DRAFT
ENVIRONMENTAL ASSESSMENT
for the
Programmatic Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument, Including the BIFROST and SEA-US Cable Systems

United States Department of the Interior
U.S. Fish and Wildlife Service

May 2023

Draft Environmental Assessment for the Programmatic Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument, Including the BIFROST and SEA-US Cable Systems

Responsible Agency: U.S. Department of the Interior, U.S. Fish and Wildlife Service

Point of Contact: Ms. Danielle Zarlengo, USFWS

Summary: USFWS is preparing this EA to analyze the environmental impact of allowing current and future marine cable installations within the Mariana Trench National Wildlife Refuge (Trench NWR) and Mariana Trench Marine National Monument (MTMNM) in order to support more efficient environmental reviews.

USFWS is proposing to provide detailed analysis to support NEPA responsibilities for its decisions on current and future marine cable ROW applications. As part of that evaluation, USFWS proposes to grant RTI Solutions, Inc. dba HMB (HMB) two new right-of-way (ROW) permits, one to allow for installation, operation, and emergency access to a new BIFROST telecommunications cable within the Trench NWR and MTMNM, the other to bring HMB into compliance with operation and emergency access rights for the existing SEA-US (Southeast Asia-US) telecommunications cable that was installed in 2017.

The SEA-US and BIFROST cables, as well as the future marine cables, are needed to provide connectivity between Guam, the Commonwealth of the Northern Mariana Islands (CNMI), Asia and the U.S. mainland within their respective greater telecommunications networks. The BIFROST cable system would further enhance and contribute to an expansion of communications networks between Asia and the United States, improve network redundancy, ensure reliable communications, and expand onward connectivity options in Guam and the CNMI.

Under the No Action Alternative, U.S. Fish and Wildlife Service (USFWS) would not consider a programmatic approach to issuing permits for current and future marine cable ROW applications through MTMNM or the Trench NWR. Future applications would require individual, site specific NEPA analyses prior to approval. USFWS would not permit HMBs new BIFROST cable, and the existing SEA-US cable would continue to operate without permitted access or use rights.

This draft Environmental Assessment (EA), in accordance with the National Environmental Policy Act (NEPA), examines the potential impacts of the No Action Alternative (Alternative A) and two Proposed Action Alternatives (Alternatives B and C).

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNMI	Commonwealth of the Northern Mariana Islands
CRE	Cable Route Estimate
CRS	Cable Route Study
DC	direct current
DCA	Duenas, Camacho & Associates, Inc.
DOI	Department of Interior
DPS	distinct population segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
ft	feet
FWCA	Fish and Wildlife Coordination Act
FUD	formerly used defense site
GIS	Geographic Information System
ICPC	International Cable Protection Committee
in	inch
ISA	International Seabed Authority
km	kilometer
LW	Lightweight Cable Type
LWS	Lightweight Screened Cable Type
m	meter
mi	mile
MIRC	Mariana Islands Range Complex
MUS	Management Unit Species
MTMNM	Mariana Trench Marine National Monument
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NM	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSCPO	U.S. Naval Seafloor Cable Protection Office
OBIS	Ocean Biogeographic Information System
Pac-SLOPES	Standard Local Operating Procedures for Endangered Species in the central and western Pacific region
PCZ	Prime Fe-Mn Crust Zone
PFE	power feed equipment

ACRONYMS AND ABBREVIATIONS

PSE	post-survey route
ROV	remotely operated vehicle
ROW	right-of-way
sq. ft	square feet
sq. m	square meter
SHPO	State Historic Preservation Office
Tbps	terabits per second
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
WD	water depth

1 PURPOSE OF AND NEED FOR PROPOSED ACTION

1.1 Introduction

USFWS is preparing this programmatic Environmental Assessment (EA) to analyze the environmental impact of granting marine cable ROW permits across the Mariana Trench Marine National Monument (MTMNM) and Mariana Trench National Wildlife Refuge (Trench NWR) in order to support more efficient environmental review of current and future applications.

This EA also analyzes the site-specific impacts of granting two new right-of-way (ROW) permits to RTI Solutions, Inc. dba HMB (HMB), one to allow for installation, operation, and emergency access to a new 98.91-mile long BIFROST telecommunications cable located east of the U.S. Commonwealth of the Northern Mariana Islands (CNMI), the other to provide operation and emergency access rights for the existing 70.01-mile long SEA-US telecommunications cable installed in 2017 and located in the southern sector of the Trench NWR and southeast of Guam.

The proposed BIFROST cable, the existing SEA-US cable, and future cables through the Trench NWR would provide or continue to provide telecommunications interconnectivity between Guam, CNMI, Philippines, Singapore, Indonesia and California; each is an integral part of their respective cable systems.

This draft programmatic EA was prepared in compliance with National Environmental Policy Act (NEPA), as implemented by Council of Environmental Quality (CEQ) regulations in the Code of Federal Regulations (CFR) title 40, Parts 1500 to 1508 (40 CFR 1500, et seq.), and CEQ guidance, including its 214 memorandum on “Effective Use of Programmatic NEPA Reviews,” which require federal agencies to assess the impacts their actions may have on the environment. USFWS is preparing this programmatic EA to analyze the potential impacts of the Proposed Action and No Action Alternatives. This EA is intended to provide sufficient evidence and analysis to determine whether the project is likely to significantly affect the environment, warranting preparation of an environmental impact statement (EIS), or if it is appropriate to prepare a Finding of No Significant Impact (FONSI).

1.2 Background

1.2.1 Mariana Trench Marine National Monument

The MTMNM was established by Presidential Proclamation 8335 issued on January 6, 2009, and consists of three units: (1) the Islands Unit, (2) the Volcanic Unit, and (3) the Trench Unit (Appendix A, Figure 2). On January 16, 2009, Secretarial Order 3284 delegated management responsibility to the USFWS and designated the Volcanic and Trench Units as units of the National Wildlife Refuge System, subject to provisions of the Proclamation. On October 8, 2009, those units were officially named “Mariana Arc of Fire National Wildlife Refuge” and “Mariana Trench National Wildlife Refuge,” respectively.

As defined in *Presidential Proclamation 8335 – Establishment of the Marianas Trench Marine National Monument*, the Trench Unit includes only the submerged lands as delineated by its boundaries within the United States of America Exclusive Economic Zone (EEZ). No waters are included in the Trench Unit (NOAA 2012).

Pursuant to the Proclamation, the Secretaries of the Interior and Commerce "shall not allow or permit any appropriation, injury, destruction or removal of any feature of this monument except as provided for by this proclamation or as otherwise provided by law." The Proclamation also requires the Secretaries to provide: "monitoring and enforcement necessary to ensure that scientific exploration and research, tourism, and recreational and commercial activities do not degrade the monument's coral reef ecosystem or related marine resources or species or diminish the monument's natural character".

1.2.2 Convention on the High Seas

The freedom to lay undersea cables has long been recognized as a lawful use of the sea. The United States recognizes this right under the Convention on the High Seas (1958), Article 2: the Convention on the Continental Shelf (1958), Article 4; and the United Nations Convention on the Law of the Sea (UNCLOS) which provides that within the Exclusive Economic Zone (EEZ; 200 nautical miles (NM)), all states enjoy the "freedoms referred to in Article 87 of navigation and overflight and of the laying of submarine cables and pipelines." (Article 58).

1.2.3 National Wildlife Refuge System

National wildlife refuges are guided by the mission and goals of the National Wildlife Refuge System (NWRS), the purposes of an individual refuge, Service policy, and laws and international treaties. Relevant guidance includes the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997, Refuge Recreation Act of 1962, and selected portions of the Code of Federal Regulations and Fish and Wildlife Service Manual.

The mission of the NWRS, as outlined by the National Wildlife Refuge System Administration Act (NWRSAA), as amended by the National Wildlife Refuge System Improvement Act (16 U.S.C. 668dd et seq.), is:

> *"... to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans"*

Additionally, the NWRSAA mandates the Secretary of the Interior in administering the NWRS (16 U.S.C. 668dd(a)(4)) to:

- Provide for the conservation of fish, wildlife, and plants, and their habitats within the NWRS;
- Ensure that the biological integrity, diversity, and environmental health of the NWRS are maintained for the benefit of present and future generations of Americans;

  Ensure that the mission of the NWRS described at 16 U.S.C. 668dd(a)(2) and the purposes of each refuge are carried out;

- Ensure effective coordination, interaction, and cooperation with owners of land adjoining refuges and the fish and wildlife agency of the states in which the units of the NWRS are located;
- Assist in the maintenance of adequate water quantity and water quality to fulfill the mission of the NWRS and the purposes of each refuge;
- Recognize compatible wildlife-dependent recreational uses as the priority general public uses of the NWRS through which the American public can develop an appreciation for fish and wildlife;
- Ensure that opportunities are provided within the NWRS for compatible wildlife-dependent recreational uses; and Monitor the status and trends of fish, wildlife, and plants in each refuge.

Thus, in order for the Secretaries to meet their resource protection obligations under the Proclamation and the National Wildlife Refuge System Administration Act, and for the U.S. to uphold its marine conservation obligations under international conventions, the Service is evaluating HMB's telecommunications cable ROW application in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense (U.S. Naval Seafloor Cable Protection Office; NSCPO). The Service consults with NOAA (National Marine Fisheries Service; NMFS) regarding impacts to Essential Fish Habitat under the Magnuson-Stevens Fisheries Conservation and Management Act. Consultation with the NSCPO is done to ensure that there are no conflicts between commercial telecommunications cables and U.S. Navy cable systems. If appropriate, the Service will issue a Compatibility Determination (Appendices C1 and C2) and a ROW Permit for each cable.

1.3 Purpose of and Need for Action

USFWS needs a programmatic approach to support efficient and timely environmental review of site-specific marine cable permit requests that may cross the MTMNM and Trench NWR. Many of these projects are similar in terms of installation methods, location, operation, and potential impacts.

USFWS also needs to respond to HMB's request for two marine cable ROW permits across the Trench NWR. The first permit would allow for installation, operation, and emergency access to a new 98.91-mile long portion of the BIFROST telecommunications cable. The second permit would provide operation and emergency access rights to the existing 70.01-mile long portion of the SEA-US telecommunications cable installed in 2017. USFWS needs to review the compatibility of the permits to Refuge purposes and determine any necessary conditions to reasonably protect the purposes for which the Refuge was established.

In meeting the need for action, USFWS seeks to achieve the following purposes:

- Fulfill USFWS obligation to ensure the *Presidential Proclamation 8335* directive to ensure that commercial activities do not degrade deep sea ecosystems or related marine resources, or diminish the MTMNM's natural character.
- To support internationally recognized lawful uses of the sea such as the freedom of navigation and overflight and of the laying of submarine cables and pipelines.
- To achieve USFWS priorities as outlined by the NWRSAA, as amended, by evaluating whether the action is compatible with established refuge mission and purposes.

- Consider timely and efficient environmental review of future marine cable ROW permit applications through the MTMNM and the Trench NWR.
- To grant, grant with conditions, or to deny HMB's ROW permit applications for the SEA-US and BIFROST marine telecommunication cables.

2 PROPOSED ACTION AND ALTERNATIVES

This chapter includes a description of the Proposed Action Alternative, the No Action Alternative and alternatives dismissed from further consideration.

2.1 Alternative A – No Action Alternative

Under the No Action Alternative, USFWS would not use a programmatic EA to help evaluate the effects of ROW permit applications for marine cables crossing the MTMNM and Trench NWR. USFWS would continue to conduct individual NEPA analysis on each ROW permit application.

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable.

2.2 Alternative B – Proposed Action Alternative

Under the Proposed Action, USFWS would use this programmatic EA to evaluate potential environmental impacts of marine cable installations that would cross the MTMNM and Trench NWR. This description of the Proposed Action covers site selection criteria for marine cables, common installation methods for marine cables, and information about cable operation and maintenance, emergency access, and decommissioning. For both the proposed BIFROST and SEA-US cables and for future ROW authorizations considered as part of the programmatic coverage for this EA, installation methods, best management practices (BMPs) and environmental effects are the same or very similar for all deep-sea telecommunications and scientific cable laying operations.

USFWS also proposes to use this Programmatic EA to grant ROW Permits to HMB to allow for installation, operation, and emergency access to the BIFROST telecommunications cable, and operation and emergency access to the existing SEA-US telecommunications cable. Site-specific details for installation of the proposed BIFROST telecommunications cable, and operation and maintenance of the existing SEA-US telecommunications cables are also described as part of the Proposed Action.

2.2.1 Site Selection Criteria for Cable Routes

Routes for cables would be selected based on criteria developed by the International Cable Protection Committee (ICPC). The ICPC is a submarine cable protection non-profit organization formed in 1958 to promote the protection of international telecommunications and power submarine cables against human and natural hazards. The ICPC produces and maintains industry recommendations that define the minimum standards for cable route planning, installation, operation, maintenance and protection. The process of defining cable routes is routine and involves three distinct phases. This process was used for the BIFROST and SEA-US cables and is expected to be used for future cables that are proposed to be laid within the Trench NWR.

Phase I: Cable Route Estimate (CRE)

In this phase, an initial CRE serves as a starting point to connect two destinations (e.g., Davao and California). The CRE provides early cost estimates that inform more detailed route development that occurs in later phases. The CRE route is identified via a desktop analysis of existing available information and is primarily used to provide an early cost estimate. The CRE does not typically include critical data needed to inform route selection.

Phase II: Cable Route Study (CRS)

In the second phase, a CRS is commissioned to define a route for marine geophysical survey. The CRS phase works off the CRE route and considers all available information that has the potential to affect the cable during installation and operation, including the end points to be connected, seabed characteristics, risks of cable damage, water depths, and the routes and characteristics of cables already in place (ICPC 2015a and 2015b).

The CRS route is adjusted in order to address conflicts with existing cables and to comply with ICPC recommendations wherever possible, while still avoiding wherever possible any seabed features (NEC 2020). The CRS route is then used as the basis for the marine geophysical survey.

CRS considerations, as outlined by the ICPC's Recommendation No. 9, Issue: 5 (ICPC 2015a), generally include, but are not limited to those in Table 2-1.

Table 2-1. Summary of Cable Route Study Considerations

Geology	A. The tectonic setting B. Seafloor morphology and lithology, C. Volcanic activity, including sub-sea volcanoes and hydrothermal venting, with location and dates of eruption. D. Seismicity (including locations, dates and magnitude of earthquakes), E. Tsunamis F. Surface faulting, G. Turbidity currents, H. Sediment transport, I. Sand waves, J. Beach and near shore seabed stability K. Offshore geology and burial assessment L. Other geohazards, not covered in above sections.
Climatology	A. Seasonal variations in climate and weather on a regional basis for the area adjacent to and along the proposed cable route. B. Examination of the major climatological controls, such as monsoons, convergence zones and the like, temperatures, rainfall, winds and the seasonality and frequency of gales, storms, hurricanes and the like C. Proximity to flood prone areas.
Oceanography	A. Typical sea states experienced in the region of interest B. Surface, midwater and bottom currents including tidal streams and currents (in order to determine the optimum direction of installation) C. Bottom water temperatures

	D. Wind and wave data (including wave height and dominant wind directions) E. Other environmental anomalies that may affect survey and installation (e.g., sea fog and sea ice if applicable) F. Tidal levels and variations at the landings and at pertinent areas along the planned route G. Local and seasonal variations should be investigated for the above parameters
Commercial Operations, Hazards and Restricted Areas	A. Shipping B. Shipping patterns C. Designated shipping channels D. Anchorages E. Informal anchoring practices F. Cable protection zones and other no-anchoring areas
	H. Restricted areas (full-time or part-time) such as: 1. Mined areas, 2. Military exercise areas, 3. Dumping grounds (chemical/industrial wastes, explosives, radioactive materials) either in use, abandoned or planned, 4. Culturally significant sites 5. Tourist attractions.
	I. Commercial and research activities such as; 1. Artisanal and commercial fishing activities (current and future), including information on fish aggregation devices, 2. Offshore petroleum leases (current and future) that may require the construction of in-field or platform to shore transmission pipelines or umbilicals, 3. Offshore renewable energy installations (current and future) 4. Pipelines (current and future), 5. Other submarine cables (out-of-service and in-service, both current and planned in the vicinity of the proposed route) and their fault history, with tabulated information on the crossed systems name, cable type, position, water depth and angle at the crossing point and, where possible, distance to the crossed systems underwater plant, (i.e. Repeaters and equalizers), 6. Plans to remove existing out-of-service submarine cables, 7. Oceanographic and weather buoys, 8. Dredging activities, 9. Submarine resource development (including deep-sea mining) and offshore renewable energy developments, 10. Coastal construction projects such as new port facilities, outfalls and intake structures

	J. Other obstructions such as shipwrecks, artificial reefs etc, K. Known security threats and piracy, or political groups that may pose security risks (including 'non friendly' countries or unstable governments).
Biological Factors	A. Marine Protected Areas (MPAs) or similar marine conservation zones for example coral reefs (including cold water corals), marine sanctuaries and national parks B. flora and fauna (particularly endangered and protected species) located at the proposed landings C. seabed communities including shellfish, crustaceans, and coral D. fish and crustacean spawning grounds and nursery areas E. local and migratory bird populations F. marine mammals

Addressing cable conflicts:

During CRS route development, the alignment is changed where necessary to avoid off-shore hazards and third-party cables and assets.

Where in-service cables lay parallel to each other, the ICPC recommends a minimum cable distance between them of three times the water depth (3 × WD) where possible (ICPC, 2015b). Cable separation can be decreased to 2 × WD on one side of the cable if a separation of 3 × WD remains on the opposite side.

Whenever feasible, the routes of new cables should be selected to avoid crossings of other cables, in particular existing in-service cables. When crossings are unavoidable, the ICPC recommends that they shall be made as near to a right angle (90 degrees) as possible. If a 90-degree angle is not technically feasible, then angles down to 45 degrees may be considered depending on the circumstances (ICPC, 2015b).

Phase III: Post-Survey Route (PSR)

During the final phase of the process, the CRS route is surveyed to acquire bathymetry data along a corridor, and a PSR is developed based on actual survey data. The accurate bathymetry data allows the cable alignment to be adjusted to the smoothest route possible by avoiding avoid steep slopes, troughs or other seafloor features. Therefore, the PSR is the most practical route within the survey corridor.

This site selection process was used for the SEA-US and BIFROST cables and will be used to identify future cable routes that may be proposed in the Trench NWR.

BIFROST Cable Route. The proposed BIFROST cable route is the PSR route, which is shown in Appendix A, Figures 1 and 2. The cable would enter the Trench NWR from the west at a depth of 3,799 meters (m). This is HMBs preferred route for the BIFROST cable, which traverses a shorter length of moderate to steep slopes. As it is laid flush on the seafloor by a cable-laying ship, the BIFROST cable would cross over the Mariana Trench and through the Trench NWR for a total linear distance of approximately 98.90 miles (159.17 km). The route crosses the existing TPC-1 cable, which is out of service, and avoids any active telecommunication cables within the Trench NWR (Appendix A, Figure 4). The BIFROST cable would be laid at depths between 3,660-7,230 m along the Proposed Route, (Appendix A, Figure 5a).

SEA-US Cable Existing Route. The SEA-US fiber-optic communications submarine cable was installed in 2017 through a portion of the Trench NWR for a distance of 70.07 mi (112.77 km) (Appendix B, Figures 1 and 2). The SEA-US cable enters the Trench NWR from the west at a depth of 6,148 m (Appendix B). The SEA-US cable was laid at depths of 6,100-9,725 m in the Trench NWR.

2.2.2 Characteristics of Marine Cables

Subsea Fiber-Optic Cable Types

Subsea fiber-optic cables, regardless of use or purpose, are all made up of the same basic materials and structures and operate the same way. These are Lightweight (LW) or Lightweight Protected (LWP) as shown in Figure 1. For the purposes of this analysis, it was assumed that cable types would be substantially similar to the proposed BIFROST cable described below and shown in Figure 1.

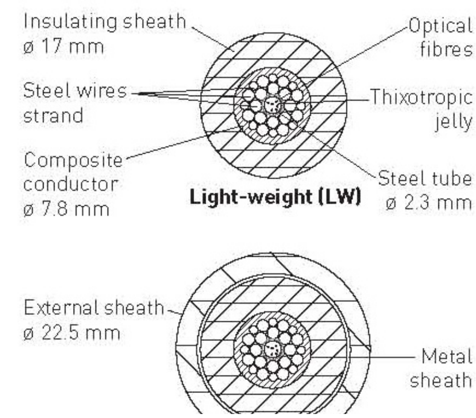


Figure 1. LW and LWP cable types at life size (Carter et al., 2009).

Subsea Fiber Optic Cable Uses

There are two basic uses of subsea fiber-optic Cables that may be proposed for siting through the Trench NWR: commercial telecommunications, and scientific. Commercial telecommunications cables are those subsea cables that are carry a variety of data that is used for commercial purposes. The data these cables carry may be used by public, private, military etc. entities to conduct their business. Data carried on these cables may well be used for scientific purposes, but they are commercial cables. The two cables proposed by this project are examples of commercial telecommunications cables. Scientific cables are those subsea cables that are being used for various scientific research purposes. For example, the G-P (Guam-Philippines) system gathers data in real-time for scientific research. The data collected is used for ocean management, disaster mitigation (early warning for tsunami) and environmental monitoring (ICPC 1999-2023). In some cases, telecommunications cables that are out of service or have been decommissioned can be repurposed for use as scientific cables.

BIFROST Cable. The BIFROST cable is designed as a LWP cable that is 2.25 centimeters (cm) (0.88 inch (in)) in diameter with inner steel wires surrounding a thick insulant of natural polyethylene coating (ICPC, 2014).

Water depths within the Trench NWR range from approximately 3,660 m to 7,230 m along the Proposed Route. These depths span the abyssal (4,000 to 6,000 m) and hadal (6,000 to 11,000 m) zones, based on a non-intrusive bathymetric survey by Fugro in 2021.

The total cable footprint for the BIFROST cable through the Trench NWR is approximately 0.89 acres (38,550 square feet (sq. ft)), with a total linear distance of 98.91 mi (85.95 NM or 159.18 km).

A summary of cable dimensions of the Proposed Route within the Trench NWR is presented in Table 2-2.

SEA-US Cable. The SEA-US is a Lightweight (LW) cable, which is 1.7 cm in diameter (0.669 in). The LW cable type has inner steel wires surrounding an insulant of natural polyethylene that is a thinner coating than the LWP cable type (ICPC 2014).

The existing SEA-US cable route within the Trench NWR lies entirely within the hadal (6,000 to 11,000 m) zone, with depths ranging from approximately 6,100 m to 9,725 m based on a non-intrusive bathymetric survey conducted in 2016. The total cable footprint within the Trench NWR is approximately 0.47 acres (20,630.75 square feet (sq. ft)), with a total linear distance of 70.07 mi (60.89 NM or 112.77 km). A summary of cable dimensions of the SEA-US cable route within the Trench NWR is presented in Table 2-3.

Table 2-2. Summary of Alternative B - BIFROST Proposed Cable Dimensions within the Trench NWR

Cable Length	**Cable Type**	**m**	**km**	**ft**	**mi**	**NM**
	LWP	159,176	159.176	522230.9711	98.91	85.9482
Cable Width	**Cable Type**	**mm**	**cm**	**m**	**in**	**ft**
	LWP	22.5	2.25	0.0225	0.88582	0.07382
Cable Area	**Cable Type**	**sq. m**	**sq. km**	**sq. ft**	**sq. mi**	**acre**
	LWS	3,581.46	0.00358	38,550.5146	0.00138	0.885

Table 2-3. Summary of SEA-US Cable Dimensions within the Trench NWR

Cable Length	**Cable Type**	**m**	**km**	**ft**	**mi**	**NM**
	LW	112,771.82	112.77182	369,986.2861	70.07316	60.89191
Cable Width	**Cable Type**	**mm**	**cm**	**m**	**in**	**Ft**
	LW	17.00	1.70	0.0170	0.670	0.056
Cable Area	**Cable Type**	**sq. m**	**sq. km**	**sq. ft**	**sq. mi**	**acre**
	LW	1,917.121	0.00192	20,635.7179	0.00074	0.47373

2.2.3 Cable Repeaters

Repeaters are added to the system design and positioned to avoid conflict with existing cables. Light pulses can be transmitted only approximately 37 to 50 miles (60 to 80 km) along the cable before they need to be regenerated. This regeneration would be done by regenerator equipment, known as repeaters, attached to the cable at the appropriate intervals. Repeaters are typically 18 inches (1.5 ft. or 45.7 cm) in diameter and 72 inches (6 ft. or 1.8 m) in length with an approximate maximum footprint of 36 sq. ft. (3.34 sq. m.). They typically operate from 48 volts of direct current (DC) electricity. The marine cable would contain a copper conductor to transmit the DC electrical power to the repeaters. The DC power system for the repeaters would be housed at the power feed equipment (PFE) facility located in Guam, and contains protective equipment that can detect either a sharp decrease or sharp increase in electrical current flow. Upon detection of abnormal current flow, the DC power system would be shut down. The DC generates a magnetic field on the order of 5 milligauss at a distance of 3.28 feet (1 meter) from the cable. The field diminishes with distance from the cable (such that at 33 feet [10 meters] it would be approximately 0.5 milligauss).

BIFROST Cable. The proposed BIFROST cable would use up to two repeaters in the Trench NWR. The total area of these repeaters would be approximately 72 sq. ft (6.68 sq. m).

SEA-US Cable. The existing SEA-US cable uses two repeaters along its route within the Trench NWR. The total area of these repeaters is approximately 72 sq. ft (6.68 sq. m).

2.2.4 Cable Installation

Deep sea cables are laid directly on the seabed using a cable laying ship. The cable laying ship can proceed at approximately 3.7 kilometers per hour (2 knots). Slack would be continuously applied at various rates throughout the installation to allow the cable to conform to the contour of the seabed as much as feasible.

BIFROST Cable. The BIFROST fiber-optic cable would be laid directly on the seabed using a cable laying ship. While USFWS is the lead agency for activities in the MTMNM, the U.S. Army Corps of Engineers (USACE) has issued a Department of the Army Permit application for legs of the BIFROST cable-laying activity within jurisdictional waters (within 3 NM of Guam). The Alternative B would implement BMPs and follow the Standard Local Operating Procedures for Endangered Species in the central and western Pacific region (Pac-SLOPES), which are conditions of the BIFROST cable Department of the Army Permit. While no biological monitors are proposed to be onboard the cable ship, since it will not make port weekly, the cable ship operators will be briefed on the potential presence of marine mammals and sea turtles by qualified biologists. The training will occur either in port on Guam, or by video communication if the cable ship will not come into port on Guam. The awareness training would include descriptions of any marine mammal or sea turtle species that have the potential to occur in areas where the cable ship will be operating, and suggested procedures if they are observed within the vicinity of the vessel.

2.2.5 Cable Operations and Maintenance, and Emergency Repair

There is no routine monitoring or maintenance associated with the submerged segments of cables laid within the Trench NWR. The Permittee would not access the cable other than for emergency repairs. Emergency repair activities could occur if there is a cable fault. The typical triggers for emergency repair for any of the cables would be such things as ship anchors being dragged across the cable route during active anchoring, fishing gear entanglement during active fishing (neither of which would be a concern in the Trench NWR due to the great depths), and equipment failure. If emergency repairs are necessary, the Permittee would notify the Service in advance to ensure that ROV operations are not taking place in the area while repairs take place.

If any of the cables need to be repaired in the Trench NWR, it would need to be recovered to the cable ship for repair. Because of the depth of the cable, the operation would take place in several steps. First a flatfish grapnel fitted with a cutting blade would be deployed a few hundred meters to one side of the cable and be dragged perpendicularly to the cable until it snags the cable, indicated by an increase in tension on the cable. The cable ship would then continue to apply pressure until the cable is cut. Then a Gifford grapnel would be used to retrieve one end of the cable to the cable ship. The length of cable that needs to be recovered to make a repair is approximately 1.5 times the water depth. After the cable is recovered, the end would be prepared and the fibers tested using a conventional optical time-domain reflectometer (OTDR). After conducting the necessary tests onboard the cable ship, this end of the cable would be sealed and buoyed off for easy recovery later.

Next, the other cable end would be recovered and similarly tested to locate the fault more precisely. The cable ship would retrieve this end of cable until the fault is aboard. After the fault site (either a cable or repeater section) is removed from the system, the repaired cable would be joined to the fault-free cable end and paid out as the vessel returns to the buoyed end. When the buoy is recovered aboard the ship, the two cable ends would be joined. After final testing, the cable would then be paid out through the stern of the ship to settle on the ocean floor.

2.2.6 Remotely Operated Vehicle (ROV) Operation

The ROW Permit for any marine cables would include conditions governing the ability to continue to conduct scientific research using remotely operated vehicles (ROVs) in proximity to each cable. The Service would be notified before cable-laying through the ROW commences, and before emergency repairs take place, to ensure that ROVs are not operating in the area during cable laying or repair operations.

2.2.7 Retirement, Abandonment, or Removal of the Cable Systems

Once installed, each cable project would have an operating life of approximately 25 years. After a cable is decommissioned, it is typically abandoned in place. Permit conditions for the SEA-US and BIFROST cables would stipulate that cables would be abandoned in place. This is a likely stipulation for future cables as well.

2.2.8 Landing Schedule

The BIFROST cable would be installed in the Trench NWR in 2023. The SEA-US cable was laid in the Trench NWR in 2017. Specific schedules for the future cables have not been determined.

2.3 Alternative C – BIFROST Cable Alternative Route

Under Alternative C, the actions described in the Alternative B - Proposed Action Alternative would be the same, except for a shorter alternative path identified for installation of the BIFROST cable through the Trench NWR. Instead of using the PSR route identified in Alternative B, this cable through the Trench NWR. Instead of using the PSR route identified in Alternative B, this alternative would use the CRS route shown in green in Appendix A, Figures 2, 3a, 4, 5a, 5b, 6 and 7. The route would enter the Trench NWR from the west at a depth of 3,850 m.

