing-tradition-in-the-nmi>).
- ⁸ Richmond, Robert H *et al.* (2007) Watersheds and Coral Reefs: Conservation Science, Policy, and Implementation. <http://bioscience.oxfordjournals.org/content/57/7/598.full>
- ⁹ CNMI Constitution, Article I, Section 9
- ¹⁰ CNMI Constitution, Article XIV, Section 2
- ¹¹ Marine National Monument Program (http://www.fpir.noaa.gov/MNM/mnm_index.html)
- ¹² Letter from Friends of the Monument to Delegate Gregorio Sablan, April 2009
- ¹³ Kaipat, Cinta. Palau: That could have ben us...and it still can. Saipan Tribune. 2015. <http://www.saipantribune.com/index.php/palau-that-could-have-been-usand-it-still-can/>
- ¹⁴ Lubchenco, *et al.* 2015 http://www.papahanaumokuakea.gov/education/physical_pnm_size.html
- ¹⁵ O'Leary, B.C., Winther-Janson, M., Bainbridge. J.M., Aitken, J., Hawkins, J.P., Roberts, C.M. (2016), Effective coverage targets for ocean protection. *Conservation Letters*. 10.1111/conl.12247.
- ¹⁶ Wilson, E.O. (2016) *Half Earth: Our Planet's Fight for Life*. Harvard University Press.
- ¹⁷ Camilo Mora, Derek P. Tittensor, Sina Adl, Alastair G. B. Simpson, Boris Worm. How Many Species Are There on Earth and in the Ocean? *PLoS Biology*, 2011; 9 (8): e1001127 DOI: 10.1371/journal.pbio.1001127
- ¹⁸ Mora, *et al* (2011) How Many Species Are There on Earth and in the Ocean? *PLoS Biology*. 10.1371/journal.pbio.1001127
- ¹⁹ Nelson (2015) Obama Says Climate Change Endangers National Security. *Wall Street Journal*. <http://www.wsj.com/articles/obama-to-cast-climate-change-as-a-national-security-threat-1432126767>
- ²⁰ Hazen, E. L., S. Jorgensen, R. R. Rykaczewski, S. J. Bograd, D. G. Foley, I. D. Jonsen, S. A. Shaffer, J. P. Dunne, D. P. Costa, L. B. Crowder, and B. A. Block. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change* 3:234-238.
- ²¹ Perry, A. L., P. J. Low, J. R. Ellis, and J. D. Reynolds. 2005. Climate change and distribution shifts in marine fishes. *Science* 308:1912-1915.
- ²² PJ Mumby *et al.* (2013). Operationalizing the Resilience of Coral Reefs in an Era of Climate Change. *Conservation Letters* 7(3): 176 – 187.
- ²³ Edgar, G. *et al.* (2014) Global conservation outcomes depend on marine protected areas with five key features. *Nature* 506, 216–220.
- ²⁴ Jenkins and Van Houtan (2016) Global and regional priorities for marine biodiversity protection. *Biological Conservation*: 10.1016/j.biocon.2016.10.005
- ²⁵ Brander, L., Baulcomb, C., van der Lelij, J. A. C., Eppink, F., McVittie, A., Nijsten, L., van Beukering, P. (2015) The benefits to people of expanding Marine Protected Areas. VU University, Amsterdam, The Netherlands.

-
- ²⁶ Van Beukering, P., & Cesar, H. (2004). Economic analysis of marine managed areas in the main Hawaiian Islands. paper submitted to HCRI as part of Study Assessment 12.
- ²⁷ Pascal, N. (2011). Cost- Benefit analysis of community-based marine protected areas: 5 case studies in Vanuatu, South Pacific. 107 pp. Component 3A, Socio-economic and coral reef ecosystems. CRISP Research Reports. CRIIBE (EPHE/C).
- ²⁸ Sala E, Costello C, Dougherty D, Heal G, Kelleher K, Murray JH, et al. (2013) A General Business Model for Marine Reserves. PLoS ONE 8(4): e58799. doi:10.1371/journal.pone.0058799.
- ²⁹ Scientists' Consensus Statement on Marine Protected Areas (MPAs): Characteristics, Governance, and Sustainable Financing:
http://www.italyun.esteri.it/rappresentanza_onu/resource/resource/2016/03/scientists_consensus_statement_on_marine_protected_areas.pdf
- ³⁰ *ibid*
- ³¹ MASCIA, M. B., CLAUS, C. A. and NAIDOO, R. (2010), Impacts of Marine Protected Areas on Fishing Communities. Conservation Biology, 24: 1424–1429. doi:10.1111/j.1523-1739.2010.01523.x
- ³² *Ibid.*
- ³³ Lauck, T., C. Clark, M. Mangel, and G. Munro. Implementing the precautionary principle in fisheries management through marine protected areas. Ecological Applications 8 N. 1(1998): s72-s78.
- ³⁴ Geosciences Students Deepen Their Knowledge of Mariana Trench (2016)
http://www.utdallas.edu/news/2016/11/2-32274_Geosciences-Students-Deepen-Their-Knowledge-of-Mar_story-wide.html?WT.mc_id=NewsHomePage
- ³⁵ Paleczny M, Hammill E, Karpouzi V, Pauly D (2015) Population Trend of the World's Monitored Seabirds, 1950-2010. PLoS ONE 10(6): e0129342. doi:10.1371/journal.pone.0129342.
- ³⁶ *Ibid.*
- ³⁷ Maxwell, S. M., and L. E. Morgan. 2013. Facilitated foraging of seabirds on pelagic fishes: implications for management of pelagic marine protected areas. Marine Ecology Progress Series 481:289-303.
- ³⁸ Hebshi, A. J., D. C. Duffy, and K. D. Hyrenbach. 2008. Associations between seabirds and subsurface predators around Oahu, Hawaii. Aquatic Biology 4:89-98.
- ³⁹ Spear, L. B., D. G. Ainley, and W. Walker. 2007. Foraging dynamics of seabirds in the eastern tropical Pacific Ocean. Studies in Avian Biology 35:1-99.
- ⁴⁰ Maxwell, S.M. and Morgan, L.E. (2013) Foraging of seabirds on pelagic fishes: implications for management of pelagic marine protected areas. Marine Ecology Progress Series. 481:289-303.
- ⁴¹ Fulling, G.L., Thorson, P.H. & Rivers, J. (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. *Pacific Science*, 65, 321–343.
- ⁴² Mobley, J. 2007. Marine mammal monitoring surveys in support of "Valiant Shield" training exercises (Aug. 13 – 17, 2007). Final report submitted to Environmental Division, Commander, U.S. Navy, Pacific Fleet
- ⁴³ Fulling, G.L., Thorson, P.H. & Rivers, J. (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. *Pacific Science*, 65, 321–343.
- ⁴⁴ Smith CR, Baco AR (2003) Ecology of whale falls at the deep-sea floor Oceanography and Marine Biology: An Annual Review 41:311-354.
- ⁴⁵ Smith CR, Glover AG, Treude T, Higgs ND, Amon DJ (2015) Whale-Fall Ecosystems: Recent Insights into Ecology, Paleoecology, and Evolution Annual Review of Marine Science 7:571-596
doi:10.1146/annurev-marine-010213-135144.