As it is laid flush on the seafloor by a cable-laying ship, the BIFROST cable alternative route would cross over the Mariana Trench and through the Trench NWR for a total linear distance of approximately 95.21 miles (153.23 km). The BIFROST cable alternative route is slightly shorter than under Alternative B, but is closer to a known occurrence of deep-sea corals and sponges (Appendix A, Figure 7). Under Alternative C, the BIFROST cable would cross the TPC-1 cable, which is out of service, but would avoid crossing any active telecommunication cables within the Trench NWR (Appendix A, Figure 4). The total cable footprint for the Alternative Route within the Trench NWR would be approximately 0.85 acres (37,109 sq. ft), with a total linear distance of 95.21 mi (82.74 NM or 95.21 km).

Installation depths within the Trench NWR range from approximately 3,620 m to 7,460 m (Appendix A, Figure 5a). These depths span the abyssal (4,000 to 6,000 m) and hadal (6,000 to 11,000 m) zones, based on a non-intrusive bathymetric survey by Fugro in 2021.

A summary of cable dimensions of the Alternative C - BIFROST Cable Alternative Route within the Trench NWR is presented in Table 2-4.

Table 2-4. Summary of Alternative C - BIFROST Alternative Cable Route Dimensions within the Trench NWR

Cable Length	**Cable Type**	**m**	**km**	**ft**	**mi**	**NM**
	LWP	153,230	153.23	502,723.097	95.2127	82.7376
Cable Width	**Cable Type**	**mm**	**cm**	**m**	**in**	**ft**
	LWP	22.5	2.25	0.0225	0.88582	0.07382
Cable Area	**Cable Type**	**sq. m**	**sq. km**	**sq. ft**	**sq. mi**	**acre**
	LWP	3,447.585	0.00345	37,109.4961	0.00133	0.85192

Installation and operation for Alternative C would be similar to Alternative B. Additionally, this alternative would include the USFWS granting ROW Permits to allow the SEA-US, and up to three future cables to be located within a portion of the Trench NWR, as under Alternative B.

2.4 Alternatives Considered but Eliminated from Further Analysis

2.4.1 MTMNM Avoidance Alternative

The routing of the cable around the MTMNM in order to avoid crossing the Trench NWR was evaluated for the BIFROST cable. A path to the north of the Trench NWR would require manufacturing and laying several hundred additional miles of cable. This would apply to future cables that need to cross from Guam to Hawaii or the west coast of the U.S. mainland. While this alternative would meet the needs of the BIFROST and future cable projects, the cost associated with the additional cable length required for this route would be prohibitive.

Table 2-5. Best Management Practices and Mitigation Measures for the Proposed Action Alternatives.
The measures and best management practices (BMPs) listed here either avoid the resource or minimize resource impacts of the proposed and future ROWs considered under this programmatic EA.

Description of BMP or Mitigation Measure
Geology and Topography
Avoid geologically active features, e.g. serpentinite mud volcanoes, serpentinite mud volcano springs, and Mariana Arc of Fire NWR.
Biological Resources (Seabirds, Marine Mammals, Threatened and Endangered Species, Deep-Sea Coral and Sponge Communities)
Avoid areas with higher probability of deep-sea coral and sponge communities.
Abandon cables in place at the end of their lifespan (no salvage).
Implement biosecurity protocols described in the CD stipulations.
Reduce ship speed during cable-laying operations.
Use the minimum amount of light necessary for legal and safe transit when cable ship is underway at night.
Brief cable ship operators on protocols for handling of seabirds.
Employ constant vigilance for the presence of ESA-listed marine species (sea turtles, marine mammals, sharks, rays) during all aspects of the proposed action by an appropriate number of competent trained observers who will not be simultaneously engaged in any other activity (e.g., captaining, operating equipment, etc.). Surveys shall be made prior to the start of work each day, and prior to resumption of work following any break of more than one half hour.
Postpone or halt all work when ESA-listed marine species are within 50 meters (54.7 yards, 164 feet) of the proposed work, and will only begin/resume after the animals have voluntarily departed the area. If ESA-listed marine species are noticed within 50 meters (54.7 yards, 164 feet) after work has already begun, that work may continue only if, in the best judgement of a biologist, the activity will not adversely affect (i.e. disturb or harm) the animal(s).
Project construction must cease under unusual conditions, such as large tidal events and high surf conditions, except for efforts to avoid or minimize resource damage.
Cable ship will employ a contingency plan to control and clean spilled petroleum products, hydraulic leaks, and other toxic materials. Appropriate materials to contain and clean potential spills will be stored on board and be readily available.
All project-related materials and equipment placed in the water will be free of pollutants. Equipment will be inspected prior to beginning work each day to ensure the equipment is in good working condition, free of pollutants and there are no contaminant (e.g., oil, fuel) leaks. Work will be stopped until leaks are repaired and equipment is cleaned. Equipment will be stored in appropriate staging area designed to be preventative in terms of containing unexpected spills when equipment is not in use or during fueling.
Debris and other wastes will be prevented from entering or remaining in the marine environment during the project.

Description of BMP or Mitigation Measure
Before any equipment, anchor(s), or material enters the water, verify that no ESA-listed marine animals are in the area.
Equipment operators shall employ "soft starts" when initiating work each day and after each break of 30 minutes or more that directly impacts the bottom. Equipment shall be sent to the bottom in a slow and controlled manner for the first several cycles before achieving full operational impact strength or tempo. All objects lowered to the bottom shall be lowered in a controlled manner.
Temporary in-water tethers, as well as mooring lines for vessels and marker buoys shall be kept taut to the minimum length necessary and shall remain deployed only as long as needed to properly accomplish the required task.
Vessel operators shall alter course to remain at least 100 m (109 yds) from whales, and at least 50 m (54.7 yds, 164 feet) from other ESA-listed marine animals. Reduce vessel speed to 10 knots or less when piloting vessels in proximity of ESA-listed marine mammals, sharks, and rays. Reduce vessel speed to 5 knots or less when piloting vessels in areas of known or suspected sea turtle activity. If despite efforts to maintain the distances and speeds described above, a marine mammal or turtle approaches the vessel, the vessel operator will put the engine in neutral until the animal is at least 15 m (~50 ft) away, and then slowly move away to the prescribed distance. Marine mammals, sea turtles and other ESA-listed motile species shall not be encircled or trapped between multiple vessels.
Fueling of project-related equipment shall take place at least 50 ft, or the maximum distance possible, from the water and within a containment area, preferably over an impervious surface.
Prior to in-water work, sanitize equipment or dive gear that has been previously used in an area known to contain invasive species. The crew of the vessel should try to minimize the amount of detergents and other noxious substances that might be washed overboard as part of an effort to clean instruments or equipment used during the cruise or in day-to-day operation of the vessel.
The cable ship will not uptake or discharge any ballast water within the Trench NWR to avoid the spread of invasive species.
Public Health and Safety
Notify USFWS in advance of cable laying operations or emergency repair within the Refuge and Monument
Land and Water Use for Transit, Other Cable Operations, Research and Military Operations
Notify USFWS in advance of cable laying operations or emergency repair within the Refuge and Monument.
Coordinate with NSCPO to avoid impacts to U.S. Navy cable installations.
Coordinate with U.S. military to avoid conflict with military operations in training areas.
Noise
Operate the cable ship at a low speed during cable installation.
Air Quality
Minimize vessel transit time through the Trench NWR.

3 AFFECTED ENVIRONMENT

This chapter describes the affected environment of the proposed action within the Trench NWR, which spans the abyssal (4,000 to 6,000 m) and hadal zones (6,000 to 11,000 m) of the western Pacific Ocean (Figure 2). The hadal zone comprises the deepest areas of the world's oceans, and hadal trenches in this zone are one of the least understood habitats on Earth (Jamieson et al., 2009).

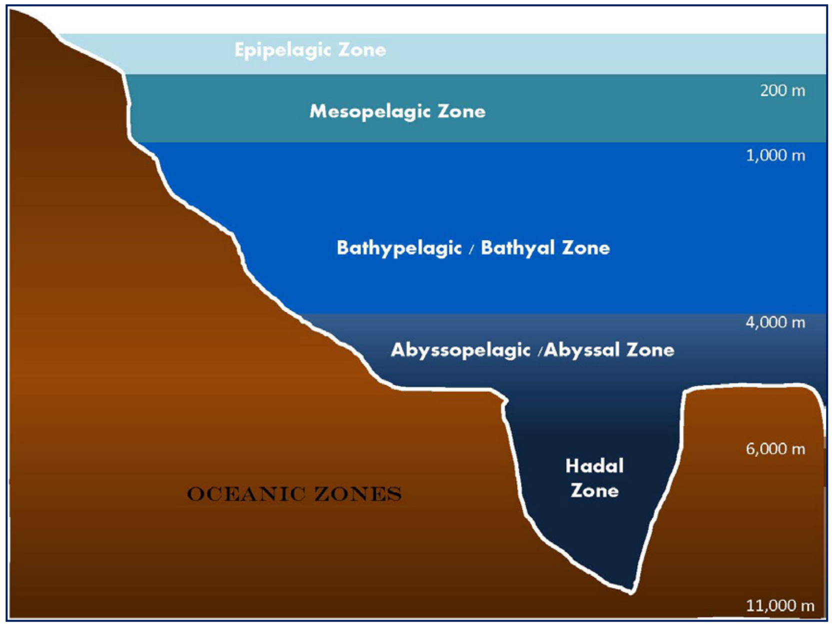


Figure 2. Oceanic zones in the Pacific Ocean.

The MTMNM was established by a Presidential Proclamation of George W. Bush on January 6, 2009 under the authority of the Antiquities Act of 1906. According to Presidential Proclamation 8335, the MTMNM includes the waters and submerged lands of the three northernmost Mariana Islands (i.e., Farallon de Pajaros (Uracas), Maug, and Asuncion) (collectively, the ''Islands Unit'') and only the submerged lands of designated volcanic sites (the Mariana Arc of Fire NWR) and the Mariana Trench NWR. The boundary of the Trench NWR extends from the northern limit of the U.S. EEZ in the Commonwealth of the Northern Mariana Islands (CNMI) to the southern limit of the U.S. EEZ in Guam (Appendix A, Figure 1).

The Mariana Trench is a crescent-shaped hadal trench that averages 2,550 km in length and 69 km in width. In the portion within the U.S. EEZ, the Mariana Trench is approximately 940 NM (1,740 km) long and 38 NM (70 km) wide. The deepest known point on the Earth's seafloor, Challenger Deep, is located at the southern extent of the Mariana Trench and lies beyond the western boundary of the MTMNM. While the depth has been estimated at approximately 10,984 ± 25 m based on multi-beam echosounder mapping (Gardner et al. 2014), the deepest depth reached by a manned submersible is 10,928 m (Five Deeps 2019). Sirena Deep (estimated at 10,732 m) (Fryer et al. 2003) is located within the MTMNM near 12º N latitude approximately 145 km south of Guam. The proposed BIFROST cable route (between 16º-18º N latitude) and the existing SEA-US cable route (between 11º-13º N latitude) within the Trench NWR are both located over 150 km (85 NM) to the northeast of these deepest known points.

USFWS was delegated to manage the MTMNM through the DOI Secretary's Order No. 3284, which directed that the Volcanic Unit and the Trench Unit be managed as part of the National Wildlife Refuge System as the "Mariana Arc of Fire NWR" and "Mariana Trench NWR". The Secretary of the Department of Commerce (DOC), through the National Oceanic and Atmospheric

Administration (NOAA), has primary management responsibility for fishery related activities in the waters of the MTMNM.

3.1 Hydrology

The bottom currents in the Mariana Trench near the Challenger Deep, at depths between 6,000 and 10,890 m, are less than 1.5 cm per second (0.029 knots) for 22.9–63.8% of the time (Taira 2004). The typical bottom currents along the proposed BIFROST cable laying corridor and existing SEA-US cable corridor are anticipated to be similar.

3.2 Geology and Topography

The underlying geology along the proposed BIFROST cable route and existing SEA-US cable route have not been extensively surveyed or studied. A bathymetric survey was conducted for HMB in 2020 in order to determine and study topological features, substrate hardness, and slope along the BIFROST cable route (Appendix A, Figures 4 and 5); however, no intrusive activities, such as sediment sampling, were conducted. The proposed BIFROST cable route would cross over and through the Trench NWR for a total linear distance of approximately 98.91 mi (159.18 km). Along the proposed cable route, slopes range from 0.61º to 8.37º (1.07% to 14.61%), and water depths range from 3,660 to 7,320 m, while slopes range from 0.61º to 15.42º (1.06% to 26.91%) and water depths range from 3,620 to 7,460 m along the alternate cable route (Appendix A, Figure 5a). Approximately 15.87 km of the proposed route and 16.73 km of the alternate route would traverse slope areas of 10.66% to 26.91%, which are moderate to steep slopes. Upon entering the Trench NWR from the west, the proposed and alternative routes would cross over a section of rock outcrop, then proceed east over coarse sediment comprising sand and gravel before exiting the Trench NWR (Appendix A, Figure 5a). The existing SEA-US cable route crosses over and through the Trench NWR for a total linear distance of approximately 70.07 mi (112.77 km). Slopes along the existing cable route range from 0.90º to 15.20º (1.57% to 27.16%), and water depths range from 6,100 to 9,725 m (Appendix B, Figure 5). Approximately 26.90 km of the SEA-US cable route traverses slope areas of 10.04% to 27.16%, which are moderate to steep slopes.

Seabed geology is not available for the SEA-US cable route, which crosses a much deeper section of the Trench NWR than the BIFROST cable; however, rock outcrop and coarse sediment are likely components. Hadal zone researchers Alan Jamieson and Heather Stewart studied areas in the hadal and adjacent abyssal slope zones of the southern Trench NWR, approximately 133 km southwest of the existing SEA-US cable (Stewart and Jamieson 2018). They classified the basic geologic structure by depth zones. Their study involved taking images of the seafloor using two free-fall lander vehicles: the Hadal-lander and the Abyssal-lander. Substrate types were categorized through the analysis of photographic data since the landers were not capable of returning physical samples. Within the water depth range of 4,506 m to 5,641 m, the dominant seabed sediment observed is comprised of muddy gravel, with one observation each of bedrock, bedrock and fine-grained sediment, and gravelly fine-grained sediment across all fifteen sampling stations (Stewart and Jamieson 2018). Within the water depth range of 6,008 m to 7,941 m, gravelly fine-grained sediment was the dominant sediment type; fine-grained sediment, bedrock, slightly gravelly fine-grained sediment, and muddy gravel were also observed within this depth range (Stewart and Jamieson 2018).

The Mariana Trench marks the convergent boundary of the subduction of the Pacific plate beneath the western Philippine plate. The Mariana forearc is located between the trench and volcanic islands of the Mariana island arc. Several serpentinite mud volcanoes (hydrothermal geologic landforms that erupt slurries of mud, water, and gas) occur in this Mariana forearc region, reaching heights of 2.5 km and diameters of 50 km, which are larger than sedimentary mud volcanoes observed in other convergent margins of the world (Fryer et al. 2012) and are the only known currently active sites of serpentinite mud eruptions (Fryer et al. 2020). Serpentinite mud is named for the magnesium-rich mineral serpentine. Serpentine and a related mineral, brucite, form when the Pacific plate sinks into the mantle, and the pelagic sediments and hydrated basalts begin to dehydrate, releasing water and volatiles into the mantle beneath the Mariana arc. This mixture of water and volatiles interacts with the peridotite material in the mantle (beneath the overriding Philippine plate) to form serpentine and brucite. There are no serpentinite mud volcanoes or serpentinite mud volcano springs mapped within the path of the BIFROST and SEA-US cable routes as they enter the Trench NWR (Appendix A, Figure 3a and Appendix B, Figure 3a). The SEA-US cable traverses the northeastern flank of an unnamed seamount within the Trench NWR at depths of approximately 6,500 m and deeper (Appendix B, Figure 5).

3.3 Biological Resources

Since project-specific biological surveys were not performed in the Trench NWR portion of the proposed BIFROST cable corridor and existing SEA-US cable corridor, this EA draws from past surveys, in addition to other available desktop resources, such as peer-reviewed scientific journal articles and publications.

3.3.1 Marine Flora

Photosynthetic marine plants are not expected to occur along the proposed BIFROST or existing SEA-US cable routes due to the complete absence of light in the abyssal and hadal zone depths of the Trench NWR.

3.3.2 Fauna

INVERTEBRATE MACROFAUNA

Hadal communities are generally dominated by actinians (sea anemones), polychaetes (bristle worms), isopods, amphipods, echiurids (spoon worms), and holothurians (sea cucumbers) (Wolff 1970), with the deepest epibenthic community comprising holuthurians, amphipods, and xenophyophores in the Challenger Deep (Gallo et al. 2015). These organisms would be expected in the Trench NWR portion of the proposed and existing cable corridors, although their densities are unknown.

The 2016 Deepwater Exploration of the Marianas Expedition is among a series of expeditions launched by NOAA under the "Campaign to Address Pacific monument Science, Technology, and Ocean Needs" (CAPSTONE), with a goal to collect baseline information in unknown and poorly known deepwater areas within U.S. national marine monuments and sanctuaries located throughout the Pacific. The three legs of the Mariana Islands cruises (EX1605L1, EX1605L2, and EX1605L3) were designed to survey the biology and geology from unexplored areas in and around the MTMNM, Guam, and the CNMI. During Leg 3 (EX 1605L3) of the expedition, the NOAA ship *Okeanos Explorer* conducted one dive (Dive 21 or 1605L3-21) with its ROV *Deep Discoverer* in the vicinity of the cable route within the Trench NWR, approximately 21 km (13 mi) to the north of the proposed BIFROST cable route.

Among the objectives of CAPSTONE was to discover and produce baseline characterization of large-scale, high-density deep-sea coral and sponge (DSCS) communities within and outside the monuments. High-density DSCS communities are defined as having at least 3,000 combined coral and sponge counts per km with very high-density communities having over 10,000 counts per km, while moderate-density communities are defined as those with 1,000-2,999 combined counts per km, and low-density communities are those with less than 1,000 combined per km (Kelley et al. 2019). Out of 41 ROV dives in the Mariana Islands region, three yielded very high-density DSCS communities, five were high-density sites, and five were moderate-density sites, while the remaining 28 dives were sparsely populated (Kelly et al. 2019) (Appendices A and B, Figure 7).

The highest density of DSCS communities was observed at Supply Reef (1605L3-06) with 97,890 combined counts per km, followed by Zealandia Bank (1605L1-12) with 18,260 counts per km, and Maug (1605L3-03) with 10,070 counts per km (Kelly et al., 2019) (Appendix A, Figures 8 to 10). The depths of these very high-density sites ranged between 278-655 m, which are relatively shallow for cold-water corals (Kelley et al. 2019). All three very high-density sites are located west of the Trench NWR (Appendix A, Figure 7). Two high-density coral and sponge sites were also shallow, with depths between 245-533 m, while the remaining three high-density sites were at depths between 1,702-2,269 m. These deeper sites encompassed Enrique Guyot (1605L1-15), Vogt Guyot (1605L3-19) and Pigafetta Seamount (1605L1-14), which are all located east of the Trench NWR.

Deep-sea coral and sponge communities occur in areas of clear water, such as on ridges, seamounts, canyon walls and shelf-edge breaks, where there is hard substratum, sufficient food, and moderate to strong currents (Hourigan et al. 2017). Based on data from other regions explored in the CAPSTONE project, dissolved oxygen values were found to vary considerably within a single community, and thus, are not good predictors of the presence of high-density communities (Kelley et al. 2019). Temperature was also not a good predictor, since similar values were observed between low-density and high-density communities (Appendices A and B, Figure 7).

Since there is limited information on the distribution of these communities, the slope and terrain roughness (rugosity) of the nearest high-density deep-sea and sponge communities ROV dives were used for comparison with the proposed BIFROST cable route and existing SEA-US cable route. The high slope and rugosity for 1605L3-21 (Hadal Wall) (Appendix A, Figure 3b), and for 1605L1-4 (Enigma Seamount) (Appendix B, Figure 3b) were overlaid with the coral and sponge observations along the ROV dive routes. Hadal Wall is located approximately 21 km (13 mi) north of the BIFROST cable alternative route, while Enigma Seamount is located approximately 185 km (115 mi) southwest of the SEA-US cable route. Only a very small number of sponges were observed at Hadal Wall at a depth of 5,816 m, while Enigma Seamount yielded low-density communities of cnidaria and sponges at a depth range of 3,636-3,782 m. In contrast with these rugose areas, the proposed BIFROST cable corridor and existing SEA-US cable corridor within the Trench NWR have a much flatter terrain in the eastern sector, and areas of higher slope and terrain roughness in the western sector. Approximately 15.87 km of the BIFROST cable proposed route and 16.73 km of the alternate route would traverse slope areas of 10.66% to 26.91%, which are moderate to steep slopes. The SEA-US cable traverses approximately 26.90 km over slope areas of 10.04% to 27.16%, which are moderate to steep slopes. At these locations of higher slope and terrain roughness along each route, there is an inferred higher probability for the presence of deep-sea corals and sponges. However, the Mariana Trench expedition surveyed a variety of ridge features over a broad range of depths, geologic features and environmental conditions, and found that the presence of a ridge does not guarantee the presence of a high-density community, but that other factors, such as substrate consolidation and depth, are clearly important (Kelley et al. 2019). High-density coral and sponge communities were found on two ridge dives at depths above 3,000 m, while other ridge dives conducted at depths below 3,000 m have not yet observed high-density communities (Kelley et al. 2019). The deepest 2016 Mariana Islands expedition ROV dives were below a depth of 5,000 m: Petite-spot volcano (1605L3-18), Hadal Ridge (1605L3-04), Hadal Wall (1605L3-21) and Subducting Guyot 1 (1605L3-16). A low-density community of 20 counts per km was observed at Petite-spot volcano, while deep-sea corals and sponges were scarce at the other three deepest dives (Kelley et al. 2019) (Appendices A and B, Figure 7). On Leg 3, Dives 4 (Hadal Ridge), 16 (Subducting Guyot 1) and 18 (Petite-spot volcano), the expedition documented glass sponges and carnivorous sponges (Cladorhizidae), including several previously undescribed specimens, at depths up to 5,894 m (NOAA 2017, Hesetun et al. 2019).

FISH

Elongate, scavenging fish are more common in the abyssal plain, though members of these families are able to extend their range into the abyssal-hadal transition zone of the Mariana Trench between 4,506 to 6,198 m (Lindley et al. 2017). These include Macrouridae (*Coryphaenoides yaquinae*), Ophidiidae (*Barathrites iris*, *Bassozetus* spp. and *Bassozetus* cf. *compressus*), and Zoarcidae (Lindley et al. 2017). Zoarcids, also known as eelpouts, are eels in the order of Perciformes (Nelson 1994). An undescribed species of eelpout (Zoarcidae) was observed at a depth of 6,142 m within the Mariana Trench, the maximum observed depth for these fish (Linley et al. 2017). Macrourids, also known as grenadier, are dominant scavengers within abyssal plains (Jamieson 2012). Their deepest observed depth (7,012 m) is in the Mariana Trench (Linley et al. 2017). Ophidiids (cusk-eels) are a group of bony fishes in the order Ophidiiformes (Nelson 1994). They have been observed between 4,506 m and 6,198 m in the Mariana Trench (Linley et al. 2016).

The hadal zones of the trench from 6,000 m to 8,200 m deep are dominated by the predatory hadal snailfish (Liparidae), possibly because of adaptations allowing them to exploit the abundant amphipods at these depths (Jamieson 2011; Gerringer et al. 2019). Snailfish occupy the widest range of depths of any fish family, from intertidal to hadal waters (Gerringer et al. 2017). Hadal snailfish are small (less than 30 cm in length) and are found in greater densities and at deeper depths than other hadal fishes (Linley et al. 2017). Among these is the ethereal snailfish, an undescribed species which has only been observed in the Mariana Trench (8,007 m to 8,143 m depths) (Linley et al. 2017). The deepest snailfish is the Mariana snailfish (*Pseudoliparis swirei*), described from 37 individuals collected from 6,898 m to 7,966 m in the Mariana Trench, where it is likely endemic (Gerringer et al. 2017). It has been observed in the trench at a depth of 8,178 m (Oguri and Noguchi 2017). Physiological evidence suggests that bony fish cannot survive at depths greater than approximately 8,200 m because of an inability to regulate osmotic pressure beyond this depth (Yancey et al. 2014; Linley et al. 2016).

REPTILES

The endangered leatherback sea turtle (*Dermochelys coriacea*) was observed diving to depths of 1,280 m in the North Atlantic, and is recognized as the deepest diving sea turtle and reptile (Byrne 2007; Fossette 2010). Ocean Biogeographic Information System (OBIS) data compiled from surveys and incidental sightings indicates that the leatherback sea turtle has been documented at two locations within the vicinity of the proposed BIFROST cable route (Appendix A, Figure 6) and one location near the existing SEA-US cable route (Appendix B, Figure 6).

BIRDS

Pelagic seabirds are adapted to living and feeding on the open ocean, where they live most of their lives except for periods when they come ashore for breeding. Among the major groups are albatrosses, petrels and tropical terns (USFWS 2005). Migratory shorebirds that are not resident in the Mariana Islands travel seasonally between summer breeding grounds and wintering areas in Guam and other parts of the Pacific along the West Pacific Flyway. The West Pacific Flyway includes various other Pacific archipelagos, such as New Zealand, Samoa, Line Islands, Phoenix Islands, Hawaii, and continental sub-arctic and arctic regions in Alaska (U.S. Department of the Navy 2015). The Navy-funded *Mariana Islands Sea Turtle and Cetacean Survey* observed a total of 40 bird species along four legs (trips), accounting for 814 individual observations of seabirds and shorebirds within the cruise area in Mariana Island waters (U.S. Department of the Navy 2015) (Table 3-1). There is a potential for these pelagic seabirds to forage or travel within the Trench NWR project area, and for nonresident migrants to transit through the Trench NWR project area during their transpacific journeys.

Table 3-1. List of Shorebirds and Seabirds that May Occur Within the Project Area

Family	Common Name	Scientific Name
Albatrosses Family Diomedeidae	Short-tailed Albatross	*Phoebastria albatrus*
	Black-footed Albatross	*Phoemastria nigripes*
Petrels and Shearwaters Family Procellariidae	Tahiti Petrel	*Pseudobulweria rostrata*
	Mottled Petrel	*Pterodroma inexpectata*
	Kermadec Petrel	*Pterodroma neglecta*
	Herald Petrel	*Pterodroma arminijoniana*
	Hawaiian Petrel	*Pterodroma sandwichensis*
	White-necked Petrel	*Pterodroma cervicalis*
	Bonin Petrel	*Pterodroma hypoleuca*
	Blacked-winged Petrel	*Pterodroma nigripennis*
	Bulwer’s Petrel	*Bulweria bulwerii*
	*White-chinned Petrel	*Procellaria aquinoctialis*
	Streaked Shearwater	*Calonectris leucomelas*
	Flesh-footed Shearwater	*Puffinus carneipes*
	Wedge-tailed Shearwater	*Puffinus pacificus*
	Short-tailed Shearwater	*Puffinus tenuirostris*
	Newell’s Shearwater	*Puffinus newelli*
	*Little Shearwater	*Puffinus assimilis*
	Audubon’s Shearwater	*Puffinus lherminieri*

Family	Common Name	Scientific Name
	Wilson's Storm Petrel	*Oceanites oceanicus*
	*Wedge-rumped Storm Petrel	*Oceanodroma tethys*
	Leach's Storm Petrel	*Oceanodroma leucorhoa*
	*Swinhoe's Storm Petrel	*Oceanodroma monorhis*
	Matsudaira's Storm Petrel	*Oceanodroma matsudairae*
Tropicbirds Family Phaethonidae	Red-tailed tropicbird	*Phaethon rubricauda*
	White-tailed tropicbird	*Phaethon lepturus*
Gannets and Boobies Family Sulidae	Masked Booby	*Sula dactylatra*
	Red-footed Booby	*Sula sula*
	Brown Booby	*Sula leucogaster*
Frigatebirds Family Frigitatidae	Great Frigatebird	*Fregata minor*
Skuas and Jaegers	Pomarine Jaeger	*Stercorarius pomarinus*
	Parasitic Jaeger	*Stercorarius parasiticus*
	Long-tailed Jaeger	*Stercorarius longicaudus*
Terns and Noddies	Gray-backed Tern	*Sterna lunata*
	Sooty Tern	*Sterna fuscata*
	Black Noddy	*Anous minutes*
	Brown Noddy	*Anous stolidus*
	White Tern	*Gygis alba*
Plovers Family Charadriidae	Pacific Golden Plover	*Pluvialis fulva*
Sandpipers, Curlews, Snipes Family Scolopacidae	Far Eastern Curlew	*Numenius madagascariensis*
	Common Sandpiper	*Actitis hypoleucos*

Source: U.S. Department of the Navy 2015 summary of *Mariana Islands Sea Turtle and Cetacean Survey* (U.S. Department of the Navy 2007) findings. Note: species marked with an asterisk (*) are believed to be sufficiently rare, unexpected, and without precedence in the Mariana Islands Sea Turtle and Cetacean Study Area that in the absence of photo or specimen documentation and supported only by written field notes, should be regarded as hypothetical.

MAMMALS

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). According to the International Union for the Conservation of Nature (IUCN) Red List GIS data on marine mammal distribution, compiled data, and 2007 surveys of the Mariana Archipelago, 30 cetaceans (marine mammals) have the potential to occur within the marine waters of the Trench NWR (Table 3-2).

Surveys in 2007 detected 13 species in the Mariana Islands (Table 3-2) (Fulling et al. 2011). OBIS data compiled over the years from surveys and incidental sightings, including the 2007 surveys, indicates that two cetacean species have been documented within the vicinity of the BIFROST cable proposed and alternative routes in or near the Trench NWR (Appendix A, Figure 6). These include sperm whales (*Physeter macrocephalus*) and dolphins observed north of the route in the Trench NWR, and humpback whales (*Megaptera novaeangliae*) and sperm whales observed north of the route west of the Trench NWR boundary. Sperm whales have been documented in the vicinity of the existing SEA-US cable route, according to OBIS data (Appendix B, Figure 6).