-
- ⁴⁶ Smith CR, Demopoulos AWJ (2003) The deep Pacific Ocean floor. In: Tyler PA (ed) Ecosystems of the World, vol Volume 28: Ecosystems of the deep ocean. Elsevier, Amsterdam, pp 181-220.
- ⁴⁷ Smith CR, Kukert H, Wheatcroft RA, Jumars PA, Deming JW (1989) Vent fauna on whale remains Nature 341:27-28.
- ⁴⁸ Amon DJ, Hilario A, Martinez-Arbizu P, Smith CR (2016) Observations of organic falls from the abyssal Clarion-Clipperton Zone in the tropical eastern Pacific Ocean Marine Biodiversity doi:10.1007/s12526-016-0572-4.
- ⁴⁹ Lundsten L, Paull CK, Schlining KL, McGann M, Ussler III W (2010) Biological characterization of a whale fall near Vancouver Island, British Columbia, Canada Deep-Sea Research Part I: Oceanographic Research Papers 57:918-922.
- ⁵⁰ IUCN Red List of Threatened Species, <http://www.iucnredlist.org/>
- ⁵¹ Herndon A, Gallucci VF, DeMaster D, Burke W. The case for an international commission for the conservation and management of sharks (ICCMS). Mar Policy 2010;34:1239–1248.
- ⁵² Ferretti, F., Worm, B., Britten, G. L., Heithaus, M. R. and Lotze, H. K. (2010), Patterns and ecosystem consequences of shark declines in the ocean. Ecology Letters, 13: 1055–1071. doi:10.1111/j.1461-0248.2010.01489.x
- ⁵³ Robbins, William D., Mizue Hisano, Sean R. Connolly, and J. Howard Choat. 2006. Ongoing collapse of coral-reef shark populations. Current Biology 16, pp 2314-2319
- ⁵⁴ Holzwarth, S.R., Demartini, E.E., Schroeder, R.E., Zgliczynski, B.J., and Laughlin, J.L. 2006 Sharks and Jacks in the Northwestern Hawaiian Islands from Towed-Diver Surveys 2000-2003. Atoll Research Bulletin. 543: 257-279.
- ⁵⁵ Baum, J., Medina, E., Musick, J.A. and Smale, M. (2015), *Carcharhinus longimanus*. The IUCN Red List of Threatened Species 2015: e.T39374A85699641. <http://dx.doi.org/10.2305/IUCN.UK.2015.RLTS.T39374A85699641.en>. Downloaded on 01 February 2016.
- ⁵⁶ Western and Central Pacific Fisheries Commission (WCPFC). (2013), Conservation and Management Measure for Silky Sharks. CMM 2013-08.
- ⁵⁷ Western and Central Pacific Fisheries Commission (WCPFC). (2011), Conservation and Management Measure for Oceanic Whitetip. CMM 2011-04.
- ⁵⁸ WCPFC Tuna Fishery Yearbook 2014
- ⁵⁹ Clarke, S. C., Harley, S. J., Hoyle, S.D. and Rice J. S. (2013), Population trends in Pacific oceanic sharks and the utility of regulations on shark finning. Conservation Biology, 27: 197–209. doi: 10.1111/j.1523-1739.2012.01943.x
- ⁶⁰ Markrich M. (2013) Managing Sustainable Shark Fishing in the Mariana Archipelago (2013) <http://www.wpcouncil.org/wp-content/uploads/2013/03/Managing-Sustainable-Shark-Fishing-final-report.pdf>
- ⁶¹ Kolinski et al. (2001) An Assessment of the Sea Turtles and Their Marine and Terrestrial Habitats at Saipan, Commonwealth of the Northern Mariana Islands. Micronesica 34(1):55-72.
- ⁶² Eldredge, L.G. (2003). The marine reptiles and mammals of Guam. Micronesica, 35, 653–660.
- ⁶³ IUCN Red List of Threatened Species, <http://www.iucnredlist.org/>
- ⁶⁴ Villanueva-Dizon (2016) Seman: Deal on sale of tuna quota done. <http://www.saipantribune.com/index.php/seman-deal-sale-tuna-quota-done/>
- ⁶⁵ Hilborn R, Sibert J. Is international management of tuna necessary. Marine Policy 1988;12(1):31–9.
- ⁶⁶ Sibert, J., & Hampton, J. (2003). Mobility of tropical tunas and the implications for fisheries management. *Marine Policy*, 27(1), 87–95.