Table 3-2. List of Cetaceans that May Occur Within the Project Area

Common Name	Scientific Name	Common Name	Scientific Name
Minke whale*	*Balaenoptera acutorostrata*	Hubb's beaked whale***	*Mesoplodon carlhubbsi*
Sei whale***†	*Balaenoptera borealis*	Blainville's beaked whale*	*Mesoplodon densirostris*
Bryde's whale*†	*Balaenoptera edeni*	Ginkgo-toothed beaked whale**	*Mesoplodon ginkgodens*
Blue whale**	*Balaenoptera musculus*	Deraniyagala's beaked whale**	*Mesoplodon hotaula*
Fin whale**	*Baleanoptera physalus*	Killer whale*	*Orcinus orca*
Short-beaked common dolphin**	*Delphinus delphinus*	Melon-headed whale*†	*Peponocephala electra*
North Pacific right whale**	*Euhalaena japonica*	Sperm whale*†	*Physeter macrocephalus*
Pygmy killer whale*†	*Feresa attenuata*	False killer whale*†	*Pseudorca crassidens*
Short-finned pilot whale*†	*Globicephala macrorhynchus*	Pantropical spotted dolphin*†	*Stenella attenuata*
Longman's beaked whale*	*Indopacetus pacificus*	Striped dolphin*†	*Stenella coeruleoalba*
Risso's dolphin*	*Grampus griseus*	Spinner dolphin*†	*Stenella longirostris*
Pygmy sperm whale*	*Kogia breviceps*	Rough-toothed dolphin*†	*Steno bredanensis*
Dwarf sperm whale*	*Kogia sima*	Indo-Pacific bottlenose dolphin***	*Tursiops aduncus*
Fraser's dolphin*	*Lagenodelphis hosei*	Common bottlenose dolphin*†	*Tursiops truncatus*
Humpback whale*†	*Megaptera novaeangliae*	Cuvier's beaked whale*	*Ziphius cavirostris*

*Sources: IUCN Red List, 2019; Fulling et al. 2011. Key: * = Regular (occurs as usual part of fauna of the area, regardless of its abundance); ** = Rare (occurs only sporadically); *** = Extralimital (occurs outside of its usual range); † = observed in Mariana Archipelago during 2007 surveys.*

3.3.3 Threatened and Endangered Species, and Critical Habitat

NOAA Fisheries or National Marine Fisheries Service (NMFS) lists 17 marine species in the Mariana Islands region as protected under the U.S. Endangered Species Act (ESA) (Table 3-3).

According to NMFS, there is no critical habitat designated in the Mariana Islands. The only designated critical habitat for ESA-listed species in the Pacific Islands region is for the Hawaiian monk seal (*Neomonachus schauinslandi*) in the Northwestern Hawaiian Islands and the main Hawaiian Islands insular false killer whale (*Pseudorca crassidens*). On November 27, 2020, NMFS published a proposed rule to designate critical habitat for seven threatened corals that occur in the Indo-Pacific in U.S. jurisdictions, including Guam and the CNMI, pursuant to section 4 of the ESA (85 FR 76262). The critical habitat designation would protect the three listed coral species that occur in the Mariana Islands at depths up to 40 m.

Table 3-3. Threatened and Endangered Species in the Mariana Islands Region

Common Name	Scientific Name	ESA Listing
Marine Mammals		
Blue Whale	*Balaenoptera musculus*	Endangered
Fin Whale	*Balaenoptera physalus*	Endangered
Humpback Whale	*Megaptera novaeangliae*	Endangered
Sei Whale	*Balaenoptera borealis*	Endangered
Sperm Whale	*Physeter macrocephalus*	Endangered
Dugong	*Dugong dugon*	Endangered
Birds		
Short-tailed Albatross	*Phoebastria albatrus*	Endangered
Hawaiian Petrel	*Pterodroma sandwichensis*	Endangered
Newell's Shearwater	*Puffinus newelli*	Threatened
Sea Turtles		
Green Turtle	*Chelonia mydas*	Endangered
Hawksbill Turtle	*Eretmochelys imbricata*	Endangered
Leatherback Turtle	*Dermochelys coriacea*	Endangered
Loggerhead Turtle	*Caretta caretta*	Endangered
Olive Ridley Turtle	*Lepidochelys olivacea*	Threatened
Fish		
Scalloped Hammerhead Shark	*Sphyrna lewini*	Threatened
Giant Manta Ray	*Manta birostris*	Threatened
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened
Corals		
Needle Coral	*Seriatopora aculeata*	Threatened
Staghorn coral	*Acropora globiceps*	Threatened
Blunt Coral	*Acropora retusa*	Threatened

Sources: NOAA Marine Protected Species of the Mariana Islands, January 2018; U.S. Department of the Navy, 2015..

CORALS

In 2014, NMFS listed three coral species in the Mariana Archipelago as threatened under the ESA: *Seriatopora aculeata, Acropora globiceps,* and *Acropora retusa*. These reef-building corals occur at a maximum depth of 40 m; therefore, they would not be present within the hadal and abyssal zones of the Trench NWR.

FISH

NMFS lists three fish species in the Mariana Archipelago as threatened: scalloped hammerhead shark, giant manta ray, and oceanic whitetip shark (Table 3-3).

Scalloped hammerhead shark. The Indo-West Pacific distinct population segment (DPS) of the scalloped hammerhead shark (*Sphyrna lewini*) was listed as threatened in 2014. The biology, habitat, and conservation status of this species is described in a species status review by Miller et al. (2014). Scalloped hammerheads feed opportunistically on a varied diet of teleosts (ray-finned fish), cephalopods (octopus, cuttlefish, squid, etc.), crustaceans (crab, shrimp, krill, etc.) and rays (Miller et al. 2014). The main threats to the Indo-West Pacific DPS are overutilization by industrial/commercial and artisanal fisheries, as well as illegal, unregulated and unreported (IUU) fishing and high at-vessel mortality; habitat degradation, inadequacy of current regulatory mechanisms, and schooling behavior were considered moderate risks (Miller et al. 2014). The scalloped hammerhead shark was known to visit depths up to 450 m (Klimley 1993); however, data from a tagged female in the tropical eastern Pacific indicates activity ranged from the surface to a depth of 980 m in the mesopelagic zone (200 to 1,000 m) (Jorgensen et al. 2009).

Giant manta ray. The giant manta ray (*Manta birostris*) was listed as threatened in 2018. The biology, habitat, and conservation status of this species is described in a species status review by Miller and Klimovich (2016). The giant manta ray is a pelagic (open sea), migratory and solitary species that commonly occurs on offshore reefs, sea mounts, pinnacles and oceanic islands, and locations in close proximity to deep water, such as outer atoll edges near drop-offs (Kashiwagi et al. 2011). Data from the tropical eastern Pacific indicate that giant manta ray activity gradually shifts from surface waters to 100 m to 150 m during the year, as it targets surface zooplankton, then shifts to vertical migrators (Steward et al. 2016).

Oceanic whitetip shark. The oceanic whitetip shark (*Carcharhinus longimanus*) was listed as threatened in 2018. The biology, habitat, and conservation status of this species is described in a species status review by Young et al. (2016). The oceanic whitetip shark is a pelagic species, generally remaining offshore in the open ocean, or around oceanic islands in water depths greater than 600 ft (183 m) (NOAA 2018b). The oceanic whitetip shark will make short dives to the mesopelagic and bathypelagic zones (maximum observed depth 1,082 m); however, over 99% of the time is spent shallower than 200 m (Howey-Jordan et al., 2013).

Since the maximum depths for these fish species are around 1,000 m or shallower, they may be present in the water column, but are not likely to be present within the abyssal and hadal zones of the Trench NWR.

REPTILES

Five turtle species listed as occurring in the Mariana Islands are protected under the ESA: green sea turtle, hawksbill turtle, leatherback turtle, loggerhead turtle, and olive ridley turtle (Table 2-2).

Green sea turtle. In 1978, breeding colony populations of the green sea turtle in Florida and on the Pacific coast of Mexico were listed as endangered, while remaining populations were listed as threatened. NMFS and USFWS issued a final rule in 2016 that listed three DPSs of green sea turtle as endangered and eight DPSs as threatened species. The Central West Pacific DPS of turtles (including Guam and CNMI) are endangered. The biology, habitat, and conservation status of the green sea turtle is described in status reviews (NMFS-USFWS 2007a, Seminoff et al. 2015). The threats to green sea turtles include coastal development, beachfront lighting, and erosion resulting from sand mining; illegal take of turtles and eggs; nest and hatchling non-human predation; and fishing practices, marine pollution, and climate change (Seminoff et al. 2015). Occasional vessel strikes have been documented on Guam, although this threat to green sea turtles is not known to be of great consequence for the Central West Pacific DPS (Seminoff et al. 2015).

Hawksbill sea turtle. The hawksbill sea turtle was listed as endangered in 1973. The biology, habitat, and conservation status of this species is described in status reviews (NMFS-USFWS 2007b, NMFS-USFWS 2013). Hawksbill turtles are considered specialist sponge carnivores, although neonates (newborns) are thought to be pelagic herbivores before transitioning to a benthic sponge diet as they mature (NMFS-USFWS 1998b). Guam and the CNMI support a small foraging population of hawksbill sea turtles; nesting activities, although apparently rare, have also been reported, with the first one documented in 1991 (NMFS-USFWS 1998b). On Guam, the primary hawksbill sea turtle threats are directed take and coastal construction (NMFS-USFWS 1998b).

Leatherback sea turtle. The leatherback sea turtle was listed as endangered in 1973 throughout its range. The biology, habitat, and conservation status of this species is described in status reviews (NMFS-USFWS 2007c, NMFS-USFWS 2013). This species is uncommon in the insular Pacific, and nesting is not known in Guam or the CNMI, but individuals are sometimes encountered in deep water near prominent archipelagoes (NMFS and USFWS 1998c). Adults are highly migratory and forage widely in the pelagic marine habitat, with documented movement over 10,000 km in a single year (WPRFMC 2009b). To a large extent, the oceanic distribution of leatherbacks may reflect the distribution and abundance of macroplanktonic prey (NMFS-USFWS 1998c). In the western Pacific, turtles nesting in Indonesia were found to migrate to several areas, including eastern Indonesia, the central North Pacific, South China Sea, southeastern Australia, and the west coast of the U.S. (Bailey et al. 2012). Hatchlings are thought to become entrained by oceanic currents into the North Pacific, South Pacific or Indian Oceans, and drift passively for one to two years into temperate regions, then as juveniles, swim actively toward warmer latitudes before winter, and higher latitudes during spring (NMFS-UFWS 2013). The threats to leatherback sea turtles include natural and anthropogenic impacts to their foraging habitats, by-catch in fisheries, boat strikes, ingestion of marine debris, and exposure to heavy metals and other contaminants (NMFS-USFWS 2013).

Loggerhead sea turtle. The loggerhead sea turtle was listed as threatened in 1978 throughout its worldwide range. In 2011, the USFWS and NMFS determined that the loggerhead sea turtle is composed of nine DPS, and they listed four DPSs as threatened and five DPSs as endangered under the ESA. The biology, habitat, and conservation status of this species is described in status reviews (NMFS-USFWS 2007d). For the endangered North Pacific DPS (including Guam), loggerheads are present throughout tropical to temperate waters; however, nesting occurs only in Japan, and possibly in areas surrounding the South China Sea (USFWS-NMFS 2011). Sightings of loggerheads have not been reported in Guam or the CNMI (NMFS-USFWS 1998d); therefore, this species is unlikely to occur within the vicinity of the Action Alternatives.

Olive ridley sea turtle. The olive ridley sea turtle was listed in 1978 as endangered for breeding colony populations along the Mexican coast and listed as threatened elsewhere. The biology, habitat, and conservation status of this species is described in status reviews (NMFS-USFWS 2007e). Nesting is not known to occur in Guam or the CNMI. The olive ridley sea turtle is rare in the central Pacific, both at sea and around islands; the only at sea occurrences in waters under U.S. jurisdiction are limited to Hawaii and the west coast of the continental U.S. (NMFS-USFWS 2007e). Therefore, this species is unlikely to occur within the vicinity of the Action Alternatives.

All of these listed turtles occupy shallow depths above the abyssal and hadal zones, with the deepest recorded dive among these species made by the leatherback turtle to 1,280 m in the North Atlantic (Byrne 2007; Fossette 2010). Leatherback sea turtles have been observed in the vicinity of the project area in 2006, based on OBIS data compiled from surveys and incidental sightings (Appendix A, Figure 6).

BIRDS

The USFWS lists three pelagic seabirds under the ESA that have been seen in the waters around the Mariana Islands (U.S. Department of the Navy 2015), and therefore, may occur within the Trench NWR: the short-tailed albatross (*Phoebastria albatrus*) and Hawaiian petrel (*Pterodroma sandwichensis*), which are listed as endangered, and the Newell's shearwater (*Puffinus newelli*) which is listed as threatened (Table 3-3). None of these species breed on land in the Mariana Islands; and the Hawaiian petrel and Newell's shearwater are considered rare in the Mariana Islands based on their known ranges (U.S. Department of the Navy 2015).

MAMMALS

Six mammals listed as occurring within the Mariana Archipelago are protected under the ESA: blue whale, fin (or finback) whale, humpback whale, sei whale, sperm whale, and dugong. All five whales have been classified as endangered under the ESA since the Act was passed in 1973.

Dugong. The dugong is listed as endangered under the jurisdiction of the USFWS. This shallow-water species is not known to occur in Guam, with only anecdotal sightings at Cocos Island in 1975 and 1985 (Eldredge 2003); therefore, this species is not expected to occur in the MTMNM.

Blue whale. In the North Pacific, the blue whale (*Balaenoptera musculus*) ranges from Kamchatka to southern Japan in the west, and from the Gulf of Alaska and California to at least Costa Rica in the east; whales have been sporadically reported within several hundred km of the Hawaiian Islands (NMFS 1998a). The blue whale is considered rare in the waters of Guam and the CNMI; no whales were observed during extensive surveys in these waters in 2007 (Fulling et al. 2011). Seasonal migrations governed by food requirements lead to movement of whales toward the polar waters in the spring, and movement toward the subtropics in the fall (NMFS 1998a). There are three subspecies of blue whale, including *B. m. brevicauda*, or pygmy blue whale, which had a maximum confirmed dive depth of 506 m near Australia, the deepest record for the blue whale (Owen et al. 2016). The potential threats to the blue whale include collisions with vessels, entanglement in fishing gear, reduced zooplankton production from habitat degradation, and disturbance from low-frequency noise (NMFS 1998a). The risk of ship strike is greatest for blue whale calves or feeding animals that are thought to spend the greatest amount of time at the surface (Owen et al. 2016).

Fin whale. The fin whale is a cosmopolitan species (a species whose range extends across most of the world within its appropriate habitats) that has a generally anti-tropical distribution centered in the temperate zones (NMFS 2010a). This species is considered rare in the Mariana Archipelago; no fin whales were observed during extensive surveys in these waters in 2007 (Fulling et al. 2011).

Sei whale. The sei whale is a highly mobile and cosmopolitan species, but tends to avoid polar and tropical waters, preferring temperate and subtropical zones (NMFS 2011). A total of 16 sei whale sightings were documented during extensive surveys between 10º-18º N around the Mariana Islands in 2007 (Fulling et al. 2011). The sei whale is considered extralimital and unique in the waters around Guam and the CNMI because the species was not previously confirmed to occur south of 20ºN. Winter distribution of sei whales in the North Pacific is not well understood, and no breeding or calving grounds have been found, although the 2007 Mariana Islands survey reported several cow-calf sightings of this species (Fulling et al. 2011). It is unclear if the 2007 sightings were an unusual occurrence, or whether the sei whale is indeed a regular component of the cetacean community in the Mariana Islands region (Fulling et al. 2011).

Humpback whale. Humpback whales are found in temperate and tropical waters (10º-23º latitude) of both hemispheres during the winter months, when they mate and calve, although reproductive events may also occur during migration (NMFS 1998a). In the North Pacific, three distinct wintering grounds are identified: 1) the coastal and insular waters along Baja California; 2) main islands of Hawaii; and 3) the islands south of Japan, including the Ryuku, Bonin, and Northern Mariana Islands (NMFS 1998a). Humpbacks were acoustically and visually detected during extensive surveys between 10º-18º N around the Mariana Islands in January-April 2007, although no cow-calf pairs were observed (Fulling et al. 2011). Surveys around Saipan and Tinian in February-March 2015 yielded 12 whales, including four cow-calf pairs, with multiple sightings of two of the pairs, suggesting that the waters off western Saipan and adjacent areas may be a breeding ground for humpback whales (Hill et al. 2015). This was confirmed by similar cow-calf sightings and observations of competitive groups (a common breeding behavior) in February-March 2016, February 2017, and February 2018 (NOAA 2018a). Recent comparisons with other North Pacific whale catalogs and DNA profiling of biopsy samples have established the Mariana Archipelago as a breeding ground for western North Pacific humpback whales, with data suggesting that they are part of the western North Pacific population with connections to the Ogasawara (Bonin) Islands breeding ground and Commander (Komandorski) Islands (Russian Far East) feeding ground (Hill et al. 2020) to the north of the Mariana Islands.

Humpbacks migrate long distances to high latitude (35º-65º N) summering areas in waters over continental shelves, where they feed intensively; shorter, within-season migration occurs through a portion of the summer range to locate or follow prey concentrations (NMFS 1998a). These summering grounds are 1) the coast of Central California; 2) Southeastern Alaska; and 3) Southcentral Alaska (NMFS 1998a). Humpbacks have been observed to dive as deep as 240 m (Hamilton et al. 1997). The most frequently identified source of human-caused injury or mortality to humpbacks is from entrapment and entanglement in active fishing gear, particularly around northeastern continental shelf waters during summer months (NMFS 1998a).

Sperm whale. The sperm whale is a cosmopolitan species found in all oceans. With a total of 23 sperm whale sightings, this was the most frequently sighted species during extensive surveys between 10º-18º N around the Mariana Islands in January-April 2007 (Fulling et al. 2011). The observations ranged from individuals to a mixed sighting of 25 sperm whales (including calves) logging on the surface near the Challenger Deep and bottlenose dolphins (Fulling et al. 2011). Sperm whales are the second deepest diving mammal at 2,250 m (7,382 ft), after Cuvier's beaked whale (Ponganis 2011). The current potential threats to this species are vessel strikes, entanglement in fishing gear, reduced prey due to overfishing, habitat degradation, disturbance from anthropogenic noise, and possible illegal whaling (NMFS 2010b).

3.3.4 Essential Fish Habitat

EFH AND HAPC DESIGNATIONS

Essential Fish Habitat (EFH) are those waters and substrates necessary for a fish species' full life cycle, including aquatic areas and their associated physical, chemical, and biological properties. On Guam, EFH is defined as the marine water column from the surface to the 1,000 m depth, from the shoreline to the outer boundary of the EEZ (310 km/200 nm/230 miles), and the seafloor from the shoreline out to a depth of 700 m around the island. This EFH designation includes the water column and seafloor where the cable project is proposed within the MTMNM, and its surrounding waters and submerged lands that support various life stages for the Management Unit Species (MUS) identified under the Western Pacific Regional Fishery Management Council's (WPRFMC) Pelagic and Mariana Archipelago Fishery Ecosystem Plans (FEP) (2009a, 2009b). In addition to EFH, the WPRFMC identified Habitat Areas of Particular Concern (HAPC) within EFH for all Fishery Management Plans (2009a, 2009b). HAPCs are specific areas within EFH that are essential to the life cycle of important coral reef species. A summary of EFH and HACP designations is presented in Appendix D.

Bottomfish MUS. The bottomfish fishery in Guam is distinguished by species and depth, and comprises a shallow-water fishery from 0-100 m, and a deep-water fishery from 100-400 m. The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 m is EFH for bottomfish eggs and larvae. EFH for adult and juvenile bottomfish is designated as the water column and all bottom habitat extending from the shoreline to a depth of 400 m, encompassing the steep drop-offs and high-relief habitats that are important for bottomfish. All escarpments/slopes between 40-280 m depths are designated as HAPC for adult bottomfish. These limits extend into the Trench NWR; however, they do not encompass any of the submerged lands within the vicinity of the Action Alternatives.

Crustacean MUS. Rather than use individual species and life stages, the WPRFMC designated EFH for crustacean species assemblages of spiny and slipper lobsters, and Kona crab. EFH is designated as the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m for eggs and larvae, and all of the bottom habitat from the shoreline to a depth of 100 m for juvenile/adult life stages. EFH for deepwater shrimp (*Heterocarpus* spp.) is the water column and associated outer reef slopes between 550-700 m for eggs and larvae, and the outer reef slopes at depth between 300-700 m for juvenile/adult life stages. HAPC for the spiny and slipper lobster complex is designated as all banks with summits less than or equal to 30 m (15 fathoms [fm]) from the surface. These limits extend into the Trench NWR, however, they do not encompass any of the submerged lands within the vicinity of the Action Alternatives. No HAPC is designated for deepwater shrimp.

Precious Coral MUS. Precious coral MUS may be divided into deep- and shallow-water species. Deep-water precious corals are generally found between 350 and 1,500 meters and include pink coral (*Corallium secundum*), gold coral (*Gerardia* sp. And *Parazoanthus* sp.), and bamboo coral (*Lepidistis olapa*) (WPRMFC 2009b). Shallow-water species occur between 30 and 100 meters and consist primarily of three species of black coral: *Antipathes dichotoma*, *Antipathes grandis*, and *Antipathes ulex* (WPRMFC 2009b). Until the *Okeanos Explorer* expedition in 2016, no precious coral beds had been identified in the Mariana Islands (Glickson et al. 2017). Previous surveys in the CNMI in the 1970s for pink and red corals (*Corallium* sp.) and black coral (*Antipathes* spp.) yielded very few results, and there have been no reports of precious coral harvests around Guam (WPFMC 2009b).

EFH for precious coral was based on assemblages to reduce the complexity and the number of EFH identifications required for individual species and life stages. The species complex designations are based on the ecological relationships among the individual species and their preferred habitat. The WPRFMC considered using the known depth range of individual precious coral MUS to designate EFH, but rejected this alternative because of the rarity of the occurrence of suitable habitat conditions. Instead, the WPRFMC designated the six known beds of precious corals as EFH, which are all found in the Hawaiian Islands. There are no EFH or HAPC designated for precious corals in the Mariana Archipelago.

Coral Reef Ecosystems MUS. The WPRFMC designated EFH Coral Reef Ecosystem MUS (CRE-MUS) by linking MUS to specific habitat "composites" (e.g., sand, live coral, seagrass beds, mangrove and open ocean) for each life history stage, consistent with the depth of the ecosystem to 50 fm (152 m) and to the limit of the EEZ. These limits extend into the Trench NWR, however, they do not encompass any of the submerged lands within the vicinity of the Action Alternatives. CRE-MUS HAPC are designated at five coastal locations for Guam: Cocos Lagoon, Orote Point Ecological Reserve Area, Haputo Point Ecological Reserve Area, Ritidian Point, and Jade Shoals. These HAPCs are all located outside the Trench NWR.

Pelagic MUS. Pelagic MUS (PMUS) include temperate and tropical species complexes, sharks and squids (Appendix D). The water column down to a depth of 1,000 m from the shoreline to the outer limit of the EEZ is EFH for juvenile and adult life stages of PMUS. The eggs and larvae of all teleost PMUS are pelagic. They are slightly buoyant when first spawned, are spread throughout the mixed layer and are subject to advection by the prevailing ocean currents. Because the eggs and larvae of the PMUS are found distributed throughout the tropical (and in summer, subtropical) epipelagic zone, EFH for these life stages has been designated as the epipelagic zone (0-200 m depth) from the shoreline to the outer limit of the EEZ. The water column down to 1,000 m that lie above all seamounts and banks within the EEZ shallower than 2,000 m (1,000 fm) is designated as HAPC for PMUS.

DESCRIPTION OF ESSENTIAL FISH HABITAT IN ACTION AREA

The following habitat is available in the project areas for the SEA-US and BIFROST cables and future cable projects within the Trench NWR to provide EFH for MUS in the Mariana Archipelago, as summarized in Appendix D. These project areas do not encompass any designated seafloor EFH for MUS, nor are they located within any designated HAPC for MUS.

Water Column: The water column includes EFH for bottomfish eggs and larvae; adult/juvenile bottomfish; spiny and slipper lobster complex and Kona crab complex eggs and larvae; CRE-MUS complexes; temperate and tropical species complex PMUS eggs and larvae and juveniles/adults; shark eggs and larvae and juveniles/adults; and squid eggs and larvae and juveniles/adults.

DEEP-SEA CORALS AND SPONGES

Precious corals are non–reef-building species that inhabit the dark depths below the euphotic zone (WPRFMC 2009b). Pink, bamboo, and gold corals all have planktonic larval stages and sessile adult stages; their larvae settle on solid substrate where they form colonial branching colonies. Little is known about the larval stage of black corals (Wagner et al. 2012). Precious corals are found in areas with moderate-to-strong (>25 cm/sec or 0.49 knots) bottom currents, which help prevent the accumulation of sediments that would smother young coral colonies and interfere with the settlement of new larvae (WPRFMC 2009b). Within the Trench NWR, the closest documented precious corals to the project areas were at 1605L3-20 (Subducting Guyot 2), with observations of bamboo corals (Keratoisidinae) at depths of up to 4,306 m (NOAA 2017). The existing SEA-US and proposed BIFROST cable routes are over 175 km (109 mi) from this dive location. The nearest ROV dives to the BIFROST and SEA-US cable routes in the Trench NWR are 1605L104 (Enigma Seamount) and 1605L3-21 (Hadal Wall). Only demosponges were found at Hadal Wall, while the Enigma Seamount dive yielded observations of glass sponges, carnivorous demosponges (Cladorhizidae), and gorgonian corals, including undescribed specimens in taxonomic groups that include precious corals.

FISH

Six EX1605L1 expedition ROV dives (Dives 1, 2, 12, 17, 18 and 19) focused on collecting data on deep-water bottom fishery habitats where species of deep-water snapper, grouper, roughy, tuna, pomfret, and jack were documented. The ROV observations revealed that while there was little overlap observed between bottomfish and precious coral habitats, there was overlap between bottomfish and non-precious coral habitat (Glickson et al. 2017). These dive locations are not within the Trench NWR (Appendices A and B, Figure 3a).

3.4 Cultural Resources

No known cultural resources have been documented within the Trench NWR along the proposed BIFROST cable route or existing SEA-US cable route. The 2020 Fugro bathymetric survey of the proposed BIFROST cable corridor did not indicate the presence of any potential cultural resources, such as shipwrecks.

3.5 Public Health and Safety

3.5.1 Hazardous Waste

The existing SEA-US cable and the routes of the BIFROST cable and future cables under both Action Alternatives are not located over any existing documented U.S. military formerly used defense (FUD) site (U.S. Army Corps of Engineers 2008).

3.5.2 Unexploded Ordnance

The existing SEA-US cable location and the routes of the BIFROST cable and future cables under both Action Alternatives do not contain any areas of known unexploded ordnance (UXO). The potential for encountering UXOs is considered low.

3.5.3 Military Training

The U.S. military has established a Mariana Islands Range Complex (MIRC) in the Mariana Archipelago that includes land training areas, ocean surface and subsurface areas, and special use airspace (Department of the Navy (DON) 2020). The MIRC encompasses the sea and undersea space from the ocean surface to the ocean floor, and includes designated sea and undersea space training areas, such as designated drop zones, underwater demolition, and floating mine exclusion zones. Portions of the MTMNM lie within the MIRC and under all MIRC warning areas; the prohibitions required by the Presidential Proclamation establishing the MTMNM do not apply to exercises and activities of the Armed Forces (DON 2020). Two warning areas, W-13A and W-13B, located south of the CNMI island of Guguan, overlay a portion of the BIFROST cable route (Appendix A, Figure 4). These two areas are part of W-13A/B/C, which encompasses approximately 18,000 square NM (DON 2020). The existing SEA-US cable lies northeast of warning area W-11A, which is part of the 10,500 square NM area encompassed by W-11A/B (Appendix B, Figure 4) (DON 2020). It is assumed that future cables could also be located in these warning areas. These warning areas are designated as special use airspace where the sea space underneath may be restricted from public access during hazardous training events. Scheduled training and testing activities are published in Notices to Mariners issued by the U.S. Coast Guard (DON 2020).

3.6 Land and Water Use

Vessels, such as fishing or commercial freight, navigating through the waters above the Trench NWR are the only regular human use in this area. Water depths along the existing SEA-US cable location and the routes of the BIFROST cable and future cables under both Action Alternatives range from 3,620 to 9,725 m within the Trench NWR, therefore, anchoring would not be feasible. The Mariana Trench is not considered a tourist attraction, but it continues to be an area of great scientific interest to international researchers. Exploration and research, such as the 2016 *Okeanos Explorer* expedition (Glickson et al. 2017), is conducted infrequently in the Trench NWR with the oversight and permits from the USFWS.

3.7 Noise

There are no permanent noise generators in the vicinity of the existing SEA-US cable location and the routes of the BIFROST cable and future cables under both Action Alternatives within the Trench NWR. Temporary sources of noise comprise mobile sources, such as fishing boats or commercial freight ships that may pass through the Trench NWR. The project areas, and future cable project areas within the Trench NWR, are within the range of sensitive noise receptors such as marine mammals.

3.8 Air Quality

The National Ambient Air Quality Standards (NAAQS) are pollutant concentration limits established by U.S. Environmental Protection Agency (USEPA) under the Clean Air Act (CAA) to protect human health and welfare, including sensitive populations, such as children and the elderly. The NAAQS encompass the following criteria air pollutants: carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), particulate matter less than 10 and 2.5 microns (PM10, PM2.5), lead (Pb) and ozone (O3). Since the proposed BIFROST cable and future cables would be laid in the open ocean and the existing SEA-US cable was laid on the seafloor in 2017, there are no permanent stationary emission sources of air pollutants in the project areas. Temporary emission sources of air pollutants comprise mobile sources, such as fishing boats or commercial freight ships that may pass through the Trench NWR. The cable ship laying the cable or repairing a fault also represents a temporary emission source.

3.9 Aesthetics

The benthic environment of the Trench NWR may be considered a scenic area by some people, although it is not easily accessible. The majority of the public experiences the Trench NWR benthic environment indirectly via images and videos captured by researchers.

3.10 Socioeconomic Characteristics

The Trench NWR comprises only the submerged lands extending from the northern limit of the EEZ of the United States in the CNMI to the southern limit of the EEZ in the U.S. territory of Guam (USFWS 2017). No households or permanent populations exist in the Trench NWR. Within the Trench NWR, the BIFROST cable route is approximately 268 km (167 mi) southeast of Agrihan and Pagan, while the existing SEA-US cable is approximately 93 km (57 mi) southeast of Guam; these islands are the nearest inhabited land masses to the cable routes. It is assumed that future cables would be similarly located.