-
- ⁶⁷ Graham, B. S., Koch, P. L., Newsome, S. D., McMahon, K. W., & Aurioles, D. (2010). Using Isoscapes to Trace the Movements and Foraging Behavior of Top Predators in Oceanic Ecosystems. In J. B. West, G. J. Bowen, T. E. Dawson, & K. P. Tu (Eds.), *Isoscapes* (pp. 299–318). Springer Netherlands
- ⁶⁸ Grewe, P.M. *et al.* Evidence of discrete yellowfin tuna (*Thunnus albacares*) populations demands rethink of management for this globally important resource. *Sci. Rep.* 5, 16916; doi: 10.1038/srep16916 (2015).
- ⁶⁹ Lutcavage M., Brill R.W., Skomal G.B., Chase B.C. & P.W. Howey (1999). Results of pop-up satellite tagging of spawning size class in the Gulf of Maine: do North Atlantic blue fin tuna spawn in the mid-Atlantic? *Canadian Journal of Fisheries and Aquatic Science* 56, pp 173-177
- ⁷⁰ Van Dover CL (2000) *The Ecology of Deep-Sea Hydrothermal Vents*. Princeton University Press, Princeton, New Jersey
- ⁷¹ *Ibid.*
- ⁷² *Ibid.*
- ⁷³ Kojima S, Watanabe H (2015) Vent Fauna in the Mariana Trough. In: *Subseafloor Biosphere Linked to Hydrothermal Systems*. Springer, Japan, pp 313-323
- ⁷⁴ *Ibid.*
- ⁷⁵ Okutani T, Ohta S (1988) A new gastropod mollusk associated with hydrothermal vents in the Mariana Back-Arc Basin, Western Pacific *Venus* 47:1-9
- ⁷⁶ Wittenberg JB, Stein JL (1995) Hemoglobin in the symbiont-harboring gill of the marine gastropod *Alviniconcha hessleri* *Biological Bulletin* 188:5-7
- ⁷⁷ Lupton J et al. (2006) Submarine venting of liquid carbon dioxide on a Mariana Arc volcano *Geochemistry, Geophysics, Geosystems* 7
- ⁷⁸ Nakamura K, Embley, R.W., Chadwick, W.W., Butterfield, D.A., Takano, B., Resing, J.A., de Ronde, C.E., Lilley, M.D., Lupton, J.E., Merle, S.G. and Inagaki, F. (2006) Liquid and Emulsified Sulfur in Submarine Solfatara Fields of two Northern Mariana Arc Volcanoes. Paper presented at the AGU Fall Meeting Abstracts
- ⁷⁹ Embley RW et al. (2014) Gas Chemistry of Submarine Hydrothermal Venting at Maug Caldera, Mariana Arc. Paper presented at the AGU Fall Meeting Abstracts.
- ⁸⁰ Chadwick WW et al. (2008) Direct video and hydrophone observations of submarine explosive eruptions at NW Rota-1 volcano, Mariana arc *Journal of Geophysical Research: Solid Earth* 113:B8
- ⁸¹ Munroe TA, Hashimoto J (2008) A new Western Pacific tonguefish (Pleuronectiformes: Cynoglossidae): the first pleuronectiform discovered at active hydrothermal vents *Zootaxa* 1839:43-59
- ⁸² Buchs D.M et al. (2013), Low-volume intraplate volcanism in the Early/Middle Jurassic Pacific basin documented by accreted sequences in Costa Rica, *G-cubed*, 14 (5), 20 May 2013.
- ⁸³ Ohara Y et al. (2012) A serpentinite-hosted ecosystem in the Southern Mariana Forearc *Proceedings of the National Academy of Sciences* 109:2831-2835
- ⁸⁴ Rogers AD (1994) The biology of seamounts *Advances in Marine Biology* 30:305-350
- ⁸⁵ Rowden AA et al. (2010) A test of the seamount oasis hypothesis: seamounts support higher epibenthic megafaunal biomass than adjacent slopes *Marine Ecology* 31:95-106
- ⁸⁶ Roberts JM, Wheeler AJ, Freiwald A (2006) Reefs of the deep: the biology and geology of cold-water coral ecosystems *Science* 312:543-547
- ⁸⁷ *Ibid.*
- ⁸⁸ Jamieson AJ, Fujii T, Mayor DJ, Solan M, Priede IG (2010) Hadal trenches: the ecology of the deepest places on Earth *Trends in Ecology & Evolution* 25:190-197
- ⁸⁹ *Ibid.*
- ⁹⁰ *Ibid.*