3.11 Reasonably Foreseeable Environmental Trends and Planned Actions in the Affected Area

The crossing of future submarine fiber-optic cables through the Trench NWR would be a reasonably foreseeable planned action because of the need to provide reliable communication networks between Asia, Guam, the CNMI, and the U.S. The north-south extent of the Trench NWR effectively presents a challenge for cable systems that need to pass to the south or east of Guam. The reasonably foreseeable environmental trends from future cable-laying activities are temporary turbidity increases and direct cable impacts to slow-moving or sessile organisms on the seabed surface. Since burial of cables at the deep depths within the Trench NWR is unlikely, turbidity would dissipate with the currents in the water column. Intrusive disturbance of the seabed would be also avoided. Future cables would likely occupy similarly small footprints on the sea floor as the SEA-US and BIFROST cables and would also likely become buried in the sediments of the Trench NWR over time.

Other reasonably foreseeable planned actions in vicinity of the proposed action include further scientific expeditions and deep-sea mining exploration and operations. The serpentinite mud volcanoes of the Mariana forearc west of the trench have been the subject of focused scientific research, especially since these are the only known currently active sites of serpentinite mud eruptions (Fryer et al. 2020). Deep-sea corals and sponges were mapped in the Trench NWR during the *Okeanos Explorer* 2016 expedition as part of NOAA's Pacific Islands Deep-Sea Coral and Sponge Initiative (PICSI). Research is expected to continue in these and other fields of study. Innovative technologies, such as unmanned submersibles, would also encourage more exploration of the trench and its vicinity. Future deep-sea expeditions in the Trench NWR would be regulated through permits from the USFWS.

In the central and western Pacific, the Prime Fe-Mn Crust Zone (PCZ) extends from the border of the Mariana Trench in the MTMNM east to the Hawaiian Islands, and is the zone of greatest economic interest for deep-sea mining because of its potential to yield significant amounts of rare and critical metals compared to land-based reserves (Hein et al. 2013). The International Seabed Authority (ISA) is an organization comprising all Parties to the 1982 United Nations Convention on the Law of the Sea (UNCLOS) through which these Parties shall organize and control all mineral-related activities in the international seabed area (ISA 2022a). ISA has entered into 15-year contracts with 21 contractors for global exploration for polymetallic nodules, polymetallic sulfides, and cobalt-rich ferromanganese (Fe-Mn) crusts in the ISA's international seabed area, an area defined as "the seabed and ocean floor and the subsoil thereof, beyond the limits of national jurisdiction" (ISA 2022b). Contractors sponsored by the Peoples Republic of China, the Russian Federation, Republic of Korea and Japan have contracts with ISA for exploration of the western Pacific Ocean, including the PCZ (ISA 2022b). While the MTMNM and EEZ around Guam and the CNMI are excluded from the international seabed area, deep-sea mining of the PCZ by international groups are potential future planned actions in their vicinity.

The reasonably foreseeable environmental trends in the affected area from possible planned actions related to deep-sea mining would depend on the methods used during these activities. Deep-sea mining has the potential to directly affect benthic communities and water quality, and may have spillover effects into the affected area. These activities would occur outside the Trench NWR in the international seabed area and would not fall under the regulatory review of the USFWS. No mining operations will begin until the exploitation regulations have been adopted by the ISA Council and all members of ISA. These regulations for deep-sea mining will incorporate specific provisions to ensure the effective protection of the marine environment, and contractors will be required to conduct an environmental impact assessment in line with the rules, regulations and procedures set out by ISA before they can begin any exploitation activities (ISA 2022a).

4 ENVIRONMENTAL CONSEQUENCES

This section discusses the potential effects of Alternative A (No Action Alternative), Alternative B (Proposed Action Alternative) and Alternative C (BIFROST Cable Alternative Route) on environmental resources. A summary of the environmental effects of the No Action Alternative (Alternative A) and Action Alternatives (Alternatives B and C) is presented in Table 4-1. Impacts under Alternatives B and C would be similar for the proposed BIFROST and SEA-US cables and ROW authorizations for future cables considered using this programmatic EA.

Table 4-1. Summary of the Environmental Effects of the No Action and Proposed Action Alternatives

	Resource	Proposed Action Alternative (Alternative B)	BIFROST Cable Alternative Route (Alternative C)	No Action Alternative (Alternative A)
1	Hydrology	**No impact.** The cable size and footprint for the BIFROST, SEA-US cables and future cables is small and thus, will not have no impact on hydrology. Within the Trench NWR, the BIFROST cable would be a lightweight protected (LWP) type, and would be resistant to abrasion from strong currents. The BIFROST cable and future cables would be laid parallel to, not against, the currents to minimize the potential for a cable to shift its position.	Same as Proposed Action Alternative - **No impact.**	**No impact.**
2	Geology and Topography	**Negligible adverse impact (short term or long term).** The SEA-US cable was laid directly on the seabed and was not buried. The BIFROST cable and future cables will also be laid directly on the seabed. No cable burial is proposed for BIFROST or the future cables. No volcanoes or hydrothermal vents were discovered within the survey corridor centered on the BIFROST cable. The ROW permit will include conditions governing the ability to conduct research in proximity to the SEA-US and BIFROST cables. For future	Same as Proposed Action Alternative - **Negligible adverse impact.**	**No impact**

	Resource	Proposed Action Alternative (Alternative B)	BIFROST Cable Alternative Route (Alternative C)	No Action Alternative (Alternative A)
		cables these conditions would also be included in the ROW permit.		
3	Biological Resources	**Minor short-term adverse impact; negligible long-term adverse impact to deep-sea coral and sponge communities.** The BIFROST cable and future cables will be laid directly on the seabed and will have the potential to impact any sessile or slow-moving mobile organisms in the cable path. Deep-sea coral and sponge communities that have been mapped within the Trench NWR would be avoided by the BIFROST and future cables, and were avoided by the SEA-US cable. The BIFROST cable will be laid at depths of 3,660-7,230 m along its path in the Trench NWR. Future cables would be laid at similar depths. The SEA-US cable was laid at depths of 6,100-9,725 m within the Trench NWR. Very high-density, high-density, and moderate-density deep-sea coral and sponge communities are not anticipated to occur at the depth ranges of these cables, based on the absence of communities at these densities below the 3,000 m depth during the 2016 Mariana Islands expedition ROV dives. With the anticipated sparse coral and sponge resources and very small cable footprint along the cable route, effects from the cable-laying activity for the BIFROST and future cables are	Same as Proposed Action Alternative - **Minor short-term adverse impact; negligible long-term adverse impact.**	**No impact.**

	Resource	Proposed Action Alternative (Alternative B)	BIFROST Cable Alternative Route (Alternative C)	No Action Alternative (Alternative A)
		anticipated to be adverse, but minor.		
4	Threatened and Endangered Species	**Negligible adverse short-term impact; no adverse long-term impact.** No critical habitat has been designated or proposed within the Trench NWR. ESA-listed marine species (e.g., whales and sea turtles) have been documented within the Trench NWR. There is a potential for the BIFROST and future cable projects to encounter these species along the cable route during cable-laying activities. Cable ship movement is very slow (less than 6 knots), minimizing the likelihood of vessel strikes. HMB will comply with Pac-SLOPES conditions as part of USACE permit requirements, and the cable ship operator will be trained in protocols for avoidance of these species.	Same as Proposed Action Alternative - **Negligible adverse short-term impact; no adverse long-term impact.**	**No impact.**
5	Cultural Resources	**No impact.** No known cultural resources are within the vicinity of the cable routes.	Same as Proposed Action Alternative - **No impact.**	**No impact.**
6	Hazardous Materials	**No impact.** Telecommunication cables are benign and not a source of hazardous materials. The cable ship will be equipped with appropriate spill response kits to immediately address any releases of oil or fuel while the vessel is operating over the Trench NWR.	Same as Proposed Action Alternative - **No impact.**	**No impact.**

	Resource	Proposed Action Alternative (Alternative B)	BIFROST Cable Alternative Route (Alternative C)	No Action Alternative (Alternative A)
7	Unexploded Ordnance (UXO)	**No impact.** The cable ship would not involve the use of UXOs for BIFROST or future cables. The SEA-US cable was laid directly on the seafloor. The BIFROST cable and future cables would not be buried but laid directly on the seafloor, although UXOs are not known to exist in the project area.	Same as Proposed Action Alternative - **No impact.**	**No impact.**
8	Military Training	**No impact.** Advance notice would be issued prior to military training activities within the MIRC warning areas that are in proximity to the SEA-US, BIFROST cable and future cable routes.	Same as Proposed Action Alternative - **No impact.**	**No impact.**
9	Land Use	**No impact.** Existing regulated land uses in the Trench NWR continued after the laying of the SEA-US cable, and the land uses would continue following the laying of the BIFROST and future cables. The ROW permit will include conditions governing the ability to conduct research in proximity to the existing, new and future cables.	Same as Proposed Action Alternative - **No impact.**	**No impact.**
10	Noise	**Minor, localized short term impact; no long term impact.** The low speed of the cable ship during cable-installation would produce low noise levels in comparison to similar vessels, such as freight ships, that navigate over the Trench NWR. No noise is, or would be generated by the SEA-US, BIFROST or future cables during normal operation.	Same as Proposed Action Alternative - **Minor, localized short term impact; no long term impact.**	**No impact.**
11	Air Quality	**Minor, localized short term impact; no long term impact.** The cable ship would be an insignificant mobile source of emissions. No emissions are generated by the SEA-US cable,	Same as Proposed Action Alternative - **Minor, localized**	**No impact.**

Resource	Proposed Action Alternative (Alternative B)	BIFROST Cable Alternative Route (Alternative C)	No Action Alternative (Alternative A)
	and no emissions would be generated by the BIFROST or future cables after installation.	**short term impact; no long term impact.**	
12 Aesthetics	**Negligible short-term impact; no long-term impact.** The size and footprint of the SEA-US and BIFROST cables are small (1.7 to 2.25 cm diameter), and future cables would have similar dimensions. The existing and new cables are likely to be naturally buried in sediments over time; thus, they will not have any significant effect on aesthetics.	Same as Proposed Action Alternative - **Negligible short-term impact; no long-term impact.**	**No impact.**
13 Socioeconomic Characteristics	**Moderate beneficial impact (short term and long term).** As with the SEA-US cable, the BIFROST and future cables will increase internet bandwidth and connectivity for the region. This access to the Internet positively affects economies by facilitating faster and wider access to information, promoting competition in the markets, enhancing communication in terms of lower cost and higher speed, providing a more efficient health care system, and promoting democracy (Hadavand 2011).	Same as Action Alternative - **Moderate beneficial impact (short term and long term).**	**Moderate adverse impact (short term and long term).** The increased bandwidth and interconnectivity that the BIFROST cable and future cables would provide would not be realized. Negative economic impacts could arise as existing cables reach their end of life but are not replaced by new systems crossing the Trench NWR to Hawaii and U.S. mainland.

4.1 Hydrology

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, no effects on hydrology would occur.

ALTERNATIVE B AND ALTERNATIVE C

The BIFROST cable routes would use a lightweight protected (LWP) cable type with a 2.25 cm diameter, the SEA-US cable used a lightweight (LW) type with a 1.7 cm diameter within the Trench NWR. It is assumed that the future cables would be similar in diameter to the BIFROST cable. Given the small diameters of these cable types, the proposed BIFROST cable, the existing SEA-US cable, and future cables would not impede natural water movement or create obstructions, and would therefore have negligible effect on hydrology during installation.

The cable types used in the Trench NWR would be resistant to abrasion from strong currents. The proposed BIFROST and future cables would be laid perpendicular to bottom currents, as they generally flow along the trench axis from south to north (Kawabe, et al. 2003).

No significant post-construction impacts to marine waters are anticipated from the Proposed Action Alternative.

4.2 Geology and Topography

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect on geology, substrate and topography.

ALTERNATIVE B AND ALTERNATIVE C

The proposed BIFROST and future cables would be laid on the surface of the seabed. Minor disturbances to surface sediments would occur, temporarily increasing suspended particles and turbidity. These disturbances would settle shortly after the cable is laid or would be dispersed by natural water movement. Trenches are generally considered areas of high sedimentation (Beliaev 1989), therefore, in areas of softbottom substrate the SEA-US, BIFROST and future cables would likely become buried over time. No volcanoes or hydrothermal vents were discovered within the bathymetric survey corridor centered on the BIFROST cable and there would be no impact to those resources.

The SEA-US cable was laid along the northeastern flank of an unnamed seamount; however, given the small cable diameter (1.7 cm) and footprint, the cable is not expected to affect the topography of this area.

4.3 Biological Resources

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect on biological resources.

4.3.1 Invertebrate Macrofauna

ALTERNATIVE B

Potential adverse impacts to biological resources during the BIFROST cable-laying and future cable-laying activities would be limited to contaminants from the ship (e.g., oil or fuel spills) and vessel strikes. The cable ship will be equipped with appropriate spill response kits to immediately address any releases of oil or fuel while the vessel is operating over the Trench NWR. In order to avoid introducing any invasive or non-native marine species into Guam's waters, the cable ship will be required to fully comply with 33 CFR 151, Subpart D – Ballast Water Management for Control of Nonindigenous Species in Waters of the United States. The cable ship will not uptake or discharge any ballast water within the 12 nautical mile limit of U.S. territorial waters or within the Trench NWR.

Hydrothermal vent communities are known to have low biodiversity but an extremely high biomass relative to the surrounding deep sea (Ramirez-Llodra 2015), while seamounts can be biodiversity hotspots (Clark 2010). These vent and seamount features were not mapped during the geophysical surveys for the BIFROST cable route and will be avoided by the cable-laying activity since they pose risks to the security of the cable; this avoidance would reduce the possibility of directly impacting the organisms found in these habitats. The SEA-US cable was laid along a portion of an unnamed seamount within the Trench NWR; however, the potential for impacting deep-sea corals and sponges was low based on the very deep depths at this location (over 6,000 m) and small cable size (1.7 cm diameter) along the route.

Very high-density, high-density, and moderate-density deep-sea coral and sponge communities are not anticipated to occur at these depth ranges, based on their absence below the 3,000 m depth during the 2016 *Okeanos* Expedition 1605 ROV dives (Kelley at al. 2019). Only low-density or very sparse communities have been mapped in the vicinity of the proposed and alternate BIFROST cable routes within the Trench NWR. The closest known community is Hadal Wall (1605L3-21), a very sparse site located 33 km (20 miles) from the Proposed Route (Appendix A, Figure 7).

The closest deep-sea coral and sponge community to the SEA-US cable is Enigma Seamount (1605L1-4), a low-density community located over 185 km (115 mi) to the southwest (Appendix B, Figure 7).

Deep-sea coral and sponge communities are known to occur on ridge and seamount features (Kelley at al. 2019). The SEA-US cable was laid along the northeastern flank of an unnamed seamount at depths over 6,000 m. The bathymetry of the BIFROST and SEA-US route corridors indicates there are areas of higher slope and terrain roughness, and an inferred higher probability for the presence of deep-sea corals and sponges (Appendices A and B, Figure 3a). While deep-sea corals and sponges may exist at these locations and may be affected, these are expected to be sparse because the depth ranges for the existing and proposed cables are not considered optimal for the presence of high-density or even moderate-density communities. Using the depth and cnidarian and poriferan abundance data from the 2016 *Okeanos* surveys, both general linear models and general additive models were applied to derive a predictive model of abundance in response to depth for these invertebrate groups (Appendix F). Based on this model and the depth ranges for each cable route, the BIFROST cable proposed route would have 5.09 to 33.30 poriferan interactions per km, and 2.37 to 10.67 cnidarian interactions per km. The proposed BIFROST route would have an estimated 228 cnidarian and 2,097 poriferan interactions over a distance of 159.18 km in the Trench NWR, or a total of 2,325 interactions.

The SEA-US cable route was estimated to have 619 poriferan interactions over a distance of 112.77 km in the Trench NWR; however, because of the very deep depths (over 6,000 m) traversed by this cable, no cnidarian interactions were predicted.

For both the BIFROST and SEA-US cables, the predicted interactions per km combined for Cnidaria and Porifera are far less than the <1,000 interactions per km that define low-density coral and sponge communities (Kelley et al. 2019).

While these predictions were based on the abundances at their corresponding depths, substrate type is also a consideration. Substrate consolidation, rather than bedrock type, appears to be an important factor in predicting deep-sea corals and sponges, with about 90% of Cnidaria and 94% of Porifera recorded during the 2016 Mariana ROV dives attached to bedrock substrate, whether limestone or basalt (Kelley at al. 2019). The seabed geology for the BIFROST cable route is mostly rock outcrop in the western sector, and coarse sediment (sand and gravel) in the eastern sector (Appendix A, Figure 5b). Therefore, fewer cnidarian and poriferan interactions would be expected for the proposed and alternate routes along this eastern sector of the cable route within the Trench NWR.

Given this relationship of substrate to coral and sponge presence, combined with the less than low-density of predicted interactions along the cable route, and the extremely small footprints of the cables, the proposed activity is anticipated to result in only minimal impacts to deep-sea coral and sponge resources.

Potential impacts from the cable-laying process include laying the cable directly on, damaging, or abrading sessile or slow-moving organisms, although given the small diameters of the cable, the likelihood of direct adverse impacts is low. Organisms, including deep-sea coral and sponge communities in the vicinity of the cable route could also be adversely affected by the temporary disturbance of surface sediments and the associated increase in turbidity. Increases in turbidity and suspended sediments would be temporary and would eventually be dispersed by the benthic currents, Therefore, the impact, while adverse, would be minor, localized and temporary.

ALTERNATIVE C

The closest known community is Hadal Wall (1605L3-21), a very sparse site located 21 km (13 mi) from Alternative C, the BIFROST Cable Alternative Route (Appendix A, Figure 7).

Alternative C would have 2.37 to 11.76 cnidarian interactions per km, and 4.44 to 33.97 poriferan interactions per km. This alternative route would have an estimated 378 cnidarian and 1,948 poriferan interactions over a distance of 153.23 km in the Trench NWR, or a total of 2,326 interactions. Based on the model and depth ranges for the existing cable, the SEA-US cable route was predicted to have 1.02 to 9.52 poriferan interactions per km and zero cnidarian interactions.

Because Alternative C would be laid similarly to Alternative B, and would use the same cable type, and because the number of cnidarian and poriferan interactions would be similar, potential impacts from the cable-laying process for Alternative C would be similar to those described under Alternative B.

4.3.2 Fish

ALTERNATIVE B AND ALTERNATIVE C

The earth produces a static magnetic field of approximately 250 to 650 milligauss (Finlay, 2010). The effects of the magnetic fields from the existing SEA-US, proposed BIFROST, and future submarine fiber-optic cables are expected to be minimal since a cable produces a low-level magnetic field of 5 milligauss at 1 m (3.3 ft.) to 0.5 milligauss at 10 m (33 ft.), significantly lower than the earth's natural magnetic field. Therefore, no impacts to marine organisms, including deep-sea fish occurring in hadal and abyssal zones, would be expected as a result of cable operations.

4.3.3 Birds

ALTERNATIVE B AND ALTERNATIVE C

Pelagic seabirds, some of which are attracted to bioluminescent prey or which use stars for orientation, and migratory birds transiting between breeding and wintering habitats may be vulnerable to artificial lighting on the open ocean (Montevecchi 2006). At sea, the major sources of artificial light include vessels, light-induced fisheries, and oil and gas platforms; however, the more recent changes associated with marine gas and oil platforms, and light-induced fisheries (such a squid fisheries) are likely having the most significant influences on marine birds when compared to vessels (Montevecchi 2006). Cable-laying operations have the potential to result in the taking or harming of pelagic seabirds and migratory birds with artificial lighting as the primary human stressor. Birds at sea have the potential to be attracted to or confused by lights on the cable-laying vessel. Potential impacts include birds colliding with the light source or causing birds to circle over the light source until they are exhausted (Montevecchi 2006). Therefore, preserving darkness is an important mitigation measure to minimize impacts to pelagic and migratory seabirds when the cable ship is operating in the Trench NWR.

In order to preserve darkness, the cable ship shall use the minimum amount of light necessary for legal and safe transit when underway at night. Through coordination with the USFWS, the cable ship operators will be briefed on the potential for bird encounters and will follow these protocols:

A. After putting on gloves, the operators will pick up any downed birds and place them in a clean box to prevent soiling of their feathers .
B. The birds will be kept in a cool, safe place until daylight.
C. The birds will then be placed in an open area near the stern of the cable ship where they can take off when ready.
D. Photographs of any downed birds will be taken to document distribution of species at sea and the USFWS will be notified and provided with these photographs.

4.3.4 Reptiles and Mammals

ALTERNATIVE B AND ALTERNATIVE C

The five listed whale species that may occur within the Trench NWR are not likely to be present within the abyssal and hadal zones of the BIFROST and future cable routes; however, these species may occupy the shallower epipelagic to bathypelagic zones.

Studies show that the probability of a lethal injury (mortality or severely injured) to whales increases with vessel speed, while there is a substantial decrease in lethality as vessel speed falls below 15 knots (Vanderlaan and Taggart 2007). The cable installation activities take place at such a slow rate that the probability of impact to any marine mammal is extremely remote. During the cable landing, the cable ship will travel at speeds ranging from 1 to 6 knots (1.2 to 7 mph), which greatly reduces the likelihood of the vessel striking marine mammals or sea turtles. During other operational tasks not including cable laying, the vessel would reduce speed to 10 knots (11.5 mph) or less when in the proximity of marine mammals, and 5 knots (5.7 mph) when in areas of known or suspected turtle activity. The cable ship would alter course to remain at least 100 yds (300 ft or 274 m) away from any observed whales, and 50 yds (150 ft or 45 m) away from other marine mammals and sea turtles.

No biological monitors or "whale watchers" are proposed to be onboard the BIFROST cable ship since it would not make port weekly. Once the cable ship starts to lay the cable, it usually will not stop until it reaches the next shore landing site (i.e., California). The cable ship operators would be briefed on the potential presence of marine mammals and sea turtles by qualified biologists either in port on Guam, or by video communication if the cable ship does not come into port on Guam. The awareness training would include descriptions of any marine mammal or sea turtle species that have the potential to occur in areas where the cable ship will be operating, and suggested procedures if they are observed within the vicinity of the vessel.

4.4 Threatened and Endangered Species

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect on any threatened or endangered species listed by the federal government.

ALTERNATIVE B AND ALTERNATIVE C

This alternative would have no effect on critical habitat, since no such habitat has been designated or proposed within the vicinity of the Proposed Action Alternative. There are no proposed, candidate, or threatened or endangered species known to visit or occupy the depth ranges of the benthic abyssal and hadal environment within the Trench NWR. Therefore, the past and proposed cable-laying activities would not affect any listed species on the seafloor of the Trench NWR.

Eleven of the ESA-listed species in the Mariana Islands (see Table 3-3) are not likely to be present within the abyssal and hadal zones of the Trench NWR but they may occupy the shallower epipelagic to bathypelagic zones overlying the seafloor of the Trench NWR. These include three threatened fish (scalloped hammerhead shark, giant manta ray, and oceanic whitetip shark); three threatened turtles (green sea turtle, hawksbill sea turtle, and leatherback sea turtle); and five whales (blue whale, fin whale, sei whale, humpback whale, and sperm whale). The blue whale and fin whale are rare in the Mariana Islands and are considered the least likely of the five whale species to occur within the vicinity of the cable route, while the sperm whale and humpback whale are considered the most likely to occur. Sperm whales are the most frequently sighted among these species in the Mariana Islands (Fulling et al. 2011), and the Mariana Islands have been confirmed as a seasonal breeding ground for a small population of humpbacks (Hill et al. 2020). There is a potential for these species to be encountered during proposed and future cable-laying activities if they transit within the path of the cable ship. The cable-laying ship would be moving at a very slow rate (less than 6 knots) in order to carefully place the cable in its assigned corridor. Hence, any ESA-listed species traversing the shallower depths of the corridor would be able to anticipate and avoid interactions with the ship, minimizing the likelihood of vessel strikes.

While USFWS is the lead agency for activities in the Trench NWR, the USACE has issued a Department of the Army Permit for the other legs of the cable-laying activity within 3 NM of Guam. HMB would implement BMPs and comply with Pac-SLOPES conditions as part of Department of the Army permit requirements. In addition, the cable ship operator would be trained in protocols for avoidance of these species. These include altering course to remain at least 100 yards from whales, and at least 50 yards from other marine mammals and sea turtles, and reducing vessel speed to 10 knots or less when piloting vessels in the proximity of marine mammals, and to 5 knots or less when piloting vessels in areas of known or suspected turtle activity.

Since the cable ship would be traveling very slowly and the BIFROST and other cables would be laid atop the sea floor, the noise levels generated would be low compared with similar vessels (such as freighters) navigating over the Trench NWR. These low noise levels are not anticipated to have an adverse effect on ESA-listed species.

Three ESA-listed pelagic seabirds have the potential to forage or travel within the Trench NWR during cable-laying operations (Table 3-3). The cable ship would minimize illumination during night-time activities to avoid attracting seabirds. Protocols for handling seabirds would be implemented by the vessel crew if seabirds are encountered.

As with any motorized vessel at sea, there is a potential for accidental oil or fuel releases to occur during operations, which could introduce pollutants into marine waters that may affect ESA-listed species. The cable ship will be equipped with appropriate spill response kits to immediately address any releases of oil or fuel while the vessel is operating over the Trench NWR.

Once it is laid on the seabed, normal operation of the cable is considered benign, and would not produce any noise or emissions that would affect ESA-listed species.

Given the measures that would be implemented to safeguard ESA-listed species, the potential for vessel strikes, collisions from artificial lighting, noise effects and pollutants would be low. Therefore, the Proposed Action Alternative may affect, but would not adversely affect any threatened or endangered species listed by the federal government.

4.5 Cultural Resources

No known cultural or historic resources have been documented along the SEA-US cable route or the proposed BIFROST cable routes. No such resources were detected by the 2021 Fugro bathymetric survey of the BIFROST cable corridor. Therefore, no impacts to cultural or historic resources are anticipated from the No Action Alternative, Proposed Action Alternative, or BIFROST Cable Alternative Route.

4.6 Public Health and Safety

4.6.1 Hazardous Materials

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect to hazardous materials.

ALTERNATIVE B AND ALTERNATIVE C

The only source of hazardous materials would be petroleum-based fuel and oil used in the operation of the cable ship during cable-laying activities. The cable ship will be equipped with appropriate spill response kits to immediately address any releases of oil or fuel while the vessel is operating over the Trench NWR. While working in the Trench NWR, discharge of gray water (drainage from dishwasher, shower, washbasin, and laundry) and cooling water shall be kept to a minimum; black water discharge or biodegradable solid waste (ground or ungrounded) shall only be discharged as permitted by MARPOL (International Convention for the Prevention of Pollution from Ships) and U.S. Coast Guard regulations. Chemicals (oil, detergent, etc.) from deck wash or those related to normal vessel operations shall be prevented from entering the marine environment to the greatest extent practicable.

To minimize the risk of introducing contaminants into the marine environment, all instruments and equipment (including small boats) would be checked prior to deployment to ensure that there are no contaminant leaks (oil, fuel, hydraulic fluid, etc.) which could affect marine resources in the project area. If any instruments or equipment is found to not be in good working order, it would be removed from service until all necessary repairs have been made which would prevent a release of contaminants. Also, the crew of the vessel used to lay the cable would try to minimize the amount of detergents and other noxious substances that might be washed overboard as part of an effort to clean instruments or equipment used during the cruise or in day-to-day operation of the vessel. To prevent the spread of disease or invasive species, all equipment used in the cable laying operation would be rinsed with fresh water when practical.

Because spill response kits would be utilized in the event of a fuel or oil spill, and ship operations such as routine cleaning, repairs, and discharges would be limited in time and by permit, any hazardous materials impacts would be temporary and low.

Unexploded Ordnance

There are no documented or known UXOs within the vicinity of the proposed project. There would be no impact from the No Action Alternative, Proposed Action Alternative, or BIFROST Cable Alternative Route.

4.6.2 Military Training

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect to military training areas.

ALTERNATIVE B AND ALTERNATIVE C

Under either Alternatives B and C, the BIFROST cable route within the Trench NWR would pass through Warning Areas W-13B (Appendix A, Figure 4), while the SEA-US cable exists northeast of Warning Area 11A (Appendix B, Figure 4). These warning areas are designated as special use airspace where the sea space underneath may be restricted from public access during hazardous training events. Notices to Mariners are issued by the U.S. Coast Guard prior to any scheduled training and testing activities in these warning areas (DON 2020). Cable ships and any repair ships would avoid these areas during any scheduled military activities resulting in no impacts to military training exercises in the MIRC.

4.7 Land and Water Use

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, this alternative would have no effect on land or water use.

ALTERNATIVE B AND ALTERNATIVE C

The BIFROST cable route would pass approximately 57 miles (92 km) to the east of the nearest seamount in the Mariana Arc of Fire NWR, and about 218 miles (351 km) to the southeast of the Islands Unit of the MTMNM. The SEA-US cable route in the southern sector of the Trench NWR passes well to the north of the Sirena Deep with a separation distance of approximately 90 miles (144 km), which would allow for unimpeded access to and scientific exploration of this important bottom feature. Future cables would also avoid these units of the MTMNM. Any ROW permit would include conditions governing the ability for researchers and ROV operators and managers to conduct research and dives in proximity to the respective cables.

The existing regulated uses within the Trench NWR have continued following the SEA-US cable installation and would continue after the laying of the BIFROST cable and future cables. Those include research and exploration of the Mariana Trench with the proper federal permits, and commercial fishing in compliance with federal regulations. No impact to land use or scientific research would occur under the action alternatives. The ROW permittee would notify USFWS in advance of cable-laying operations or emergency repair within the Refuge and Monument. The permittee would coordinate with NSCPO to avoid impacts to U.S. Navy cable installations.

4.8 Noise

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable. Therefore, there would be no change in ambient noise levels under this alternative.

ALTERNATIVE B AND ALTERNATIVE C

The cable ship and on-board machinery and equipment are the only noise sources associated with Alternatives B and C. Noise levels originating from the cable ship are similar to other vessels, such as commercial fishing boats or freight ships that could navigate these waters. The cable ship, while actively laying cable, will proceed at speeds of less than 6 knots (6.9 mph). Due to the low speed of travel, the cable ship's engines would not operate at maximum power. Noise generated would be relatively low when compared to other commercial vessels of similar size, representing a temporary, negligible increase in ambient noise during cable installation.