- ⁹¹ Henson SA, Sanders R, Madsen E, Morris PJ, Le Moigne F, Quartly GD (2011) A reduced estimate of the strength of the ocean's biological carbon pump *Geophysical Research Letters* 38
- ⁹² Parekh P, Dutkiewicz S, Follows MJ, Ito T (2006) Atmospheric carbon dioxide in a less dusty world *Geophysical Research Letters* 33
- ⁹³ Longhurst AR, Harrison WG (1989) The biological pump: profiles of plankton production and consumption in the upper ocean *Progress in Oceanography* 22 47-123
- ⁹⁴ *Ibid.*
- ⁹⁵ Herring P (2002) *The Biology of the Deep Ocean*. Oxford University Press, Oxford
- ⁹⁶ Smith, Craig R., and Amy R. Baco. "Ecology of whale falls at the deep-sea floor." *Oceanography and marine biology* 41 (2003): 311-354.
- ⁹⁷ Herring P (2002) *The Biology of the Deep Ocean*. Oxford University Press, Oxford
- ⁹⁸ Ramirez-Llodra E et al. (2011) Man and the last great wilderness: Human impact on the deep sea *PLoS ONE* 6:e22588 doi:10.1371/journal.pone.0022588
- ⁹⁹ Yancey, Paul H., et al. "Marine fish may be biochemically constrained from inhabiting the deepest ocean depths." *Proceedings of the National Academy of Sciences* 111.12 (2014): 4461-4465.
- ¹⁰⁰ Takami H., Inoue A., Fuji, F., Horikoshi K. (1997) Biodiversity in the deepest sea mud of the Mariana Trench, *JAMSTEC Journal of Deep-sea Research*, 14:545-552
- ¹⁰¹ Gauthier, Michel J., and Marina de Nicola Giudici. "Antibiotic activity of bonellin and hematoporphyrin on marine and terrestrial bacteria." *Current Microbiology* 8.4 (1983): 195-199.
- ¹⁰² Marlow (2012) Giant Crustaceans, Possible Alzheimer's Drug Among Findings from James Cameron's Deep Sea Expedition. *Wired*. <https://www.wired.com/2012/12/giant-crustaceans-possible-alzheimers-drug-among-findings-from-james-camerons-deep-sea-expedition/>
- ¹⁰³ http://climate.nasa.gov/climate_resources/24/
- ¹⁰⁴ <http://climate.nasa.gov/news/916/>
- ¹⁰⁵ <http://www.esrl.noaa.gov/gmd/ccgg/trends/>
- ¹⁰⁶ <http://www.pmel.noaa.gov/co2/file/Hawaii+Carbon+Dioxide+Time-Series>
- ¹⁰⁷ Le Quéré et al. (2013) The global carbon budget 1959–2011, *Earth Syst. Sci. Data*, 5, 165-185, doi:10.5194/essd-5-165-2013, 2013.
- ¹⁰⁸ C. L. Sabine et al (2004) The Oceanic Sink for Anthropogenic CO₂. *Science*, 305(5682), 367–371
- ¹⁰⁹ Klypas, J. & Langdon, C., Overview of CO₂-induced changes in seawater chemistry. Accessed 23 Apr 2016, <http://cals.arizona.edu/azaqua/Biosphere/Papers/CO2%20induced%20Changes%20in%20Seawater%20Chemistry%20Full%20Paper%20III.pdf>
- ¹¹⁰ Marinov, I. Follows, M., Gnanadesikan, A., Sarmiento, J.L., and Slater, R.D.. 2008. How does ocean biology affect atmospheric pCO₂? Theory and models. *Journal of Geophysical Research*, 113:C7, doi:10.1029/2007JC004598. Accessed 23 Apr 2016, <http://ocean.mit.edu/~mick/Papers/Marinov-et-al-JGR2008.pdf>
- ¹¹¹ Hoegh-Guldberg O et al. (2007) Coral reefs under rapid climate change and ocean acidification. *Science*, 319:1737. DOI: 10.1126/science.1152509.
- ¹¹² [64] IGBP, IOC, SCOR. 2013. Ocean acidification summary for policymakers- third symposium on the ocean in a high CO₂ world. International Geosphere-Biosphere Programme, Stockholm, Sweden.
- ¹¹³ Mumby, Peter J., et al. "Operationalizing the resilience of coral reefs in an era of climate change." *Conservation Letters* 7.3 (2014): 176-187.
- ¹¹⁴ *Ibid.*
- ¹¹⁵ BM Riegl et al. (2010). Pristine reefs recover better: examples from Chagos and the Red Sea. *Eos Trans. AGU*, 91(26), Meet. Am. Suppl., Abstract B11A-02.

-
- ¹¹⁶ Bell, J. D., Alexandre, G., Gehrke, P. C., Griffiths, S. P., Hobday, A. J., Hoegh-Guldberg, O., Johnson, J. E., Borgne, R. L., Lehodey, P., Lough, J. M., et al. 2013. Mixed responses of tropical Pacific fisheries and aquaculture to climate change. *Nature Climate Change*.
<http://www.nature.com/nclimate/journal/v3/n6/full/nclimate1838.html>
- ¹¹⁷ Cravatte, S., Delcroix, T., Zhang, D., McPhaden, M. and Leloup, J. (2009), Observed freshening and warming of the western Pacific Warm Pool. *Climate Dynamics*, 33 (4): 565-589.
- ¹¹⁸ Booth, D. J., N. Bond, and P. Macreadie. 2011. Detecting range shifts among Australian fishes in response to climate change. *Marine and Freshwater Research* 62:1027–1042.
- ¹¹⁹ Molinos, J. G., B. S. Halpern, D. S. Schoeman, C. J. Brown, W. Kiessling, P. J. Moore, J. M. Pandolfi, E. S. Poloczanska, A. J. Richardson, and M. T. Burrows. 2015. Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change* 6:83-88.
- ¹²⁰ Sunday, J. M., G. T. Pecl, S. Frusher, A. J. Hobday, N. Hill, N. J. Holbrook, G. J. Edgar, R. Stuart-Smith, N. Barrett, T. Wernberg, R. A. Watson, D. A. Smale, E. A. Fulton, D. Slawinski, M. Feng, B. T. Radford, P. A. Thompson, and A. E. Bates. 2015. Species traits and climate velocity explain geographic range shifts in an ocean-warming hotspot. *Ecology Letters* 18:944-953.
- ¹²¹ Perry, Allison L., et al. "Climate change and distribution shifts in marine fishes." *science* 308.5730 (2005): 1912-1915.
- ¹²² Hazen, Elliott L., et al. "Ontogeny in marine tagging and tracking science: technologies and data gaps." *Marine Ecology Progress Series* 457 (2012): 221-240.
- ¹²³ Cheung, W. W., Watson, R., & Pauly, D. (2013). Signature of ocean warming in global fisheries catch. *Nature*, 497(7449), 365-368.
- ¹²⁴ Sumaila, U. R., Cheung, W. W., Lam, V. W., Pauly, D., & Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. *Nature climate change*, 1(9), 449-456.
- ¹²⁵ Pinsky, M. L., Fogarty, M. 2012. Lagged social ecological responses to climate and range shifts in fisheries. *Nature Climate Change*.
http://www.princeton.edu/~pinsky/Publications_files/Pinsky%20%26%20Fogarty%202012%20lagged%20responses%20of%20fisheries%20-%20Clim%20Change.pdf
- ¹²⁶ Bell, J.D., et al. (2012) Mixed Responses of tropical Pacific fisheries and aquaculture to climate change. *Nature Climate Change*. 3: 591–599 doi:10.1038/nclimate1838.
- ¹²⁷ Pershing, A. J., Alexander, M. A., Hernandez, C. M., Kerr, L. A., Le Bris, A., Mills, K. E., Nye, J. A., Record, N. R., Scannell, H. A., Scott, J. D., et al. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. *Science*.
<http://science.sciencemag.org/content/sci/350/6262/809.full.pdf>
- ¹²⁸ Bell, J. D., Alexandre, G., Gehrke, P. C., Griffiths, S. P., Hobday, A. J., Hoegh-Guldberg, O., Johnson, J. E., Borgne, R. L., Lehodey, P., Lough, J. M., et al. 2013. Mixed responses of tropical Pacific fisheries and aquaculture to climate change. *Nature Climate Change*.
<http://www.nature.com/nclimate/journal/v3/n6/full/nclimate1838.html>
- ¹²⁹ Hansen, J., Nazarenko, L., Ruedy, R., Sato, M., Willis, J., Del Genio, A., Kock, D., Lacis, A., Lo, K., Menon, S., Novakov, T., Perlwitz, J., Russell, G., Schmidt, G.A., and Tausnev, N. (2004) *Earth's Energy Imbalance: Confirmation and Implications*. *Scienceexpress*.
- ¹³⁰ U.S. Geological Survey. 2012. Predicting Sea-Level Rise Vulnerability of Terrestrial Habitat and Wildlife of the Northwestern Hawaiian Islands. <<http://pubs.usgs.gov/of/2012/1182/of2012-1182.pdf>>
- ¹³¹ Kenyon, J.C., Brainard, R. E. 2006. Second recorded episode of mass coral bleaching in the Northwestern Hawaiian Islands. *Atoll Research Bulletin*.
http://www.pelagicos.net/BIOL3010/readings/KenyonARB543_Final.pdf
- ¹³² Quééré, C. Le, et al. "The global carbon budget 1959–2011." *Earth System Science Data* 5.1 (2013): 165-185.