4.9 Air Quality

ALTERNATIVE A

The No Action Alternative would have no effect on ambient air quality.

ALTERNATIVE B AND ALTERNATIVE C

Alternatives B and C would have no effect on ambient air quality on the submerged lands of the Trench NWR. The cable-laying ship would be a mobile source of emissions; however, since the ship would transit the Trench NWR within a few days, these emissions would represent a temporary, minor impact to air quality.

4.10 Aesthetics

ALTERNATIVE A

The No Action Alternative would have no effect on aesthetics.

ALTERNATIVE B AND ALTERNATIVE C

As with the existing SEA-US cable, any new cables would be laid directly on the seabed in submerged lands, and would not be visually detectable from the water surface above the Trench NWR but may be detected by scientific research ROVs in the immediate aftermath of installation. In soft-bottom benthic areas, each cable would likely become naturally buried as a result of water and sediment movement. There would be a temporary, minor change in aesthetics at the sea floor after initial installation, with no long-term change to aesthetics once the cable is buried by sediment.

4.11 Socioeconomic Characteristics

ALTERNATIVE A

Under the No Action alternative USFWS would not issue HMB a ROW permit for installation of the BIFROST communication cable or for operation and emergency access for the SEA-US cable.

The increased bandwidth and interconnectivity that the BIFROST cable would provide would not be realized. Guam is becoming an increasingly integral part of the Western Pacific's internet infrastructure needs as it provides a hub for Asia and South Pacific cable systems, and the ability to connect these systems to the Hawaii and the mainland U.S. The Mariana Islands' Internet and data capacity demands will continue to expand as the population grows and U.S. military presence increases in this region. If future cables are not permitted to cross the Trench NWR as existing cable systems become obsolete or reach their end of life, the eventual reduction in connectivity between Guam and Hawaii and the mainland U.S. could negatively impact the economy of the Mariana Islands. Reliable communication infrastructure is critical to the functioning of the military; the reduction in connectivity with the mainland U.S. and Hawaii could negatively affect military operations and the ability to defend U.S. assets.

ALTERNATIVE B AND ALTERNATIVE C

Installation of the BIFROST cable system and future cables would further enhance and contribute to the much-needed expansion of communications networks from Asia and the United States, thereby improving network redundancy, ensuring highly reliable communications, and expanding onward connectivity options in Guam. Access to the Internet positively affects economies by facilitating faster and wider access to information, promoting competition in the markets, enhancing communication in terms of lower cost and higher speed, providing a more efficient health care system, and promoting democracy (Hadavand 2011).

4.12 Relationship Between Short-Term Use of the Environment and Maintenance and Enhancement of Long-Term Productivity

The proposed BIFROST cable and future cables would individually occupy a small footprint on the seafloor, similar to the existing small footprint currently occupied by the SEA-US cable. The action alternatives would enhance long-term productivity through the efficient transmission of telecommunication information over the approximately 25-year expected life spans of existing, proposed and future cable systems.

4.13 Irretrievable and Irreversible Commitments of Resources

Labor and energy resources would be consumed during the laying of the BIFROST cable and any future cables. This would be an irretrievable commitment of resources. However, once installed, the anticipated maintenance requirement is low over the life span of the cable systems; therefore, further commitment of labor and energy resources would be minimal. Although communications cables can be salvaged (removed from the seafloor) and repurposed at the end of their life spans, leaving cables in place once they have reached the end of their lifespan results in fewer impacts to the environment than pulling cables that have become buried in sediment from the seafloor. Therefore, we would require cables to be left in place as a condition of granting the ROW Permit, and the laying of individual cables would constitute an irreversible commitment of resources.

5 ENVIRONMENTAL CONSULTATION, REVIEW, AND PERMIT REQUIREMENTS

This section describes the compliance of the Proposed Action with the following Presidential Executive Orders, federal acts and regulations. The Proposed Action Alternative is entirely within the submerged lands of the Trench NWR.

5.1 National Environmental Policy Act (NEPA) of 1969

This document was prepared in accordance with NEPA (42 United States Code §4231, et seq.), as implemented by the Council on Environmental Quality regulations (40 CFR 1500-1508), and as required by Secretarial Order 3355 and the August 18, 2018 Memorandum.

5.1.1 *Presidential Proclamation 8335*

According to the 2009 Presidential Proclamation establishing the MTMNM, the Secretaries of the Interior and Commerce shall not allow or permit any appropriation, injury, destruction, or removal of any feature of this monument except as provided for by this proclamation or as otherwise provided for by law. The USFWS was delegated to manage the Trench NWR as part of the National Wildlife Refuge System, through the DOI Secretary's Order No. 3284. The proposed action would be implemented under individual Right-of-Way Permits to allow for the laying of the SEA-US and BIFROST cables within the Trench NWR and would comply with the conditions of these respective permits.

5.1.2 *Military Coordination*

HMB has coordinated with Catherine Creese, Assistant Director, U.S. Naval Seafloor Cable Protection Office (NSCPO), in Washington, D.C. for the Proposed Action Alternative to lay the BIFROST cable. NSCPO was also informed prior to the installation of the SEA-US cable. NSCPO is the official point of contact for all Navy cables, with a mission to protect all Department of Defense interests with respect to seafloor cables by providing internal coordination and external representation of those interests to the U.S. government and the industry. Aside from protecting the Navy's existing systems, NSCPO works with the cable industry to ensure the protection of existing commercial cables in the event that the Navy builds a new cable or range.

5.1.3 *Magnuson-Stevens Fisheries Conservation & Management Act*

The 1996 Sustainable Fisheries Act (P.L. 104-267) amendments to the Magnuson-Stevens Fishery Management and Conservation Act is the primary law governing marine fisheries management in U.S. federal waters and promotes long-term biological and economic sustainability within waters of the U.S. out to 200 NM (230.2 miles) from shore. Key objectives of this act are: prevent overfishing, rebuild overfished stocks, increase long-term economic and social benefits, use reliable data and sound science, conserve essential fish habitat (EFH), and ensure a safe and sustainable supply of seafood. EFH for the proposed action was defined in Section 3.3.4.1. and Appendix D.

The Mariana Islands EFH extents relative to the Proposed Action Alternative are shallow for both the seafloor (from the shoreline to 700 m depth) and water column (surface to 1,000 m water depth); therefore, they do not encompass the abyssal (3,000-6,000 m) and hadal zones (6,000-11,000 m) of the Trench NWR. There is no precious coral fishery for Guam; however, precious corals (gold, bamboo and black corals) were found during the 2016 *Okeanos Explorer* expedition (Glickson et al. 2017). The nearest known precious corals within the MTMNM are bamboo corals (Keratoisidinae) located on Dive 20 (Subducting Guyot 2) over 175 km (109 mi) from the BIFROST and SEA-US cable routes at depths between 4,123-4,306 m (Appendices A and B, Figure 7) (NOAA 2017).

Since the action of laying the BIFROST and future cables would be performed by a slow-moving cable ship and no burial is proposed, this activity would generate only minor turbidity as the cable settles on the seafloor, and it would not create significant turbidity in the water column within the EFH depths. Therefore, the proposed action may affect, but would not adversely affect EFH for these MUS in the water column above the submerged lands of the Trench NWR.

5.1.4 *Marine Mammal Protection Act*

The U.S. Marine Mammal Protection Act of 1972 provides protection for all marine mammals, including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals and sea lions), sirenians (manatees and dugongs), sea otters and polar bears within the waters of the U.S. Under the Act, it is illegal to take (harass, hunt, capture, collect, or kill) any marine mammal or part of a marine mammal without a permit from the NMFS or USFWS, who are responsible for management of these species.

The Proposed Action Alternative would implement BMPs and follow the Standard Local Operating Procedures for Endangered Species in the central and western Pacific region (Pac-SLOPES), which would be conditions of the BIFROST Cable Department of the Army Permit. Additionally, the cable ship operators will undergo awareness training that would include descriptions of any marine mammal or sea turtle species that have the potential to occur in areas where the cable ship will be operating, and suggested procedures if they are observed within the vicinity of the vessel. These measures would collectively serve to minimize the likelihood of any take of marine mammals during the cable-laying activities. Future cable-laying activities would also implement these measures. Upon completion of the cable installation, the risk of the cable to marine mammals is remote. Previous entanglements with cetaceans, mainly sperm whales, occurred at shallow depths down to approximately 620 fm (3,720 ft or 1,133 m) between the 1850s-1950s, primarily because of excessive cable slack (Heezen 1957); however, with advances in cable design, laying and maintenance techniques, no further entanglements have been reported (Carter et al. 2009).

5.1.5 *National Historic Preservation Act (NHPA)*

Section 106 of the NHPA requires federal agencies to take into account the effects of their proposed actions on historic properties, and to preference those that avoid or mitigate those effects. No known historic resources have been documented within the vicinity of the Proposed Action

Alternative, and no potential cultural resources (e.g., shipwrecks) were detected during the 2021 Fugro survey of the BIFROST cable corridor.

5.1.6 *Clean Air Act (CAA), 42 U.S.C. 7401 et seq.*

The Clean Air Act (CAA) includes provisions that ensure Federal Actions do not obstruct local efforts to control air pollution. Section 176I of the CAA prohibits Federal agencies, departments or instrumentalities from engaging in, supporting, licensing, of approving any action that does not conform to an approved state or Federal implementation plan. Conformity to an implementation plan is defined as:

Conformity to an implementation plan's purpose of eliminating or reducing the severity and number of violations of the national ambient air quality standards and achieving expeditious attainment of such standards; and that such activities will not

- cause or contribute to any new violation of any standard in any area;
- increase the frequency or severity of any existing violation of any standard in any area; or
- delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

The proposed action would be in conformity with the CAA since there would be no significant emission sources from the cable-laying activity or following the laying of the cable.

5.1.7 *Endangered Species Act of 1973 (ESA), 16 U.S.C 1531 et seq.*

Under the ESA, Federal agencies are required to conduct their actions so as to not jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of critical habitat. Federal agencies are required to consult with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service for actions that would adversely affect listed species or habitat.

Once the BIFROST cable is laid along the proposed route, it will have a maximum depth of 7,230 m (23,720 ft) and a minimum depth of 3,660 m (12,008 ft) within the Trench NWR. The SEA-US cable was laid at depths of 6,100-9,725 m. Future cables would be laid at similar abyssal and hadal zone depths. These depths are deeper than the 0-40 m depths of proposed critical habitat for threatened corals in the Mariana Islands (85 FR 76262). There are no proposed, candidate, or threatened or endangered species known to occupy the depth ranges of the benthic abyssal and hadal environment within the Trench NWR (see Section 3.3.3). Listed turtles, fish and mammals may occupy the shallower epipelagic to bathypelagic zones. There is a potential for these species to be encountered during the cable-laying operation. During these activities, the cable-laying ship would be moving at a slow rate in order to carefully place the cable in its assigned corridor. Therefore, any ESA-listed species traversing the shallower depths of the corridor would be able to anticipate and avoid interactions with the ship. While no biological monitors or "whale watchers" are proposed to be onboard the cable ship, since it will not make port weekly, the cable ship operators will be briefed on the potential presence of marine mammals and sea turtles by qualified biologists. The training will occur either in port on Guam, or by video communication if the cable ship will not come into port on Guam. The awareness training would include descriptions of any marine mammal or sea turtle species that have the potential to occur in areas where the cable ship will be operating, and suggested procedures if they are observed within the vicinity of the vessel.

The Proposed Action Alternative would implement BMPs and follow the Standard Local Operating Procedures for Endangered Species in the central and western Pacific region (Pac-SLOPES), which would be conditions of the BIFROST Cable Department of the Army Permit.

5.1.8 *Migratory Bird Treaty Act, 16 U.S.C. 703 and Executive Order 13186, Responsibilities of Federal Agencies to Migratory Bird Treaty Act*

The Migratory Bird Treaty Act prohibits the taking or harming of migratory birds. Under the executive order a Federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations is directed to develop and implement, within two years, a Memorandum of Understanding (MOU) with the Fish and Wildlife Service (Service) that shall promote the conservation of migratory bird populations.

Cable-laying operations have the potential to result in the taking or harming of migratory birds. Birds at sea have the potential to be attracted to or confused by lights on the cable-laying vessel. Stipulations in the Compatibility Determination (Appendix B) and special conditions of the ROW Permit therefore include measures to minimize impacts to migratory birds. At night the ship shall use the minimum amount of light necessary for legal and safe transit when underway. Through coordination with the USFWS, the cable ship operators will be briefed on the potential for bird encounters and protocols that must be followed in the event of bird encounters.

5.1.9 *Fish and Wildlife Coordination Act of 1934*

The Fish and Wildlife Coordination Act of 1934 [16 U.S.c. 661 et seq.; 48 Stat. 401], as amended (FWCA) was established to provide a basic procedural framework for the orderly consideration of fish and wildlife conservation measures to be incorporated into Federal projects that may modify any body of water for any purpose. Federal agencies are required to coordinate with the USFWS when proposing activities that may result in such modifications.

Since the SEA-US cable was laid at depths between 6,100-9,725 m, and the BIFROST cable will be laid at depths between 3,660-7,230 m along its path in the Trench NWR, they avoided or are anticipated to avoid very high-density, high-density, and moderate-density deep-sea coral and sponge communities, based on the absence of these communities below the 3,000 m depth during the 2016 Mariana Islands expedition ROV dives. Only low-density or very sparse communities were mapped in the vicinity of the BIFROST and SEA-US cable routes within the Trench NWR, and all known communities would be avoided, with the closest known communities located 21 km (13 mi) from the BIFROST cable route (Appendix A, Figure 7), and 185 km (115 mi) from the SEA-US cable route (Appendix B, Figure 7). Deep-sea coral and sponge communities are known to occur on ridge and seamount features. The SEA-US cable was laid along the northeastern flank of an unnamed seamount at depths over 6,000 m. The BIFROST cable and SEA-US cable routes contain areas of higher slope and rugosity within the Trench NWR. While deep-sea corals and sponges may exist at these locations and may be affected, these are expected to be sparse because the depth ranges for the cable are not considered optimal for the presence of high-density or even moderate-density communities. Using the depth and cnidarian and poriferan abundance data from the 2016 *Okeanos* surveys, both general linear models and general additive models were applied to derive a predictive model of abundance in response to depth for these invertebrate groups (Appendix F). Based on this model and the depth ranges for each cable route, the predicted interactions per km combined for Cnidaria and Porifera are far less than the <1,000 interactions per km that define low-density coral and sponge communities (Kelley et al. 2019). While these predictions were based on the abundances at their corresponding depths, substrate consolidation, rather than bedrock type, also appears to be an important factor in predicting deep-sea corals and sponges. The seabed geology for the BIFROST cable route is mostly rock outcrop in the western sector, and coarse sediment (sand and gravel) in the eastern sector (Appendix A, Figure 5b). Therefore, fewer cnidarian and poriferan interactions would be expected for the proposed and alternate routes along this eastern sector of the cable route within the Trench NWR. Given this relationship of substrate to coral and sponge presence, combined with the less than low-density of predicted interactions along the cable route, and the extremely small footprints of the cables, the proposed activity is anticipated to result in only minor short-term adverse and negligible long-term impacts to deep-sea coral and sponge resources.

5.1.10 *Executive Order 13112, Invasive Species*

This executive order directs all federal agencies whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law:

- identify such actions;
- subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species, and (ii) not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.

The Proposed Action Alternatives (cable-laying operations) have the potential for introduction of invasive species. Stipulations in the Compatibility Determination (Appendices C1 and C2) and special conditions of the ROW permit therefore include measures to minimize risk of introduction of invasive species. To prevent the spread of disease or invasive species, all equipment used in the cable laying operation would be rinsed with fresh water when practical. In addition, a biosecurity plan would be submitted to the FWS for review and approval prior to initiation of cable-laying operations.

5.1.11 *Executive Order 13089, Protection of Coral Reefs*

Executive Order 13089 was signed in 1998 to preserve and protect the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystems and the marine environment. As such, all Federal agencies whose actions may affect U.S. coral reef ecosystems shall: (a) identify their actions that may affect U.S. coral reef ecosystems; (b) utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and (c) to the extent permitted by law, ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems.

The Proposed Action Alternative would not directly or indirectly impact any coral reef ecosystems since these habitats are not found within the deep abyssal and hadal zones of the cable corridor. No moderate-density, high-density, or very high-density deep-sea coral and sponge communities were found below a depth of 3,000 m depth during the 2016 Mariana Islands expedition ROV dives. Such communities are known to occur on ridge and seamount features. The SEA-US cable was laid along the northeastern flank of an unnamed seamount at depths over 6,000 m. The BIFROST cable and SEA-US cable routes contain areas of higher slope and rugosity within the Trench NWR. Given the scarcity of deep-sea coral and sponge communities at these depths, the likelihood of impacting these resources is considered low. The closest known deep-sea coral and sponge communities mapped by the 2016 *Okeanos Explorer* expedition are located 21 km (13 mi) from the BIFROST cable route and would be avoided by the Proposed Action Alternative. For the SEA-US cable, the nearest community is 85 km (115 mi) from the cable route and was avoided during installation of this cable. While it is possible that previously unmapped corals or sponges may occur within the proposed ROW and could be negatively impacted by cable-laying operations, the effect would be minor due to the anticipated sparseness of these resources and the very small footprint of the respective cables.

5.2 Separate But Related Compliance Actions

The following permits and compliance certifications are being applied for as part of the BIFROST cable landings in Alupang, Guam, or have been received prior to the landing of the SEA-US cables in Piti, Guam.

5.2.1 United States Army Corps of Engineers

BIFROST Cable. While the USFWS is the lead federal agency for activities within the MTMNM and Trench NWR, the United States Army Corps of Engineers (USACE) is the lead federal agency for projects within waters of the U.S. up to 3 NM from shore under the Rivers and Harbors Act of 1899, the Clean Water Act, and the Marine Protection Research and Sanctuaries Act of 1972. The USACE issued a verification on March 29, 2023 that the proposed landings are authorized under Nationwide Permit (NWP) 57 for Electrical Utility Line and Telecommunications Activities. The proposed action will comply with all Pac-SLOPES conditions.

SEA-US Cable. USACE issued an Individual Permit (NWP) for the SEA-US cable landings on Guam in February 2017 under DA File No. POH-2015-00172.

5.2.2 National Marine Fisheries Service

BIFROST Cable. Essential Fish Habitat (EFH) and Endangered Species Act (ESA) consultations with the National Marine Fisheries Service (NMFS) will be required for the BIFROST Guam landings for NWP 57.

SEA-US Cable. EFH and ESA consultations were completed between USACE, NMFS and USFWS for the SEA-US cable landings in Guam, prior to the issuance of an Individual Permit by the USACE.

5.2.3 Guam Department of Agriculture, Division of Aquatic and Wildlife Resources

BIFROST Cable. The BIFROST cables will not be landed within any of the Marine Protected Areas (MPA) on Guam. Therefore, an MPA Permit Application is not required.

SEA-US Cable. An MPA Permit (License No. SPI-17-002) was approved by the Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) in November 2017 for the landing of the SEA-US cables in the Piti MPA on Guam. DAWR is the lead Government of Guam agency overseeing terrestrial and marine resources, including marine protected areas and threatened and endangered species. It is also a key reviewer for activities in the Guam Seashore Reserve and Federal Consistency under Coastal Zone Management Act.

5.2.4 Guam Environmental Protection Agency

BIFROST Cable. A 401 Water Quality Certification (WQC) from the Guam Environmental Protection Agency (GEPA) will not be required for the BIFROST cable Guam landings, since this approval is not required by GEPA for activities under Nationwide Permit 57. Guam EPA is the lead agency overseeing effects on resources under U.S. and Guam Clean Water Acts, including Section 401 Water Quality Certification. It is also a key reviewer for activities in the Guam Seashore Reserve and Federal Consistency under Coastal Zone Management Act.

SEA-US Cable. GEPA approved a 401 WQC for the SEA-US cable landings on Guam in September 2016 under WQC 16-07.

5.2.5 Guam Coastal Management Program

Federal activities and development projects which directly affect the coastal zone must be conducted or supported in a manner which is, to the maximum extent practicable, consistent with the Coastal Resource Management (CRM) Program. The implementation of these federal consistency provisions will be carried out in accordance with Section 307 of the Coastal Zone Management Act (CZMAz) and Federal Regulations at 15 CFR, Part 930. The proposed action would be consistent with the Guam Coastal Management Program, which is the CRM Program on Guam, and the program administered by the Bureau of Environmental and Coastal Quality (BECQ) in the CNMI. The proposed cable system would be constructed and operated in conformance with these standards and policies.

BIFROST Cable. The Guam Bureau of Statistics and Plans (BSP) is the lead agency for review of Federal Consistency under the Coastal Zone Management Act and a key reviewer for activities in the Guam Seashore Reserve. A Guam Coastal Management Program (GCMP) Federal Consistency Application will not be required for the BIFROST cable landings on Guam, since this approval is not required by BSP for activities under Nationwide Permit 57.

SEA-US Cable. BSP reviewed the Federal Consistency application for the SEA-US cable landings, found it to be consistent with GCMP policies and issued a concurrence letter in December 2016 under GCMP FC No. 2016-0027.

6 REFERENCES

Bailey H., S. R. Benson, G. L. Shillinger, S. J. Bograd, P. H. Dutton, S. A. Eckert, S. J. Morreale, F. V. Paladino, T. Eguchi, D. G. Foley, B. A. Block, R. Piedra, C. Hitipeuw, R. F. Tapilatu, and J. R. Spotila. 2012. Identification of distinct movement patterns in Pacific leatherback populations influenced by ocean conditions. Ecol. App., 22(3): 735-747.

Beliaev, G.M. 1989. Deep-Sea Ocean Trenches and Their Fauna. Nauka Publishing House, Moscow.

Byrne, R., Fish, J., Doyle, T., Houghton, J. 2007. Leatherback turtles satellite-tagged in European waters. Endangered Species research, Vol. 3. 9 pp.

Carter L., D. Burnett, S. Drew, G. Marle, L. Hagadorn, D. Bartlett-McNeil, and N. Irvine. 2009. Submarine Cables and the Oceans – Connecting the World. UNEP-WCMC Biodiversity Series No. 31. ICPC/UNEP/UNEP-WCMC. 68 pp.

Clark, Malcolm R., Rowden, Ashley A., Schlacher, Thomas, Williams, Alan, Consalvey, Mireille, Stocks, Karen I., Rogers, Alex D.' O'Hara, Timothy D., White, Martin, Shank, Timothy M., Hall-Spencer, Jason M. 2010. The ecology of seamounts: structure, function, and human impacts. Annual Review of Marine Science, Vol. 2: 253–278.

Department of the Navy (DON). 2020. Mariana Islands Training and Testing Activities Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement. Vols. 1-3. June 2020.

Eldredge, L.G. 2003. The marine reptiles and mammals of Guam. Micronesica 35-36: 653-660.

Finlay, C.C., S. Maus, C.D. Beggan, T.N. Bondar, A. Chambodut, T.A. Chernova, A. Chulliat, V.P. Golokov, B. Hamilton, M. Hamoudi, R. Holme, G. Hulot, W. Kuang, B. Langlais, V. Lesur, F.J. Lowes, H. Luhr, S. Macmillan, M. Mandea, S. McLean, C. Majoj, M. Menvielle, I Michaelis, N. Olsen, J. Rauberg, M. Rother, T.J. Sabaka, A. Tangborn, L. Toffner-Clausen, E. Theabault, W.W.P. Thomson, I Wardinski, Z. Wei, and T.I. Zvereva. 2010. International Geomagnetic Reference Field: the eleventh generation. Geophys. Jour. Intl..183(3): 1216–1230.

Five Deeps. 2019. Deepest Submarine Dive in History, Five Deeps Expedition Conquers Challenger Deep. Five Deeps Press Release. May 13, 2019. 7 pp.

Fossette, Sabrina. 2010. Behavior and Buoyancy Regulation in the Deepest-Diving Reptile: The Leatherback Turtle. The Journal of Experimental Biology. Volume 213. Pages 4074-4083.

Fryer, P. 2012. Serpentinite mud volcanism: observations, processes, and implications. Annu. Rev. Mar. Sci. 4:345-73.

Fryer, P., N. Becker, B. Appelgate, F. Martinez, M. Edwards, and G. Fryer. 2003. Why is the Challenger Deep so deep? Earth and Planetary Science Letters, 211 (3-4): 259-269.

Fryer, P., C.G. Wheat, T. Williams, C. Kelley, K. Johnson, J. Ryan, W. Kurz, J. Shervais, E. Albers, B. Bekins, B. Debret, J. Deng, Y. Dong, P. Eickenbusch, E. Frery, Y. Ichiyama, R. Johnston, R.

Kevorkian, V. Magalhaes, S. Mantovanelli, W. Menapace, C. Menzies, K. Michibayashi, C. Moyer, K. Mullane, J. Park, R. Price, O. Sissmann, S. Suzuki, K. Takai, B. Walter, R. Zhang, D. Amon, D. Glickson, and S. Pomponi. 2020. Mariana serpentinite mud volcanism exhumes subducted seamount materials: implications for the origin of life. Phil. Trans. R. Soc. A 378:20180425.

Fulling, G.L., P.H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65(3): 321-343.

Gallo, N., Cameron, J., Hardy, K., Fryer, P., Bartlett, D., A. Levin, L. 2015. Submersible- and lander-observed community patterns in the Mariana and New Britain trenches: Influence of Productivity and depth on epibenthic and scavenging communities. Deep-Sea Research I, Vol. 99: 119–133.

Gardner, J. V., A. A. Armstrong, B. R. Calder and J. Beaudoin. 2014. So, how deep is the Mariana Trench? Marine Geodesy, 37: 1-13.

Gerringer, M.E. 2019. On the success of the hadal snailfishes. 2019. Integrative Organismal Biology. Pp. 1-18.

Gerringer, M.E., T.D. Linley, A.J. Jamieson, E. Goetze, and J.C. Drazen. 2017. A newly-discovered hadal snailfish (Scorpaeniformes: Liparidae) from the Mariana Trench. Zootaxa, 4358 (1): 161–177.

Glickson, D. A., D. Amon, L.A. McKenna, and K. Elliott. 2017. 2016 deepwater exploration of the Marianas, EX-16-05 Leg 1 cruise report: Guam and the Commonwealth of the Northern Mariana Islands Guam to Saipan, Northern Mariana Islands. NOAA Office of Ocean Exploration and Research, Silver Spring, MD. 31 pp.

Grigg RW.1993. Precious coral fisheries of Hawaii and the US Pacific Islands. Mar Fish Rev 55(2):50B60.

Hadavand, A. 2011. The Impact of the Internet on Economic Growth in Uppermiddle-Income Countries. A Thesis in Economics Submitted to the Graduate Faculty of Texas Tech University in Partial Fulfillment of the Requirements for the Degree of Master of Arts. 20 pp.

Hamilton, P.K., G.S. Stone, and S.M. Martin. 1997. Note on a deep humpback whale *Megaptera novaeanglieae* dive near Burmuda. Bull. Mar. Sci., 61(2): 491-494.

Hein, J.R., K. Mizell, A. Koschinsky, and T.A. Conrad. 2012. Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: comparison with land-based resources. Ore Geology Reviews 51:1-14.

Hesetun, J.T., H.T. Rapp, and S. Pomponi. 2019. Deep-sea carnivorous sponges from the Mariana Islands. Front. Mar. Sci. 6:371.

Hill, M., A. Ligon, A. Ü, and A. Bradford. 2015. Humpback whales in the Marianas. NOAA Pacific Islands Fisheries Science Center Blog. Posted March 23, 2015. https://pifscblog.wordpress.com/2015/03/23/humpback-whales-in-the-marianas/

Hill, M.C., A.C. Bradford, D. Steel, C.S. Baker, A.D. Ligon, A.C. Ü, J.V. Acebes, O.A. Filatova, S. Hakala, N. Kobayashi, Y. Morimoto, H. Okabe, R. Okamoto, J. Rivers, T. Sato, O.V. Titova, R.K. Uyeyama, and E.M. Oleson. 2020. Found: a missing breeding ground for endangered western North Pacific humpback whales in the Mariana Archipelago. Endangered Species Research, 41: 91-103.

Heezen, Bruce C. 1957. Whales entangled in deep sea cables. Deep Sea Research, 4: 105-115.

Hourigan T.F., P.J. Etnoyer P.J. and S. D. Cairns. 2017. The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. 467 p.

Howey-Jordan L.A., E.J. Brooks, D.L. Abercrombie, L.K.B. Jordan, and A. Brooks. 2013. Complex Movements, Philopatry and Expanded Depth Range of a Severely Threatened Pelagic Shark, the Oceanic Whitetip (*Carcharhinus longimanus*) in the Western North Atlantic. PLOS ONE 8(2): e56588. https://doi.org/10.1371/journal.pone.0056588

International Cable Protection Committee. 2014. Glossary. https://www.iscpc.org/information/learn-about-submarine-cables/glossary/

International Cable Protection Committee. 2015a. ICPC Recommendation: Recommendation No. 9, Minimum Technical Requirements for a Desktop Study (also known as a Cable Route Study). ICPC Recommendation No. 9, Issue: 5. November 2, 2015. 16 pp.

International Cable Protection Committee. 2015b. ICPC Recommendation: Recommendation No. 2, Recommended Routing and Reporting Criteria for Cables in Proximity to Others. ICPC Recommendation No. 2, Issue: 11. November 3, 2015. 17 pp.

International Seabed Authority (ISA). 2022a. https://www.isa.org.jm/frequently-asked-questions-faqs

International Seabed Authority. 2022b. https://www.isa.org.jm/index.php/minerals/exploration-areas

IUCN 2019. The IUCN Red List of Threatened Species. Version 2019-1. http://www.iucnredlist.org. Downloaded on 20 March 2019.

Jamieson, A., T. Fujii, D.J. Mayor, M. Solan, and I.G. Priede. 2010. Hadal Trenches: The Ecology of the Deepest Places on Earth. Trends in Ecology and Evolution. 8 pp.

Jamieson, A. 2011. Ecology of deep oceans: hadal trenches. In: eLS. John Wiley & Sons, Ltd, Chichester.

Jamieson, A., I.G. Priede, and J. Craig. 2012. Distinguishing between the abyssal macrourids *Coryphaenoides yaquinae* and *C. armatus* from in situ photography. 2012. Deep Sea Research Part I: Oceanographic Research Papers. Volume 64, June 2012, Pages 78-85

Jorgensen, S.J., A.P. Klimley, and A.F. Muhlia-Melo. 2009. Scalloped hammerhead shark *Sphyrna lewini*, utilizes deep-water, hypoxic zone in the Gulf of California. Journal of Fish Biology, 74: 1682-1687.

Kashiwagi, T., A.D. Marshall, M.B. Bennett and J.R. Ovenden. 2011. Habitat segregation and mosaic sympatry of the two species of manta ray in the Indian and Pacific Oceans: *Manta alfredi* and *M. birostris.* Marine Biodiversity Records, 4: 1-8. Published online by Marine Biological Association of the United Kingdom.

Kawabe, M., S. Fujino, and D. Yanagimoto. 2003. Deep-water circulation at low latitudes in the western North Pacific. Deep Sea Research Part I Oceanographic Research Papers, 50(5): 631-656

Klimley, A.P. 1993. Highly directional swimming by scalloped hammerhead sharks, *Sphyrna lewini*, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. Marine Biology 117: 1.

Linley, T.D., M.E. Gerringer, P.H. Yancey, J.C. Drazen, C.L. Weinstock, and A.J. Jamieson. 2016. Fishes of the hadal zone including new species, in situ observations and depth records of Liparidae. Deep-Sea Research Part I, Volume 114, pp. 99-110.

Linley, T. D., A.L. Stewart, P.J. McMillan, M.R. Clark, J.C. Drazen, T. Fujii, and A.J. Jamieson. 2017. Bait attending fishes of the abyssal zone and hadal boundary: community structure, functional groups and species distribution in the Kermadec, New Hebrides and Mariana Trenches. Deep Sea Research Part I: Oceanographic Research Papers (2016). 58 pp.

Mestre V.J. and D. Wooten. 1979. Noise Impact Analysis. In J.G. Rau and D.C. Wooten (eds.), Environmental Impact Analysis Handbook. McGraw-Hill, New York, U.S.A. 642 pp.

Miller, M.H., Carlson, J., Cooper, P., Kobayashi, D., Nammack, M., and J. Wilson. 2014. Status review report: scalloped hammerhead shark (*Sphyrna lewini*). Final Report to National Marine Fisheries Service, Office of Protected Resources. March 2014.133 pp.

Miller, M.H. and C. Klimovich. 2016. Endangered Species Act Status Review Report: Giant Manta Ray (*Manta birostris*) and Reef Manta Ray (*Manta alfredi*). Draft Report to National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. December 2016. 127 pp.

Montevecchi, W. A. 2006. Influences of artificial light on marine birds. *Ecological consequences of artificial night lighting,* pp. 94-113. Island Press.

National Marine Fisheries Service (NMFS). 1998a. Recovery plan for the blue whale (*Balaenoptera musculus*). Prepared by Reeves R.R., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the National Marine Fisheries Service, Silver Spring, MD. 42 pp.

National Marine Fisheries Service. 1998b. Recovery plan for the humpback whale (*Megaptera novaengliae*). Prepared by Reeves R.R., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the National Marine Fisheries Service, Silver Spring, MD. 42 pp.

National Marine Fisheries Service. 2010a. Recovery plan for the fin whale (*Balaenoptera physalus*). National Marine Fisheries Service, Silver Spring, MD. 121 pp.

National Marine Fisheries Service. 2010b. Recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD. 165pp.

National Marine Fisheries Service. 2011. Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 108 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998a. Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, MD. 97 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998b. Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service, Silver Spring, MD. 95 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998c. Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998d. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998e. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007a. Green Sea Turtle (*Chelonia mydas*). 5-Year Review: Summary and Evaluation. 105 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007b. Hawskbill Sea Turtle (*Eretmochelys imbricata*). 5-Year Review: Summary and Evaluation. 93 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007c. Loggerhead Sea Turtle (*Caretta caretta*). 5-Year Review: Summary and Evaluation. 67 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2013. Hawskbill Sea Turtle (*Eretmochelys imbricata*). 5-Year Review: Summary and Evaluation. 92 pp.

Nelson, J.S., 1994. Fishes of the world. 3rd edition. John Wiley & Sons, Inc., New York. 600 pp.

NOAA, Deep Sea Coral Research & Technology Program. 2017. Deep-sea coral and sponge records from the CAPSTONE: Deepwater Exploration of the Marianas Expedition of the Okeanos Explorer (EX-16-05-L3). (www.deepseacoraldata.noaa.gov)

NOAA. 2018a. #Mihumpbacks: Humpback whales of the Mariana Islands. NOAA Fisheries News. April 9, 2018. https://www.fisheries.noaa.gov/feature-story/mihumpbacks-humpback-whales-mariana-islands

NOAA. 2018b. Oceanic Whitetip Shark, Overview, Conservation and Management Resources. https://www.fisheries.noaa.gov/species/oceanic-whitetip-shark

Oguri, K. and T. Noguchi. 2017. Deepest fish ever recorded, documented at depths of 8,178 m in Mariana Trench. JAMSTEC Press Release.

Ponganis, Paul J. 2011. Diving mammals. Comprehensive Physiology, 1: 517-535.

Ramirez-Llodra, E., T.M. Shank, and C.R. German. 2007. Biodiversity and biogeography of hydrothermal vent species: Thirty years of discovery and investigations. Oceanography, 20 (1): 30–41.

Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz, E.E. Seney, K.S. Van Houtan, R.S. Waples. 2015. Status Review of the Green Turtle (*Chelonia mydas*) Under the U.S. Endangered Species Act. NOAA Technical Memorandum, NOAANMFS-SWFSC-539. 571 pp.

Steward, J.D., E.M. Hoyos-Padilla, K.R. Kumli, and R.D. Rubin. Deep-water feeding and behavioral plasticity in Manta birostris revealed by archival tags and submersible observations. Zoology 119 (5): 406-413.

Stewart, H. and A. Jamieson. 2018. Habitat Heterogeneity of Hadal Trenches: Considerations and Implications for Future Studies. Progress in Oceanography. Volume 161: 47-65.

Taira, K., Kitagawa, S., Yamashiro, T., Yanagimoto, D., 2004. Deep and bottom currents in the Challenger Deep, Mariana Trench, measured with super-deep current meters. J. Oceanogr. Vol. 60. Pages 919–926.

U.S. Department of the Navy. 2007. *Marine mammal and sea turtle survey and density estimates for Guam and the Commonwealth of the Northern Mariana Islands: 2007* [Unpublished contract report (DRAFT)]. p. 64. Prepared by Geo-Marine Inc. Prepared for Naval Facilities Engineering Command Pacific.

U.S. Department of the Navy. 2015. The Marianas Islands Training and Testing Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). Final EIS/OEIS. Vols. 1-3.

U.S. Fish and Wildlife Service. 2005. Regional Seabird Conservation Plan, Pacific Region. Portland, OR: U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region.

Vanderlaan, A. S., and Taggart, C. T. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine mammal science, 23(1), 144-156.

Wagner, D., D.G. Luck, and R.J. Toonen. 2012. The biology and ecology of black corals (Cnidaria: Anthozoa: *Hexacorallia*: *Antipatharia*). In Advances in marine biology, Vol. 63, pp. 67-132. Academic Press.

Western Pacific Regional Fishery Management Council. 2009a. Fishery Ecosystem Plan for Pacific Pelagic Fisherie s of the Western Pacific Region. Western Pacific Regional Fishery Management Council, Honolulu, HI. 251 pp.

Western Pacific Regional Fishery Management Council. 2009b. Fishery Ecosystem Plan for the Mariana Archipelago. Western Pacific Regional Fishery Management Council, Honolulu, HI. 251 pp.

Wolff, T., 1970. The concept of the hadal or ultra-abyssal fauna. Deep-Sea Res 17(6): 983–1003.

Yancey, P.H., Gerringera, M.E., Drazen, J.C., Rowdenc, A.A., and Jamieson, A. (2014). Marine fish may be biochemically constrained from inhabiting the deepest ocean depths. Proc. Nat. Aca. Sci., 111: 4461–4465.

Young, C.N., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C.T., Wraith, J. 2016. Status review report: oceanic whitetip shark (*Carcharhinius longimanus*). Final Report to the National Marine Fisheries Service, Office of Protected Resources. November 2016. 162 pp.

7 PREPARERS

Dueñas, Camacho & Associates, Inc.
Claudine Camacho, Biologist
William Concepcion, Geographic Information System Manager/Planner

RTI Solutions, Inc. dba HMB
Chris Brungardt, President

U.S. Fish and Wildlife Service, Pacific Region
Narissa P. Brown, Conservation Planner
Claire D. McClory, Planning Branch Chief, National Wildlife Refuge System
Kendal Morris, Conservation Planner

APPENDIX A. Figures for BIFROST Cable

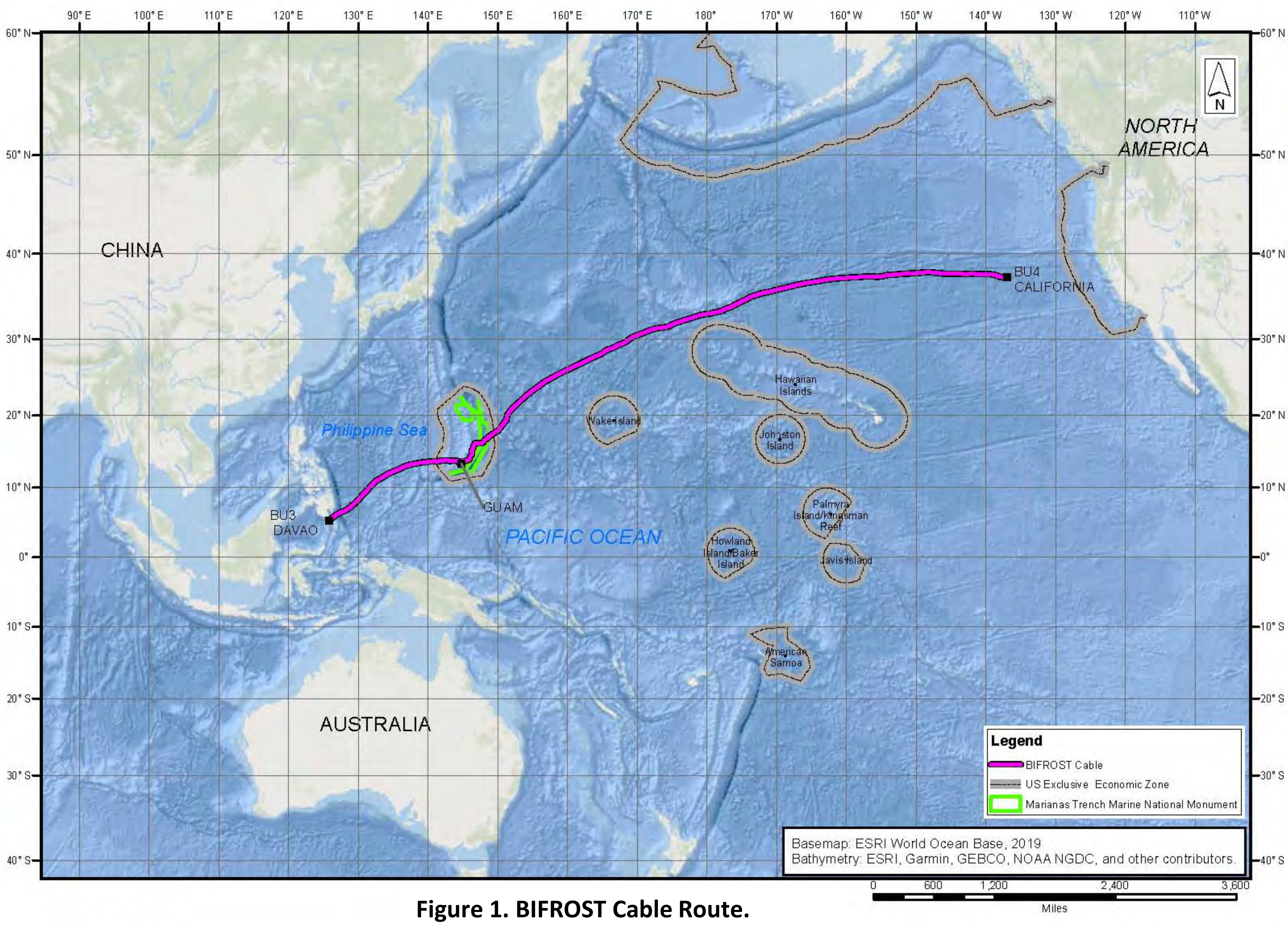


Figure 1. BIFROST Cable Route.

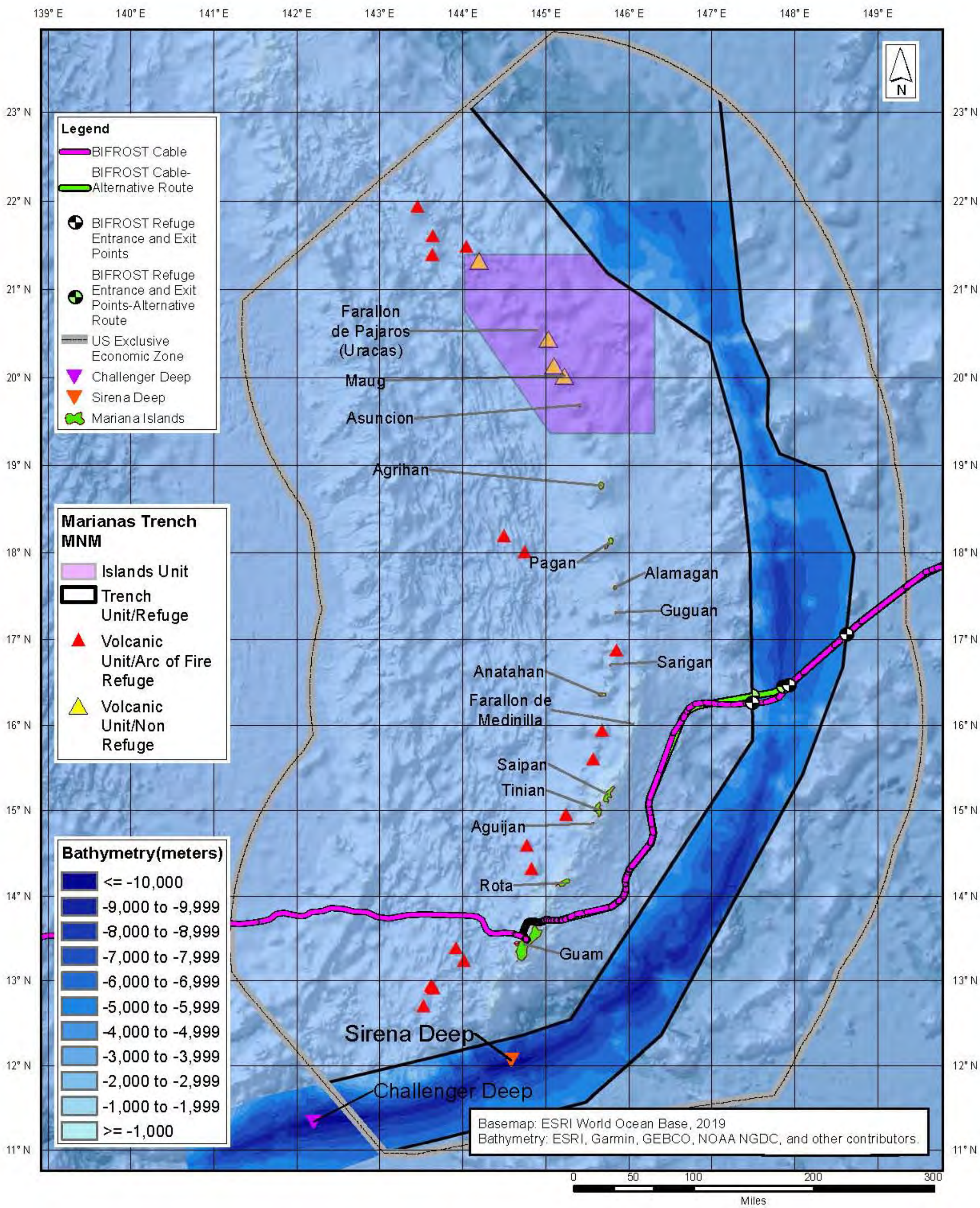


Figure 2. Site location map for the Marianas Trench Marine National Monument Units and the BIFROST Cable.

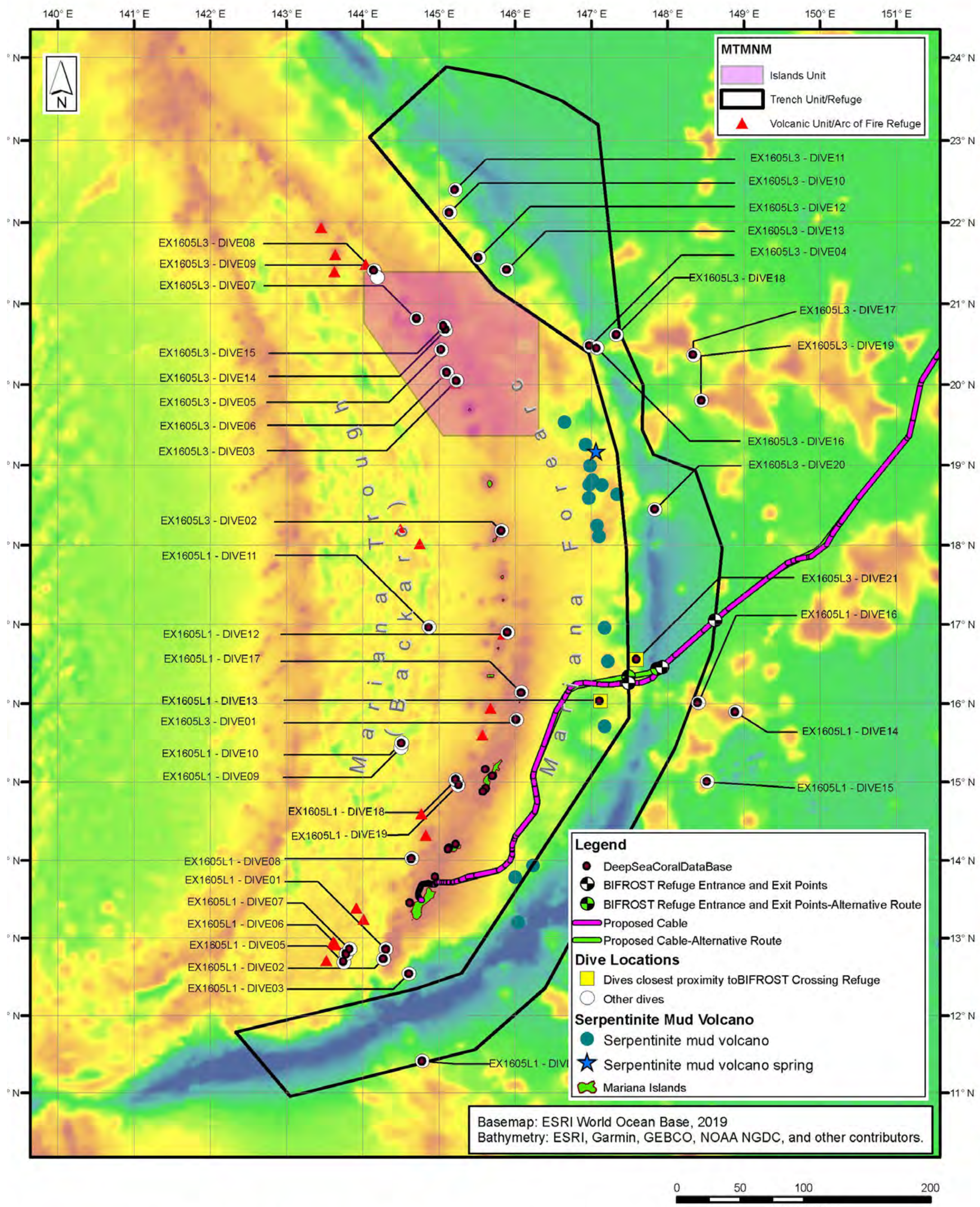


Figure 3a. Okeanc

Figure 3a. *Okeanos* Expedition 1605 Legs 1 and 3 Dive Sites along the BIFROST cable route.

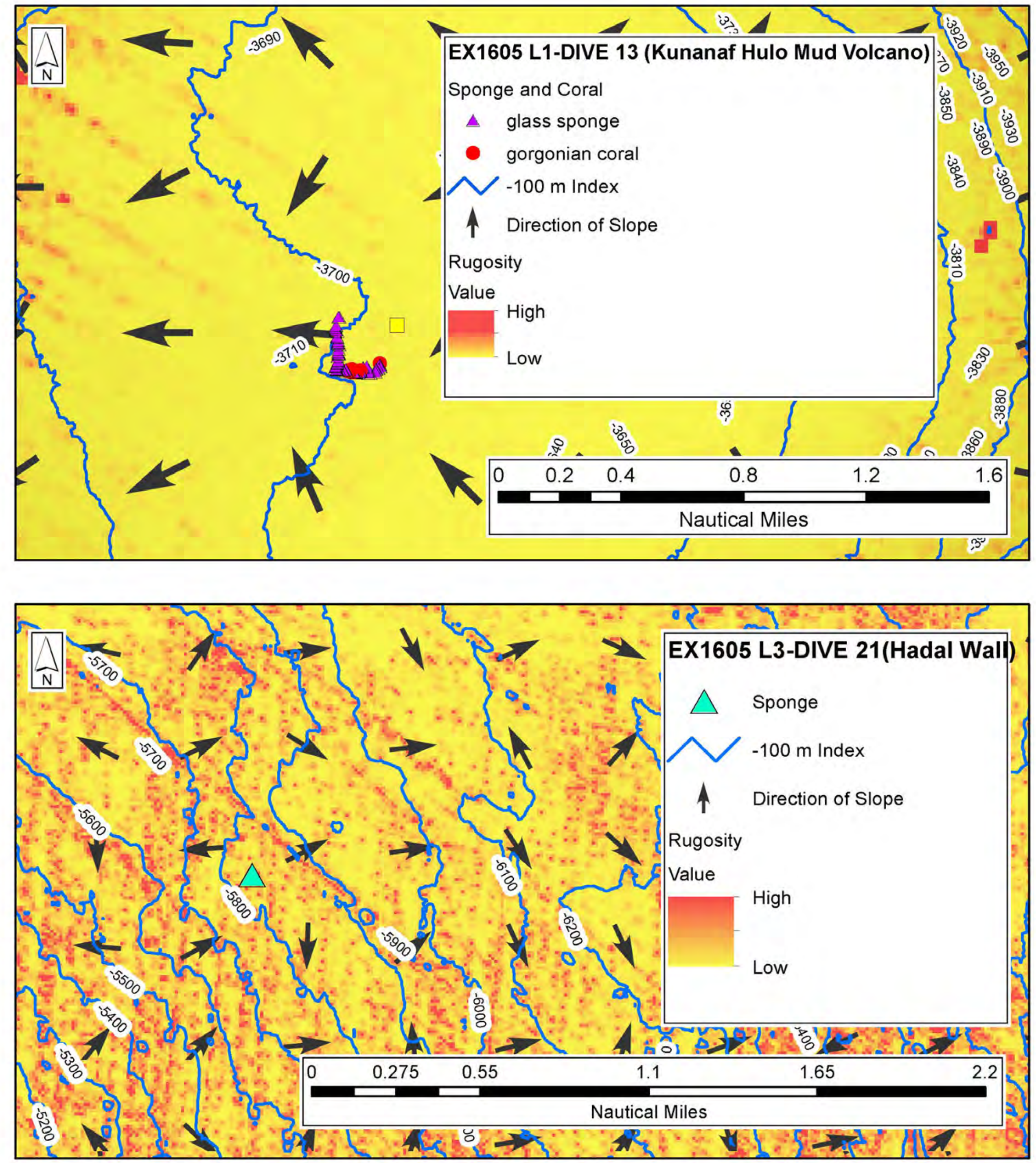


Figure 3b. *Okeanos* Expedition 1605 Leg 3 Dive 13 and Leg 3 Dive 21.

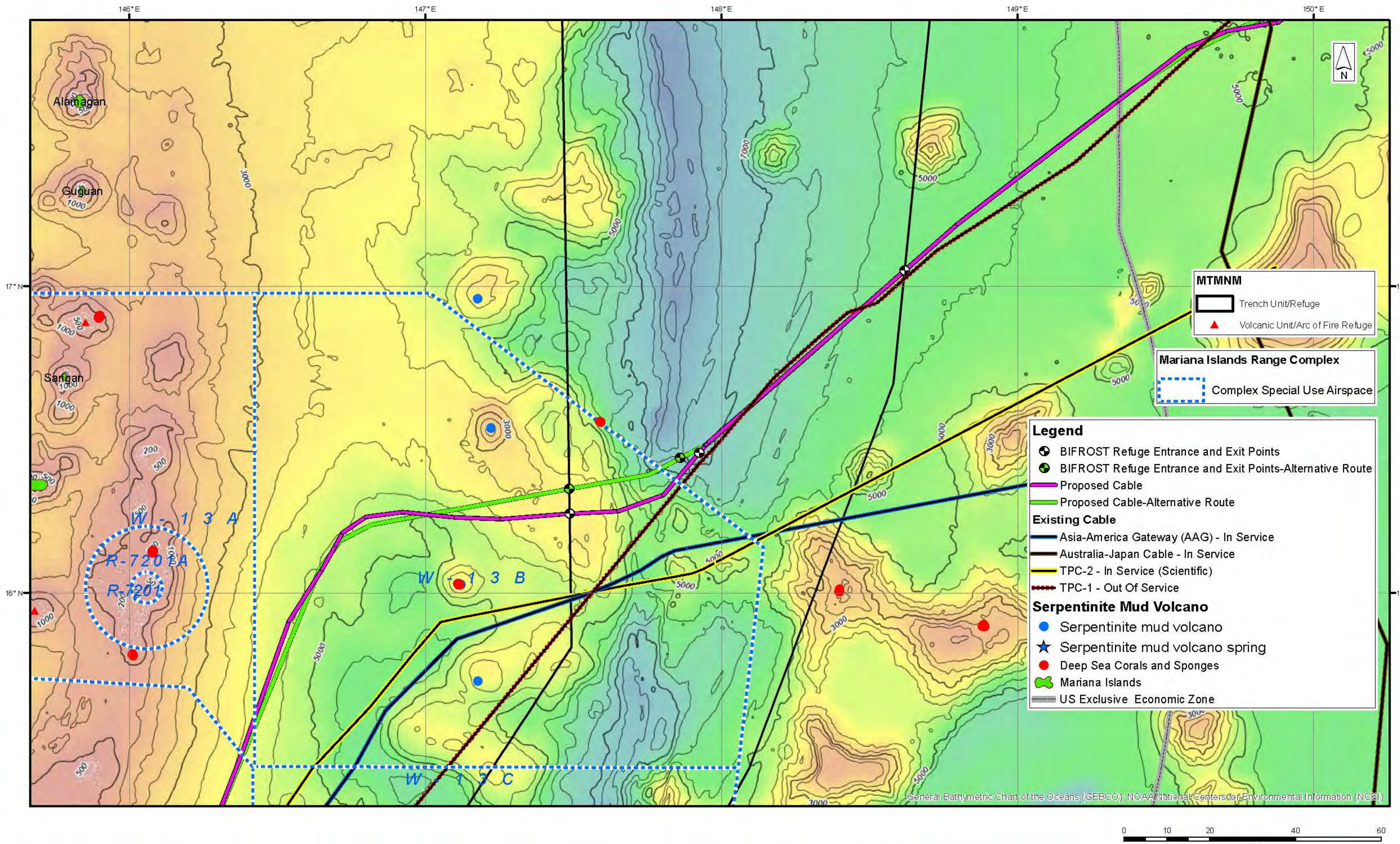


Figure 4. MIRC Warning Areas and approximate location of existing cables along the BIFROST cable route.

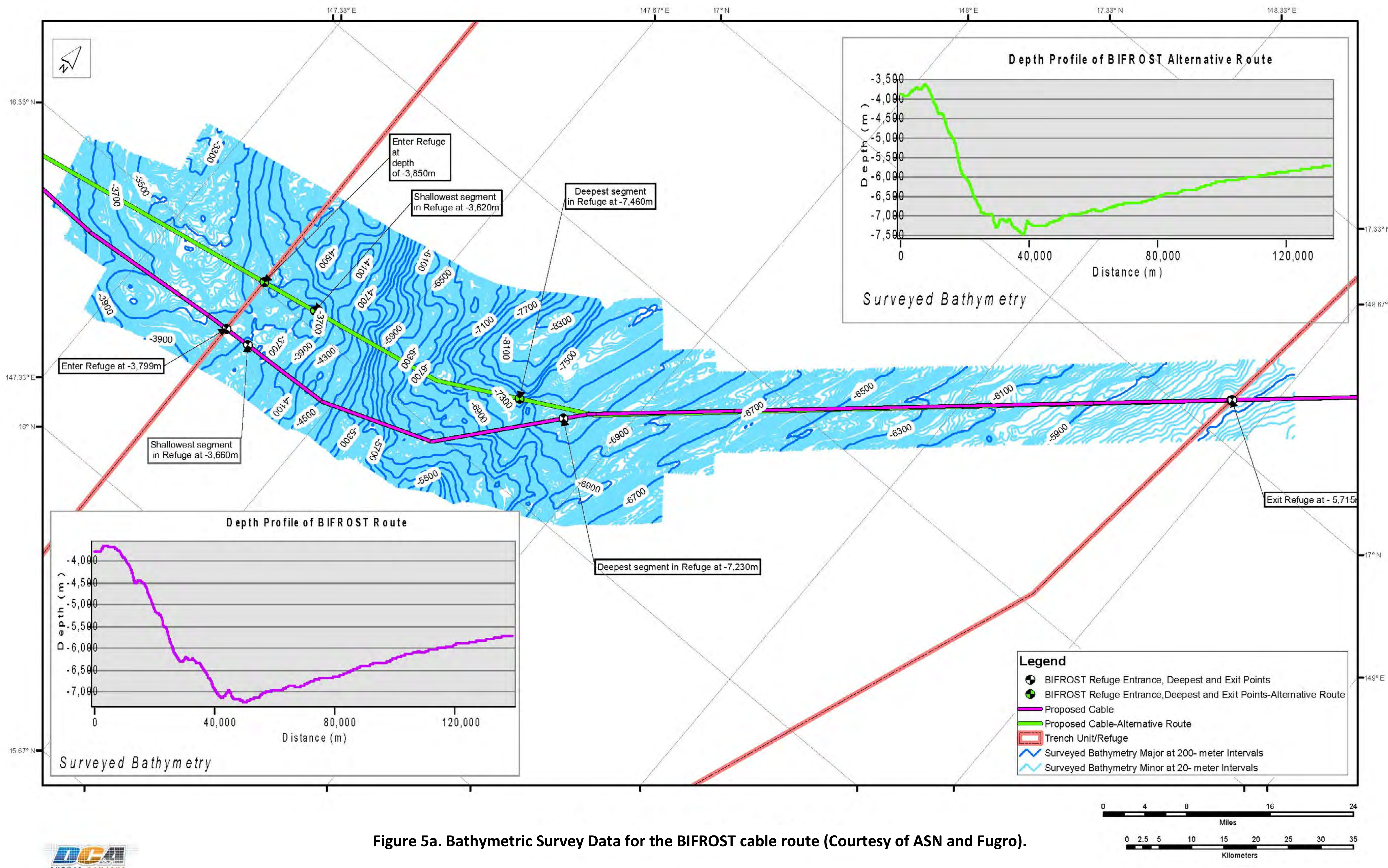


Figure 5a. Bathymetric Survey Data for the BIFROST cable route (Courtesy of ASN and Fugro).