-
- ¹³³ Sabine, C. L., Feely, R. A., Gruber, N., Key, R. M., Lee, K., Bullister, J. L., ... & Millero, F. J. (2004). The oceanic sink for anthropogenic CO₂. *science*, 305(5682), 367-371.
- ¹³⁴ D Laffoley et al. (2014). The Significance and Management of Natural Carbon Stores in the Open Ocean. IUCN.
- ¹³⁵ *Ibid.*
- ¹³⁶ Lutz and AH Martin (2014). Fish Carbon: Exploring Marine Vertebrate Carbon Services. GRID-Arendal and Blue Climate Solutions.
- ¹³⁷ Laffoley et al. (2014). The Significance and Management of Natural Carbon Stores in the Open Ocean. IUCN; SJ Lutz and AH Martin (2014). Fish Carbon: Exploring Marine Vertebrate Carbon Services. GRID-Arendal and Blue Climate Solutions.
- ¹³⁸ Atwood, T.B., Connolly, R.M., Ritchie, E.G., Lovelock, C.E., Heithaus, M.R., Hays, G.C., Fourqurean, J.W., and Macreadie, P.I. 2015. Predators help protect carbon stocks in blue carbon ecosystems. *Nature Climate Change*. 5:1038-1045.
- ¹³⁹ Ramirez-Llodra E et al. (2011) Man and the last great wilderness: Human impact on the deep sea PLoS ONE 6:e22588 doi:10.1371/journal.pone.0022588
- ¹⁴⁰ <https://www.isa.org.jm/mineral-resources/57>
- ¹⁴¹ Hein JR (2002) Cobalt-rich ferromanganese crusts: global distribution, composition, origin and research activities. Technical Study 2. International Seabed Authority, Kingston, Jamaica
- ¹⁴² <https://www.isa.org.jm/mineral-resources/57>
- ¹⁴³ <https://www.isa.org.jm/mineral-resources/56>
- ¹⁴⁴ Ramirez-Llodra E et al. (2011) Man and the last great wilderness: Human impact on the deep sea PLoS ONE 6:e22588 doi:10.1371/journal.pone.0022588
- ¹⁴⁵ *Ibid.*
- ¹⁴⁶ *Ibid.*
- ¹⁴⁷ Amon DJ et al. (2016) First insights into the abundance and diversity of abyssal megafauna in a polymetallic-nodule region in the eastern Clarion-Clipperton Zone *Scientific Reports* 6:30492 doi:10.1038/srep30492
- ¹⁴⁸ Oebius HO, Becker HJ, Rolinski S, Jankowski JA (2001) Parametrization and evaluation of marine environmental impacts produced by deep-sea manganese nodule mining *Deep Sea Research Part II: Topical Studies in Oceanography* 48:3453-3467
- ¹⁴⁹ Cunningham, Lawrence J. *Ancient Chamorro Society*. Honolulu: The Bess Press, 1992.
- ¹⁵⁰ *Ibid.*
- ¹⁵¹ Amersbury, J. R. (2013), *Terra Australis* 39, Micronesian Archaeological Research Services, Guam

NOMINATION ADDENDUM

January 17, 2017

Nomination Title: Mariana Trench National Marine Sanctuary

Nominator Name(s) and Affiliation(s): Friends of the Marianas Trench

Nomination Point of Contact:

Angelo Villagomez; The Pew Charitable Trusts; (202) 540-6606; avillagomez@pewtrusts.org; 901 E Street NW; Washington, DC 20004.

Ignacio Cabrera; Friends of the Marianas Trench; (670) 989 1452; i.cabrera@pticom.com; PO BOX 7048 SVRB; Saipan, MP 96950.

Reason for Addendum

In correspondence notifying the nominators that the Mariana Trench National Marine Sanctuary nomination met the standards for sufficiency, NOAA staff requested additional information for the national significance and management considerations review. Specifically, we were asked to supply additional information regarding (1) more specifics regarding the potential for partnerships and (2) to describe further why a national marine sanctuary is needed over and beyond a monument.

Partnerships

The current effort to begin the designation of the Mariana Trench Marine National Sanctuary is being led by U.S. Delegate Gregorio Camacho “Kilili” Sablan and CNMI Governor Ralph Deleon Guerrero Torres. In September 2016, they wrote to President Obama asking that the marine areas of the Marianas Trench Marine National Monument be overlaid with a sanctuary designation. The communities on Saipan, Tinian, Rota, and Guam have rallied behind the idea to begin the sanctuary designation and nearly every elected official has signed on to support (evidenced by letters and resolutions), more than 2,000 residents have signed paper and online petitions, and numerous local stories have appeared in newspapers and websites based on Saipan and Guam. Several prominent global personalities have also lent their support to the effort, including the only person to dive the trench solo, James Cameron, former first lady Laura Bush, Mark Benioff, founder, chairman, and CEO of Salesforce, and Sir Richard Branson.

Select media stories:

Pacific Daily News, [James Cameron, others lobby for Mariana Trench sanctuary](#)

The Guam Daily Post, [With the help of a tiny robot, scientists deepen support for a Mariana Trench sanctuary](#)

Marianas Variety, [Petition for Trench sanctuary designation gains momentum](#)

Marianas Variety, [Rota lawmakers ask US to designate marine sanctuary for Marianas Trench monument](#)

Delegate Kilili has taken a leading role in the sanctuary designation and has been in direct contact with federal officials from the White House Council on Environmental Quality, NOAA Sanctuaries, NOAA Fisheries, and US Department of Commerce. He was also reelected to his

fifth term in office in November. It is likely that the delegate will continue to take a great interest as the sanctuary designation progresses and can serve as the champion of this effort.

The nominators have provided letters of support mostly from elected officials. We recognize that securing partnerships was not a focus of the original nomination submitted on December 5, 2016, and did not request letters committing to partnerships. We believe, however, that there are partnerships that can be developed, and letters of commitment could easily be obtained. We had numerous discussions with many people in the community about their role in the sanctuary designation. Some of those discussions are described here.