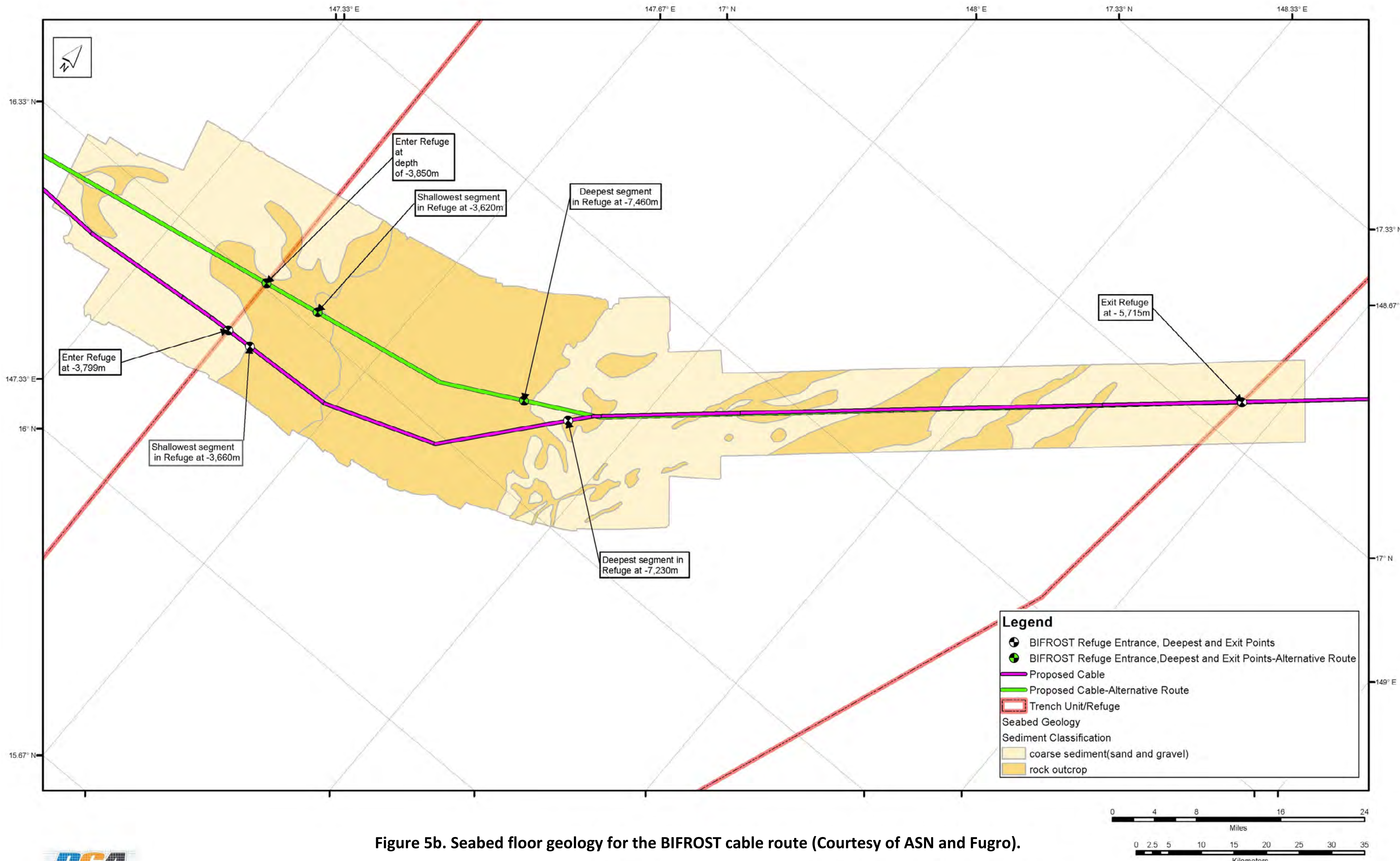


Figure 5b. Seabed floor geology for the BIFROST cable route (Courtesy of ASN and Fugro).

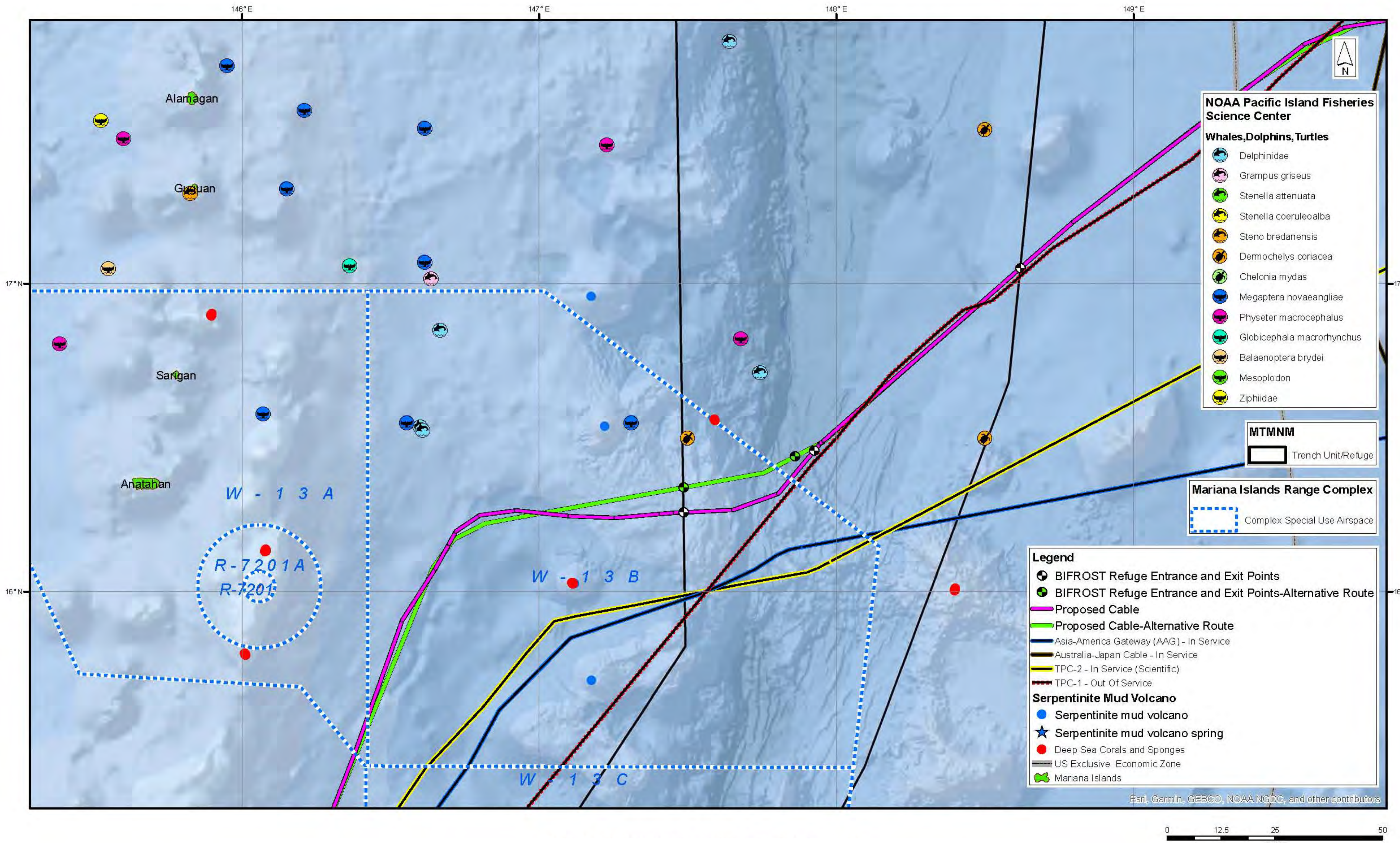
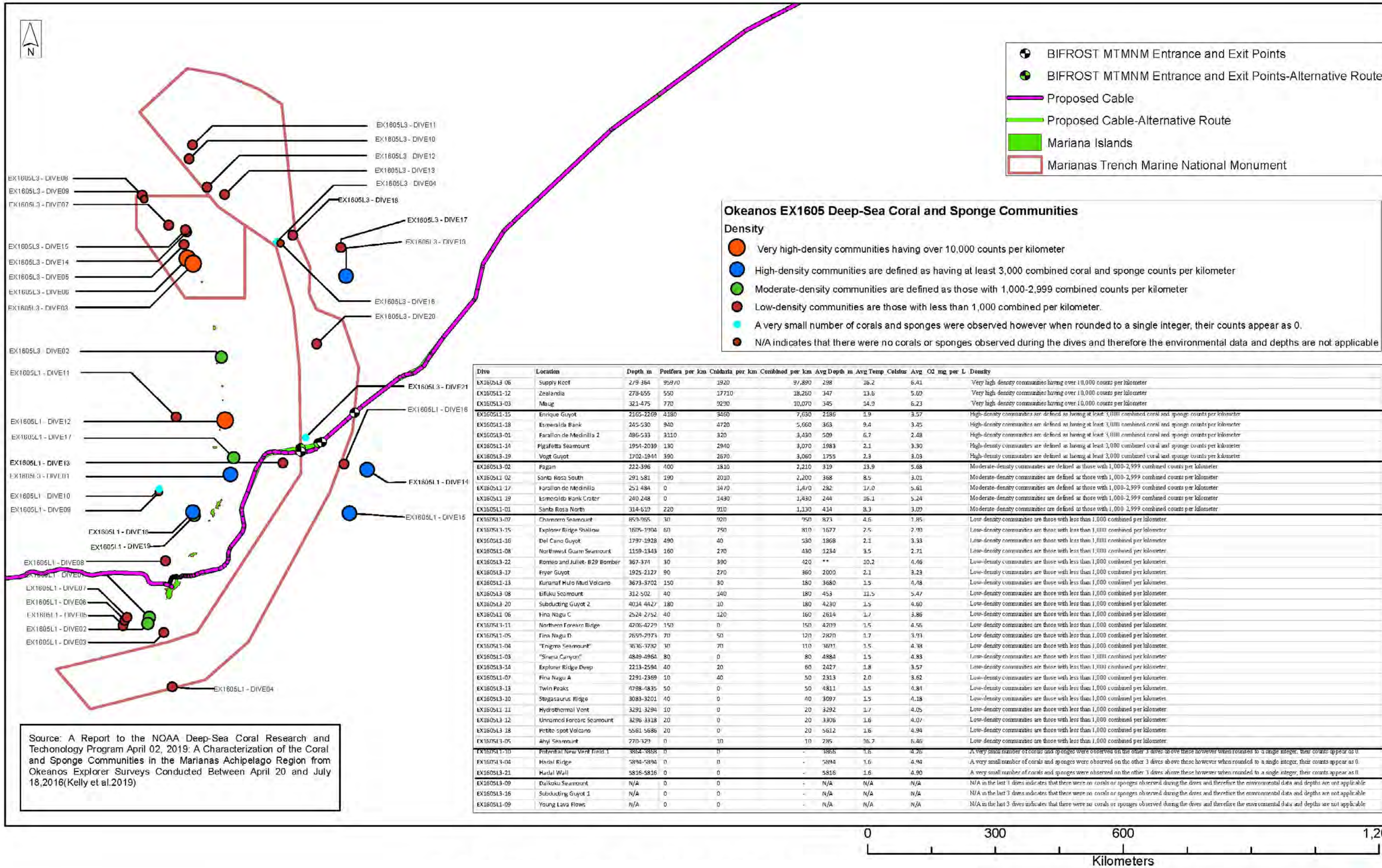


Figure 6. Sightings of marine mammals and reptiles within the Trench NWR along the BIFROST cable route.

DCA



Dive	Location	Depth m	Porifera per km	Cnidaria per km	Combined per km	Avg Depth m	Avg Temp Celsius	Avg O2 mg per L	Density
EX1605L3-06	Supply Reef	279-364	95970	1920	97,890	298	16.2	6.41	Very high density communities having over 10,000 counts per kilometer
EX1605L1-12	Zealandia	278-655	550	17710	18,260	347	13.6	5.69	Very high density communities having over 10,000 counts per kilometer
EX1605L3-03	Maug	321-475	770	9290	10,070	345	14.9	6.23	Very high density communities having over 10,000 counts per kilometer
EX1605L1-15	Enrique Guyot	2165-2269	4180	3460	7,630	2186	1.9	3.57	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L1-18	Esmeralda Bank	245-530	940	4720	5,660	363	9.4	3.45	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-01	Farallon de Medinilla 2	486-533	3110	320	3,430	509	6.7	2.48	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L1-14	Pigafetta Seamount	1954-2039	130	2940	3,070	1983	2.1	3.30	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-19	Vogt Guyot	1702-1944	390	2670	3,060	1755	2.3	3.03	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-02	Pagan	222-396	400	1810	2,210	319	13.9	5.68	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-02	Santa Rosa South	291-581	190	2010	2,200	368	8.5	3.01	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-17	Farallon de Medinilla	251-484	0	1470	1,470	282	17.0	5.61	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-19	Esmeralda Bank Crater	240-248	0	1430	1,430	244	16.1	5.24	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-01	Santa Rosa North	314-619	220	910	1,130	414	8.3	3.09	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L3-07	Chamorro Seamount	850-965	30	920	950	873	4.6	1.85	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-15	Explorer Ridge Shallow	1605-1904	60	750	810	1677	2.5	2.90	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-16	Del Cano Guyot	1797-1928	490	40	530	1868	2.1	3.33	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-08	Northwest Guam Seamount	1159-1343	160	270	430	1234	3.5	2.71	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-22	Romeo and Juliet- B29 Bomber	367-374	30	390	420	**	10.2	4.46	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-17	Fryer Guyot	1925-2127	90	270	360	2000	2.1	3.23	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-13	Kunanaf Hulo Mud Volcano	3673-3702	150	30	180	3680	1.5	4.48	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-08	Eifuku Seamount	312-502	40	140	180	453	11.5	5.47	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-20	Subducting Guyot 2	4014-4427	180	10	180	4230	1.5	4.60	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-06	Fina Nagu C	2524-2752	40	120	160	2614	1.7	3.86	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-11	Northern Forearc Ridge	4206-4229	150	0	150	4209	1.5	4.56	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-05	Fina Nagu D	2650-2973	70	50	120	2820	1.7	3.93	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-04	"Enigma Seamount"	3636-3782	30	70	110	3691	1.5	4.38	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-03	"Sirena Canyon"	4849-4964	80	0	80	4884	1.5	4.83	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-14	Explorer Ridge Deep	2213-2594	40	20	60	2427	1.8	3.57	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-07	Fina Nagu A	2291-2369	10	40	50	2313	2.0	3.62	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-13	Twin Peaks	4798-4835	50	0	50	4811	1.5	4.84	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-10	Stegasaurus Ridge	3083-3201	40	0	40	3097	1.5	4.18	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-11	Hydrothermal Vent	3291-3294	10	0	20	3292	1.7	4.05	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-12	Unnamed Forearc Seamount	3296-3318	20	0	20	3306	1.6	4.07	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-18	Petite spot Volcano	5561-5686	20	0	20	5612	1.6	4.94	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-05	Ahyi Seamount	270-329	0	10	10	285	16.7	6.46	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-10	Potential New Vent Field 1	3864-3868	0	0	-	3866	1.6	4.26	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-04	Hadal Ridge	5894-5894	0	0	-	5894	1.6	4.94	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-21	Hadal Wall	5816-5816	0	0	-	5816	1.6	4.90	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-09	Daikoku Seamount	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable
EX1605L3-16	Subducting Guyot 1	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable
EX1605L1-09	Young Lava Flows	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable

Figure 7. Map and table of deep-sea coral and sponge community densities in the Marianas Archipelago along the BIFROST Cable Route.

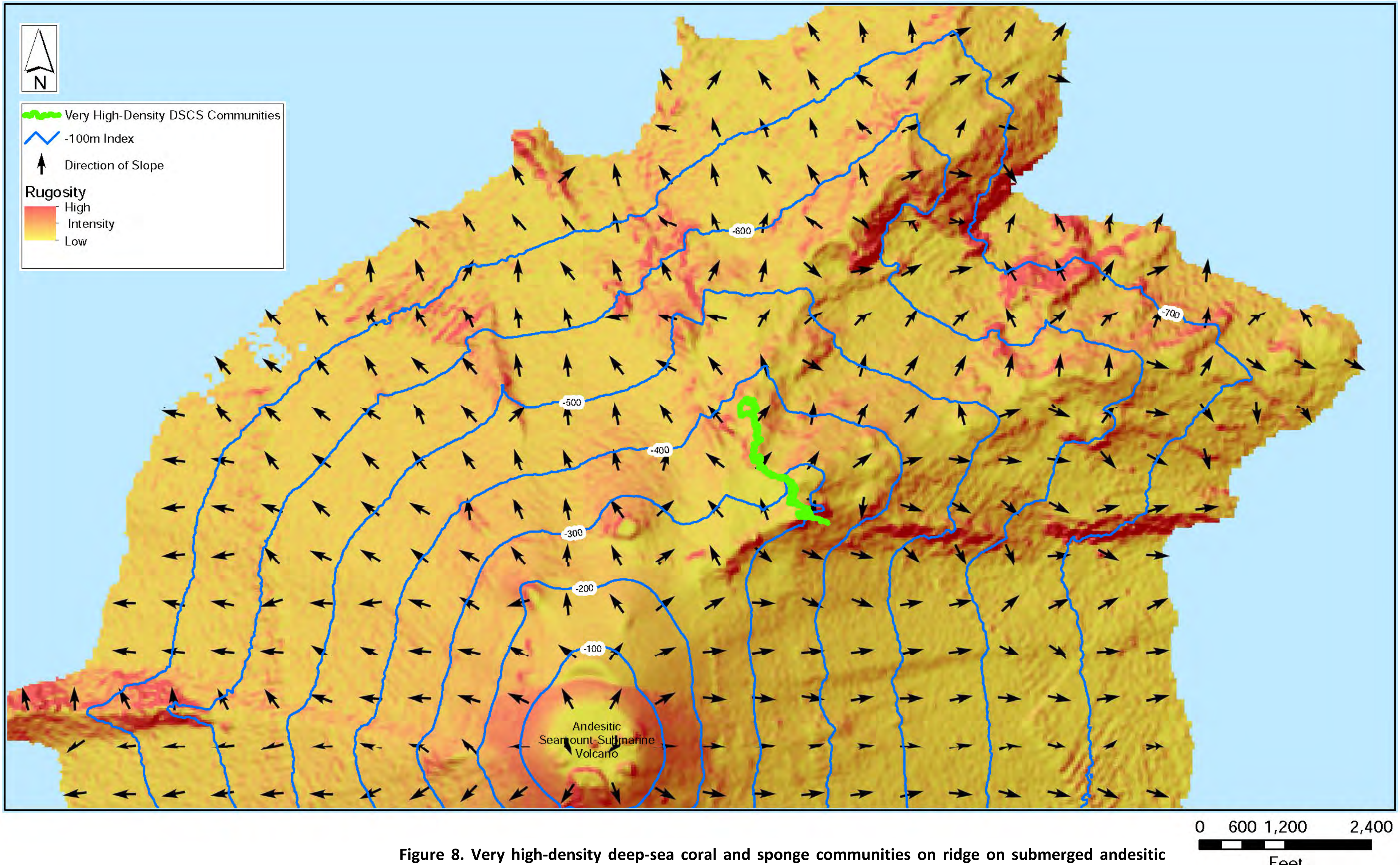


Figure 8. Very high-density deep-sea coral and sponge communities on ridge on submerged andesitic volcano - Supply Reef, EX1605L3-Dive 06.

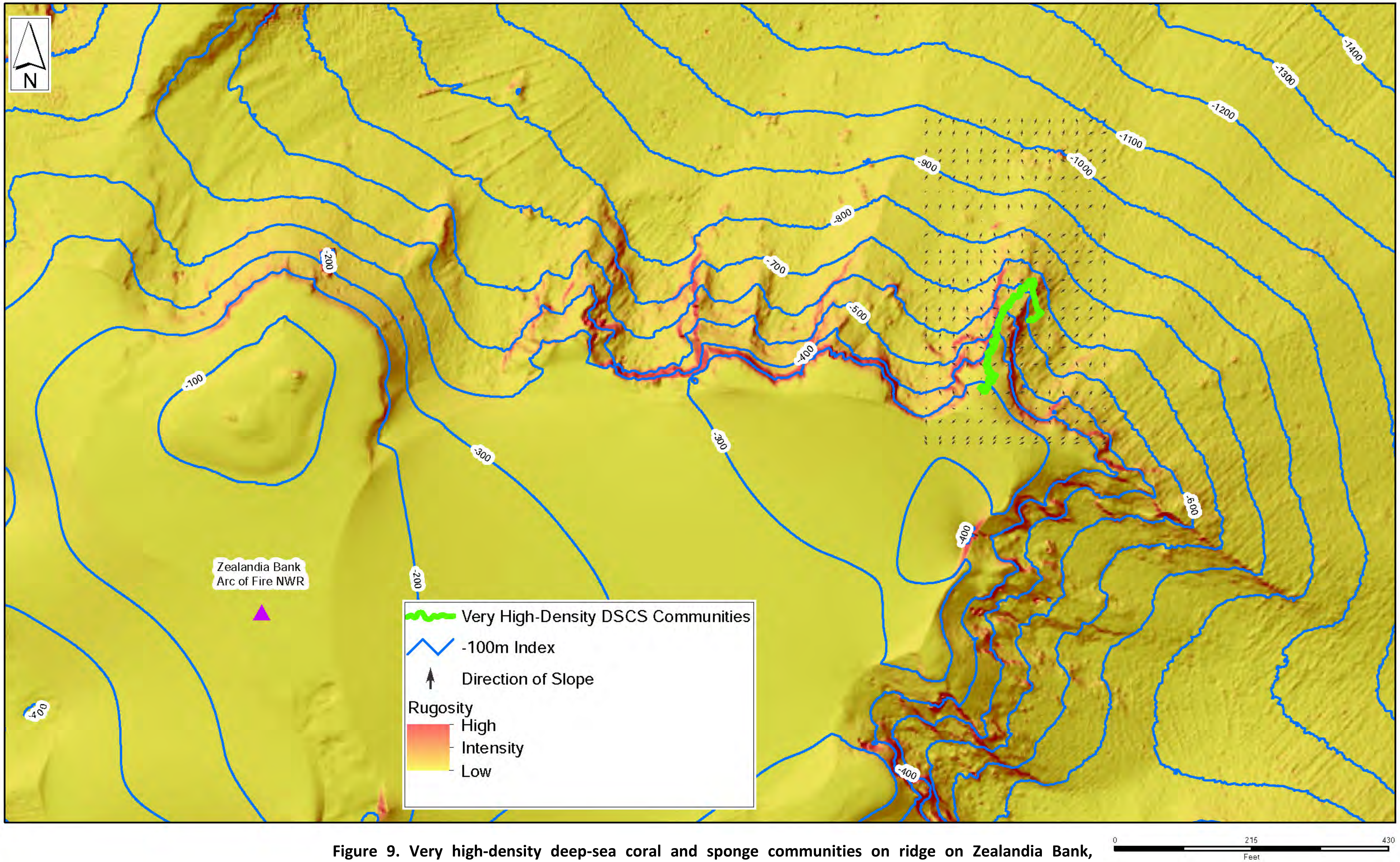


Figure 9. Very high-density deep-sea coral and sponge communities on ridge on Zealandia Bank, EX1605L1-Dive 12.

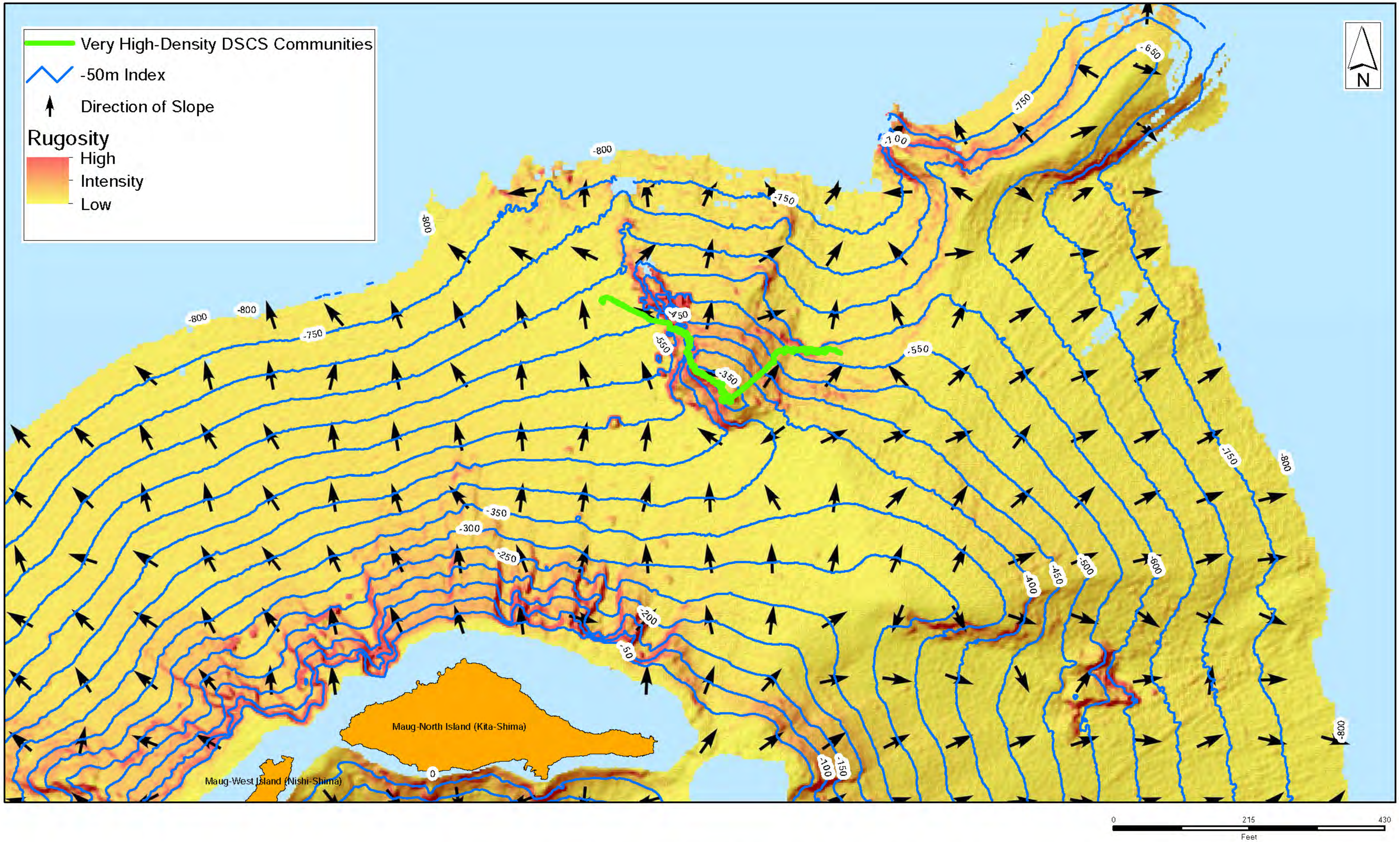


Figure 10. Very high-density deep-sea coral and sponge communities on ridge along north side of the outer slopes of Maug Crater, EX1605L3-Dive 03.