Keep in mind that these partnerships will only grow in number once the sanctuary process begins. The public scoping process for a proposed Mariana Trench National Marine Sanctuary will bring a lot of local voices to the table to discuss the much needed issue of marine protection in the Northern Mariana Islands. This is especially true considering the explosion of development taking place on the islands right now. There is already a small network of marine protected areas in local waters managed by the CNMI Department of Lands and Natural Resources. Possible comments and support for inclusion of these areas into a separate or connection NMS site are certain to be discussed. There are also many spectacular areas in federal waters, several discussed in the original nomination, that the community will want to discuss. Additionally, the Mayor of Rota, as seen in his letter of support, may also welcome the idea of a possible separate NMS site around his island, and we are sure the island residents will have other ideas and locations.

Partnerships in Government

The main partner NOAA Sanctuaries will have in the CNMI is the local government. The near-unanimous support from elected officials is a positive sign for future success.

One thing to keep in mind is that the local government is lacking in funding, and looks to the federal government to help operate several departments. In fiscal year 2013, federal grants accounted for 35.4% of the CNMI's total revenues. Federal funding for sanctuary positions will be something the local government will likely request.

Under the auspices of the CNMI Governor there are several offices that manage marine resources, including the Bureau of Environmental and Coastal Quality (BECQ), particularly the Division of Coastal Resource Management (DCRM) and Division of Environmental Quality, and the Department of Lands and Natural Resources, particularly the Division of Fish & Wildlife. These offices are charged with monitoring and managing coral reefs, fish populations, non-point source pollution, and other marine resources. These agencies have a long history of collaborating amongst one another and with federal partners, evidenced by the Coral Reef Initiative Program that has been in place since 2003. The nominators have spoken to Frank Rabualiman, BECQ Administrator, and Fran Castro, DCRM Director, about the sanctuary nomination and both have been kept up to date on progress since September.

The Public School System (PSS) and the Northern Marianas College should also be explored as possible partners. PSS teachers could take advantage of any existing curricula that has been developed by the sanctuary program, and creating additional Marianas Trench-specific curricula

should be considered. There are several teacher training days throughout the year wherein NOAA sanctuaries staff could hold workshops to teach the teachers how to use the curricula. A visitors center would also service PSS students, as well as their parents and teachers.

The nominators think that the Northern Islands Mayors Office (NIMO) and the Mayor of Rota should be considered as partners. We have had discussions with both. NIMO works with the communities that live in the islands north of Saipan, as well as the three uninhabited islands of the monument. The mayor has several staff and facilities on Pagan, the largest island in proximity to the monument. The NIMO office staff and most of the northern islands residents are on Saipan and could work as volunteers for sanctuary activities, either at a visitors center or in the community. There is a lot of interest to focus educational efforts on Rota and for an educational facility to be maintained there. The Mayor of Rota has staff that could support activities at the facility or in the community.

We hope that NOAA will pursue additional research and monitoring opportunities both with other federal agencies and local government, including the college on Saipan and the University of Guam.

Partnerships with the private sector

The second pillar of the economy is tourism, which has experienced rapid growth recently with an influx of visitors from China. Visitor arrivals recently surpassing 500,000 for the first time in many years. The tourism industry also provides numerous opportunities for partnerships.

The visitors channel on local television has already expressed an interest to the nominators to produce segments on the Marianas Trench to educate tourists about the surrounding waters. The visitors channel recently produced a 30 minute segment on recent scientific discoveries in the Marianas Trench and issues surrounding the sanctuary designation. It played on local television once in December and has received nearly 60,000 views on Facebook.

There is almost no use of the Marianas Trench in any promotional materials for the CNMI. Using the Marianas Trench as an attraction could be as simple as sharing video b-roll and photos with the Marianas Visitors Authority. Research suggests that, if local communities taking marine protected measures increase capacity for marketing or advertisement, there is potential to increase tourism in the area. To fully capitalize on the successful designation of its waters as a NMS, the CNMI should try to establish partnerships that would help to market the islands, attract tourists, and increase tourism spending.

A member of the Marianas Visitors Authority has expressed interest in building airport displays or hotel displays for visitors and locals to learn about the Marianas Trench. The Guam airport is literally the gateway to Micronesia, and would be an excellent location for sanctuary displays as seen in other NMS locations.

The Hotel Association of the Northern Mariana Islands and the Saipan Chamber of Commerce were strong supporters of the original monument declaration. They have not been approached regarding the sanctuary designation, but would likely be interested in partnerships.

There are a number of new businesses in the CNMI related to the recent growth in development that may be looking to offset some of the environmental damage they are causing by getting engaged in marine protection.

Partnerships with NGOs

The Friends of the Mariana Trench would like to be a major partner with the sanctuary. The Friends have limited funding, but have volunteers that would like to participate in the advisory council, and who can help with community outreach and can volunteer at a visitors center.

The Pew Charitable Trusts is committed to seeing a successful designation of a Marianas Trench National Monument Marine Sanctuary. Pew will commit staff time to this project and has the capacity to support scoping meetings, public hearings, scientific studies, public education, and other activities that will take place during the sanctuary designation process. Pew also has the capacity to fund public service announcements on TV and radio, has experts that can write reports and newspaper articles, and to create fact sheets for decision makers and the public. Pew would also be interested in being involved in discussion in creating the first iteration of the educational center on Rota. Pew is also working with our partners to explore additional funding opportunities should a sanctuary designation move forward.

Pew could also fund an expedition to the Islands Unit of the monument, perhaps one that focused on cultural connections and research, in addition to scientific research. During an expedition partially funded by Pew to the Islands Unit in 2009, 18 year old Dennis Chan from Saipan wrote a memoir of his participation in the trip. It was self-published in 2010, and the Friends of the Marianas Trench donated copies of the book to local schools. This was done without the involvement of the federal government. The book is still available on Amazon.com:

<http://amzn.to/2jv6d8o>

The creation of the monument in 2009 generated lots of interest in the Marianas Trench, as well as interest in exploration and research. Becoming a National Marine Sanctuary will no doubt increase that interest yet again because of the ONMS outreach and science that sanctuaries are able to leverage. While the monument has stalled, these sorts of activities could be re-catalyzed with a sanctuary.

There are no large, international or national NGOs operating in the CNMI, while The Nature Conservancy has one staff based on Guam. It is likely that The Nature Conservancy would be interested in the sanctuary, but no one has spoken to them yet.

The Micronesia Islands Nature Alliance is the only environmental NGO operating within the CNMI with regular staff and an office. They have several full time staff and more than a dozen part time staff who work on a range of issues from coral reefs to marine debris to public education. They have written a letter of support and would be an excellent partner for public education efforts, either through providing them with materials for their existing efforts or through funding some of their part time staff who work in the community.

Guam partnerships

There has been interest from a number of people and organizations on Guam regarding sanctuary designation and it may be worth exploring them. In particular, the Underwater World of Guam, a large aquarium on Tumon Bay in the main tourist district is very interested in the Mariana Trench. They are currently using private funds to build a Mariana Trench exhibit, which includes a command center with live feeds during research expeditions, and a scaled replica of the Mariana Trench.

In December 2016, the nominators traveled to Guam and had discussions with many people including Speaker BJ Cruz of the Guam Senate, teachers from several schools, staff at the US Fish & Wildlife Service and NOAA Fisheries, Guam Community College, University of Guam, and a number of environmental activists. However, other than the Underwater World of Guam, nothing concrete was discussed, but these partnerships should be explored considering the proximity of the southern arc of the Mariana Trench to Guam.

Immediate Need for Sanctuary Overlay

As stated in the nomination, there has been frustration with the pace of progress with the monument. More than 8 years after the designation, during which time President Obama served two terms as the US President, there still is no draft management plan available for public review.

There has been some progress, however. The Marianas Trench has been nominated as a new UNESCO World Heritage Site, one of only nine places in the United States being currently considered for such an honor.

There has been increased global interest in the Marianas Trench. In the last 12 months, scientific expeditions led by the Chinese government, U.S. government, and private foundations have used remotely operated vehicles to explore the depths of our surrounding water. Many new discoveries have been made in our waters, including species new to science.

The submerged lands deal that was promised by the Bush Administration to former Governor Benigno R. Fitial with the declaration of the monument is complete. Department of Interior Secretary Jewell and Governor Torres signed an agreement last month.

We are told that a draft management plan will be released in the coming months for public review. This will be one of the final steps before active management of the monument begins.

It is important to note that the lack of a public draft management plan, never mind an approved management plan, makes it difficult for us to comment on current management of the monument.

However, we believe that USFWS is unlikely to fund the types of educational and research programs that the sanctuary program has as a part of its mission. USFWS is also unlikely to fund the construction of a visitors center. For this reason, we believe that a sanctuary overlay would benefit the people of the CNMI by providing additional resources that could be applied to these activities. There may be a perception that we are overestimating the amount of funding that will be made available, but right now, and ever since the monument was declared 8 years ago, the amount available has been zero.

Also, the NMSA allows for the proposed sanctuary management plan to be continually updated and revised, unlike a monument. This will allow an adaptive approach to the management of the Mariana Trench, an area we have sparse knowledge about today. That knowledge will certainly continue to increase. Should future regulations or permit become necessary, then the NMSA will be able to provide that layer of protection for one of the deepest and most unique places on earth.

Additionally, designation as a national marine sanctuary would allow NOAA to apply the NMSA to the protection of MTMNM including but not limited to:

- the ability to issue a wide range of regulations necessary to protect and management sanctuary resources under section 308 (16 U.S.C. 1439);
- the ability to require other federal agencies to consult with NOAA on actions that may injure sanctuary resources under section 304(d) (16 U.S.C. § 1434);
- enhanced permitting authority under section 310 (16 U.S.C.1441) for special use permits and under 15 CFR, subpart E for prohibited and regulated activities;
- enhanced enforcement authority under section 307 (16 U.S.C.1437) for violation of sanctuary authority and regulations, and
- enhanced protection of sanctuary resources under section 312 (16 U.S.C. 1443) which covers destruction or loss of, or injury to sanctuary resources.

Additionally, the NMSA would provide for the establishment of a sanctuary advisory council (16 U.S.C. 1445A). The sanctuary advisory council would provide the same type of regular constituent and public input and advice into agency management decisions as the one in place for all national marine sanctuaries. This advisory council should include members of the public, not just government officials.

These NMSA-based authorities could significantly augment existing authorities under the Antiquities Act and provide additional regulatory and non-regulatory tools for management and protection of Monument resources.