APPENDIX B. Figures for SEA-US Cable

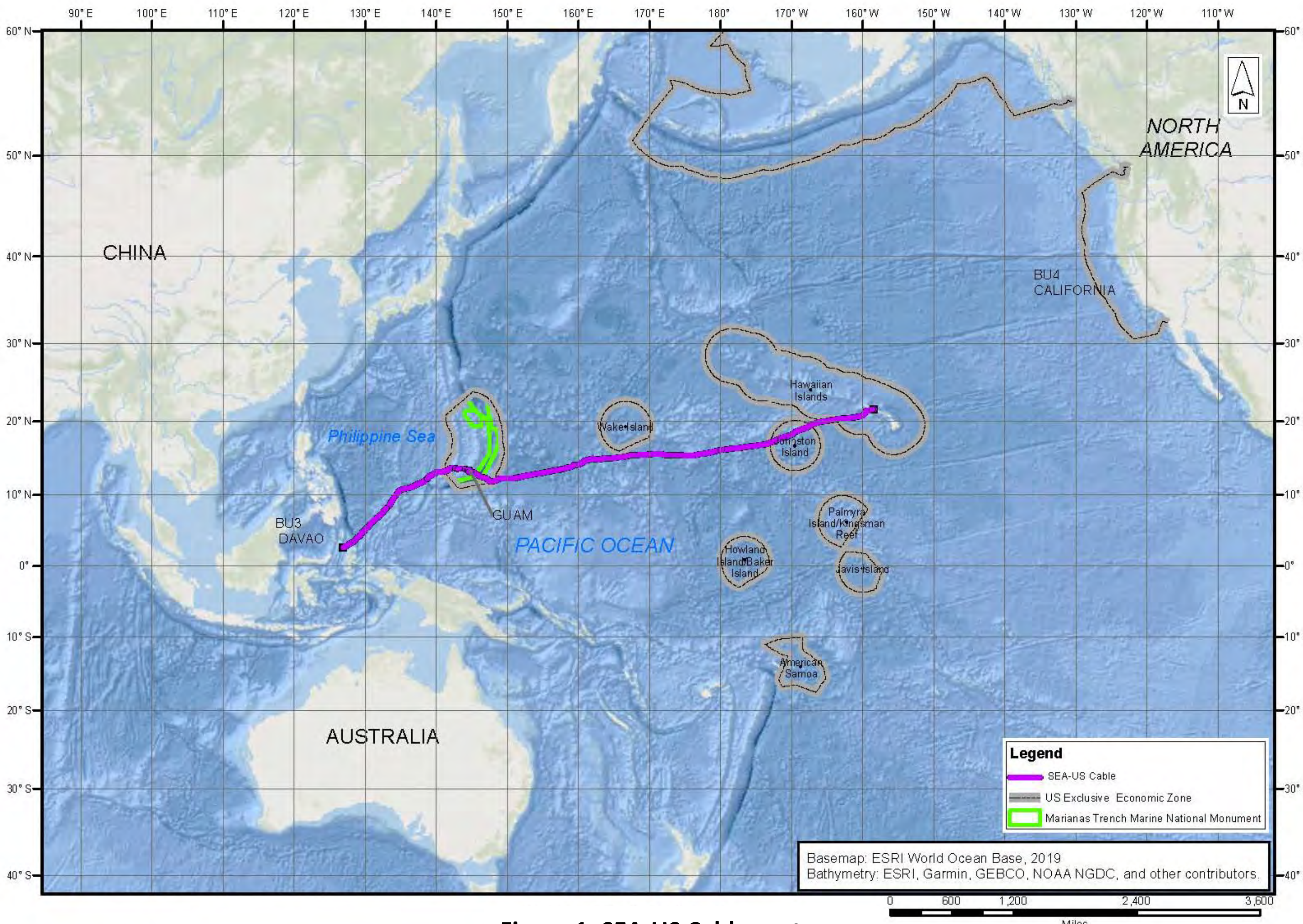


Figure 1. SEA-US Cable route.

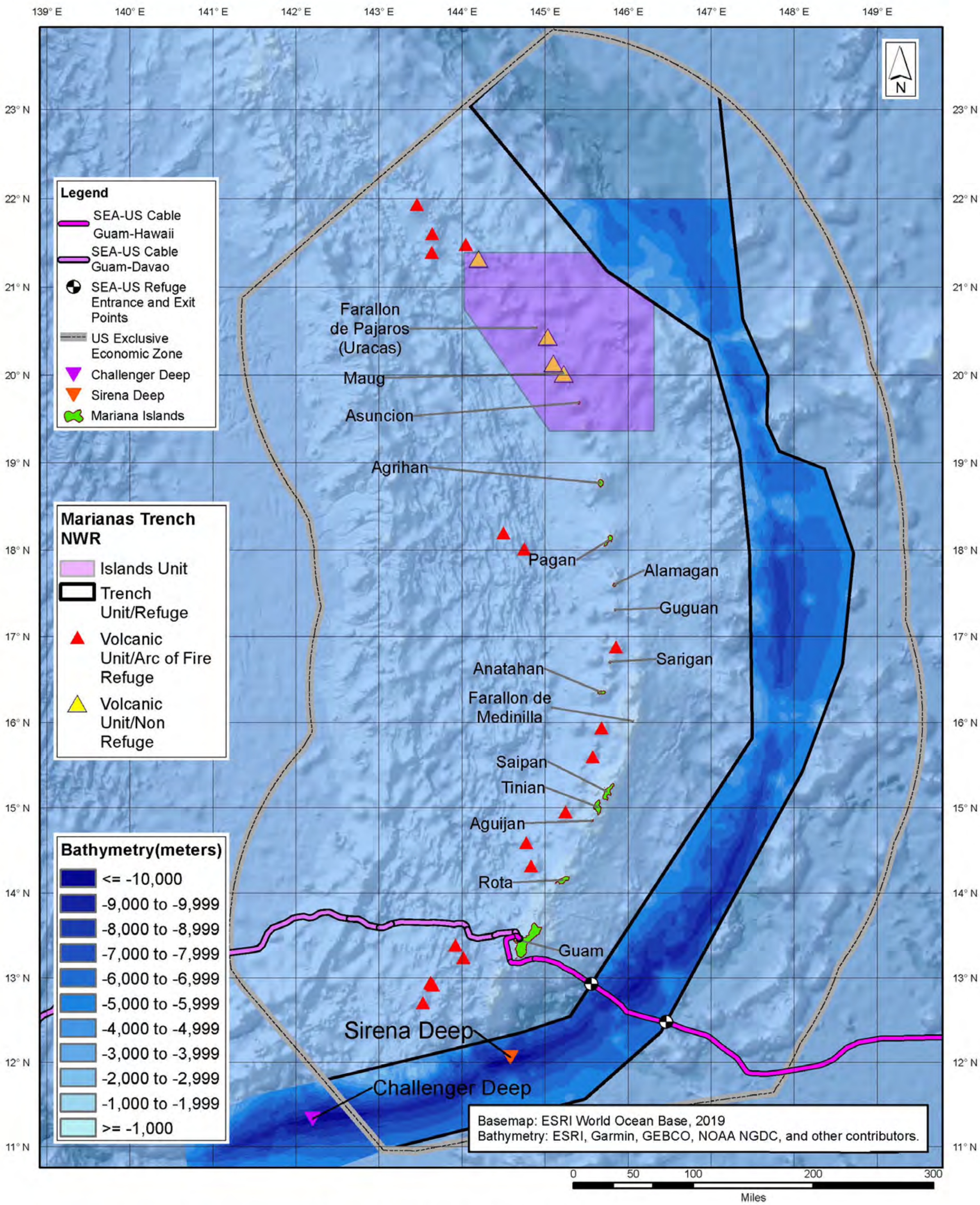
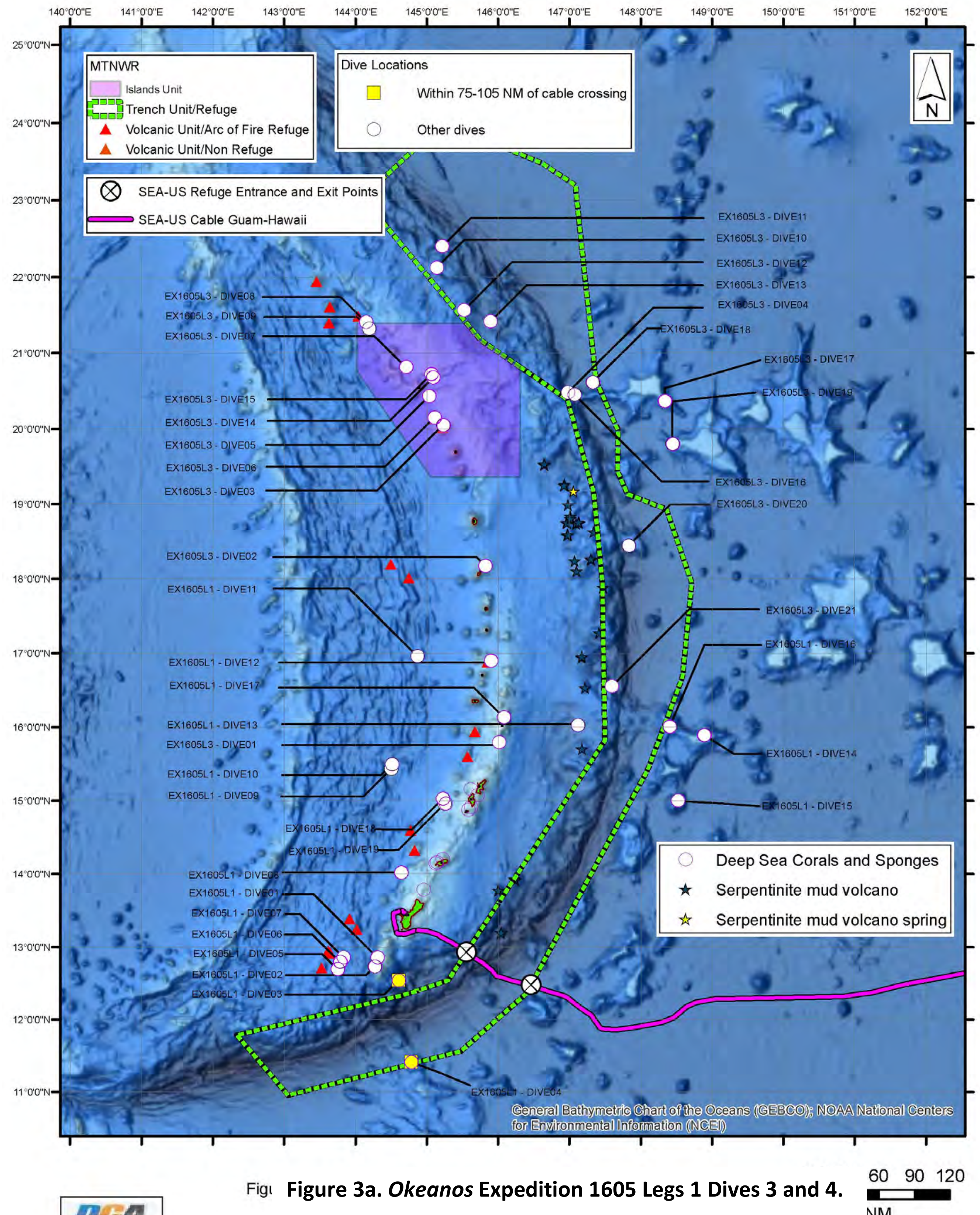


Figure 2. Site location map for the Marianas Trench Marine National Monument Units and the SEA-US Cable.



Figı **Figure 3a. *Okeanos* Expedition 1605 Legs 1 Dives 3 and 4.**

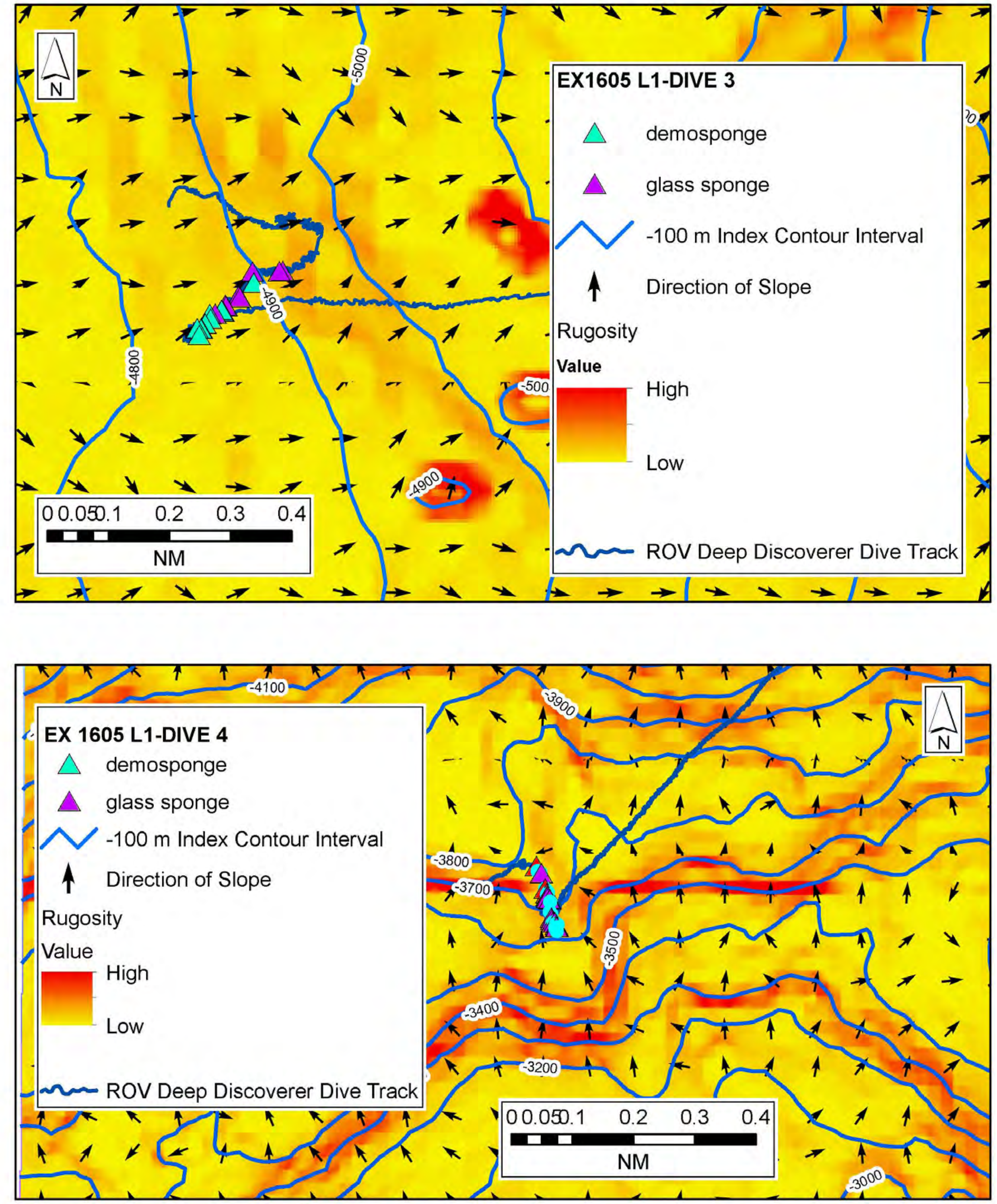


Figure 3b. (Dive 3 and

Figure 3b. *Okeanos* Expedition 1605 Leg 1 Dives 3 and 4.

multibeam bathymetric data from surveys archived at NOAA's National Centers for ...ental Information (NCEI)

NOAA National Database for Deep-Sea Corals and Sponges .

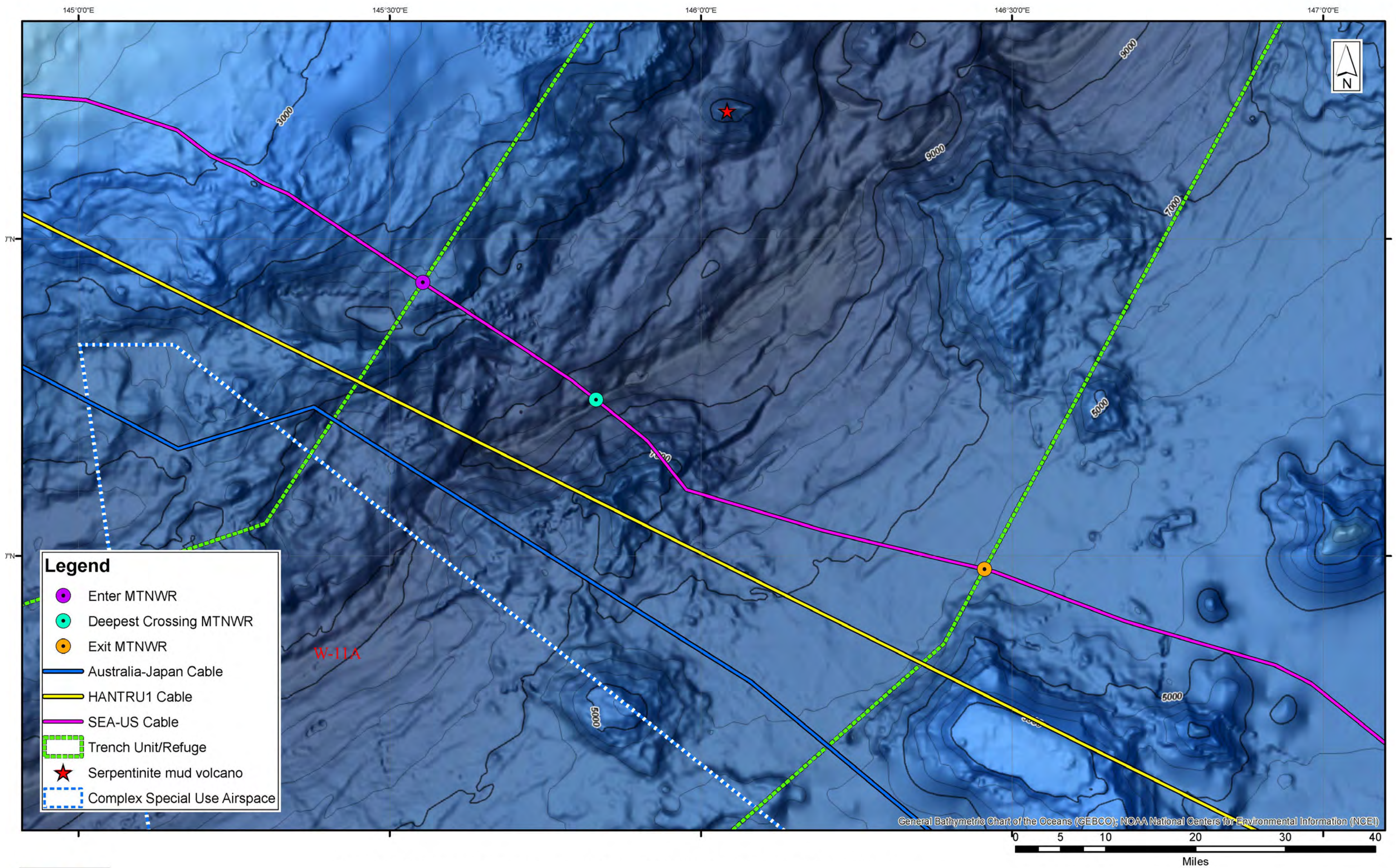


Figure 4. MIRC Warning Areas and approximate location of existing cables along the SEA-US cable route.

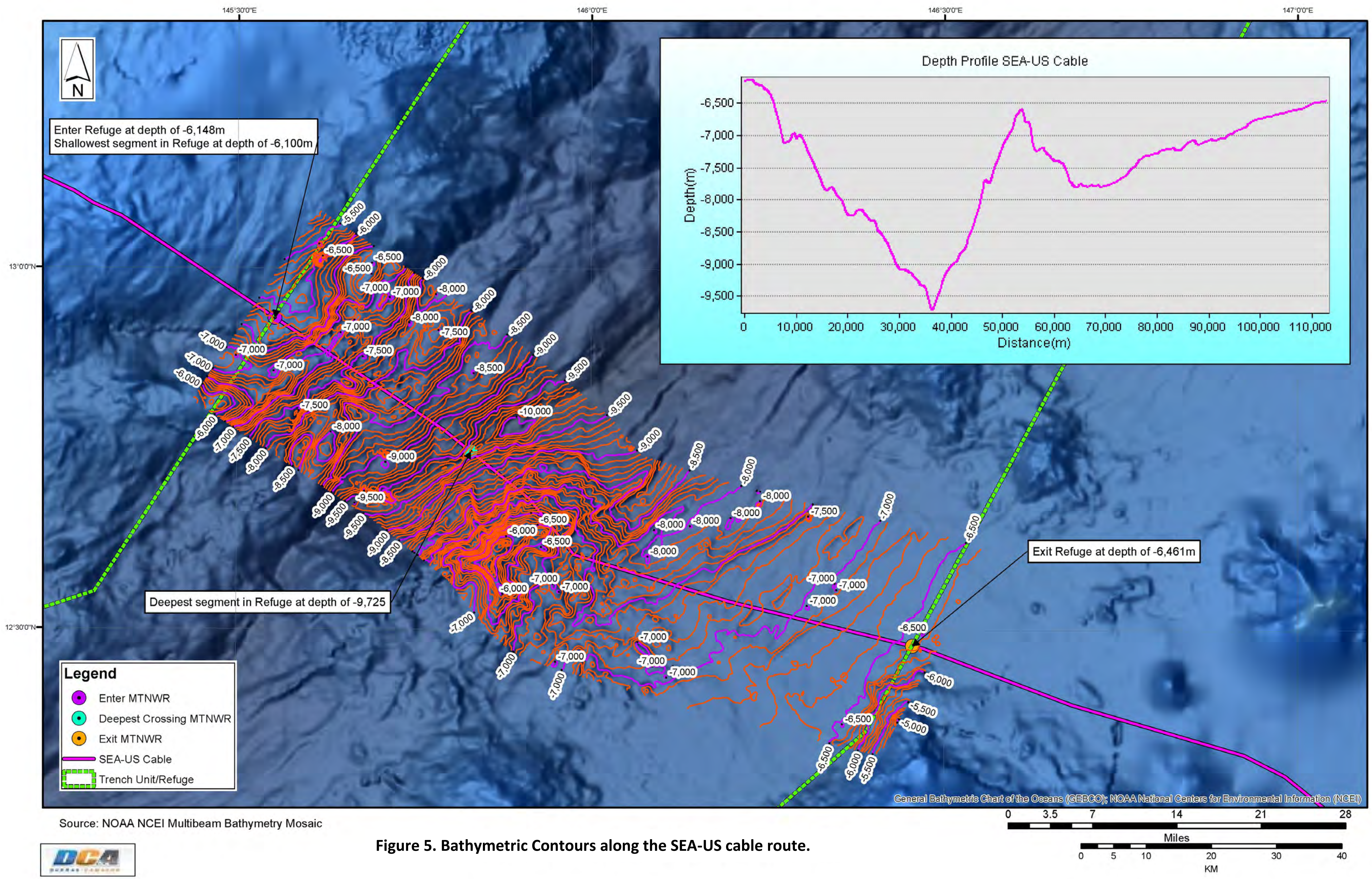


Figure 5. Bathymetric Contours along the SEA-US cable route.

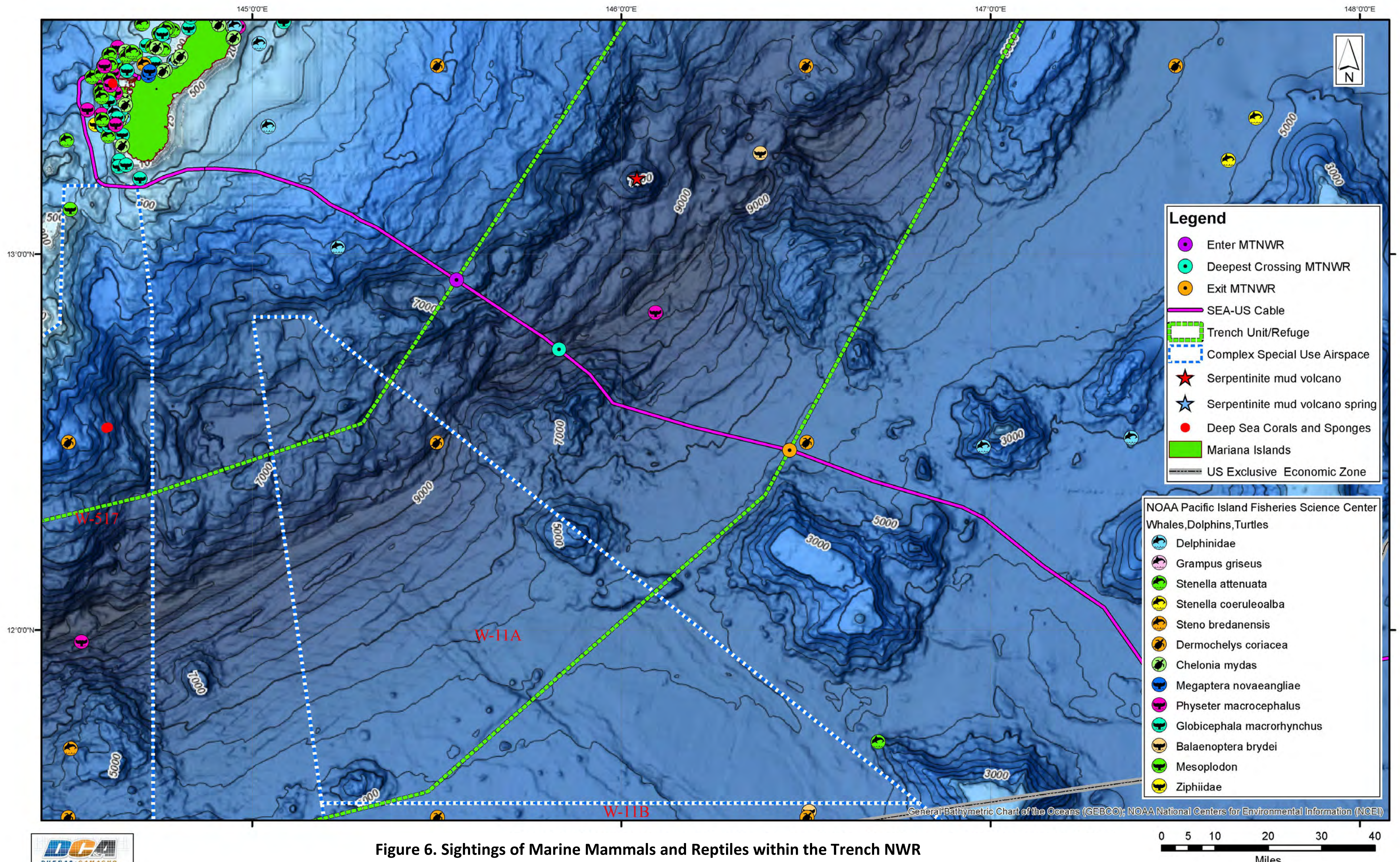
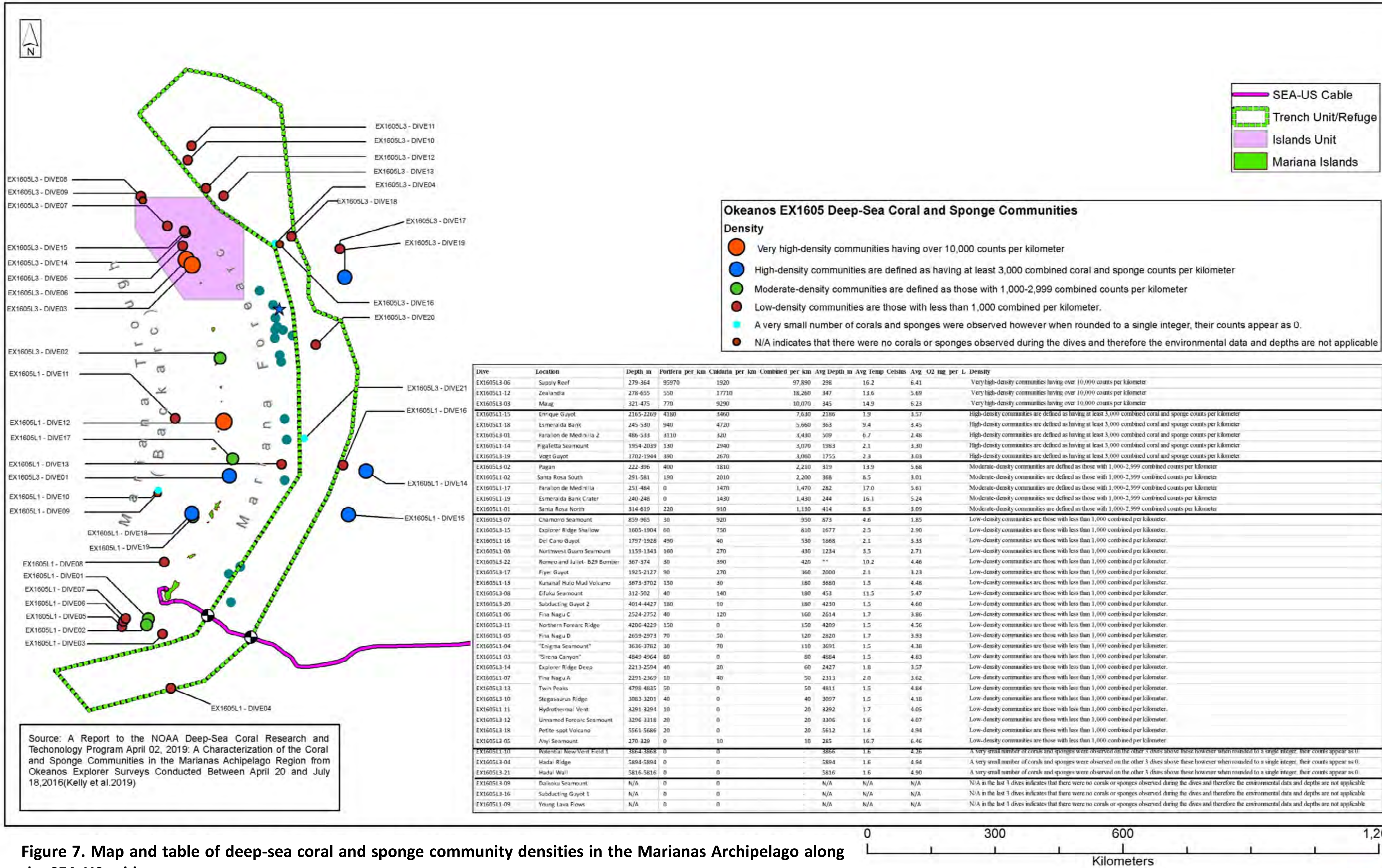


Figure 6. Sightings of Marine Mammals and Reptiles within the Trench NWR along the SEA-US cable route.



Dive	Location	Depth m	Porifera per km	Cnidaria per km	Combined per km	Avg Depth m	Avg Temp Celsius	Avg O2 mg per L	Density
EX1605L3-06	Supply Reef	279-364	95970	1920	97,890	298	16.2	6.41	Very high-density communities having over 10,000 counts per kilometer
EX1605L1-12	Zealandia	278-655	550	17710	18,260	347	13.6	5.69	Very high-density communities having over 10,000 counts per kilometer
EX1605L3-03	Maug	321-475	770	9290	10,070	345	14.9	6.23	Very high-density communities having over 10,000 counts per kilometer
EX1605L1-15	Enrique Guyot	2165-2269	4180	3460	7,630	2186	1.9	3.57	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L1-18	Esmeralda Bank	245-530	940	4720	5,660	363	9.4	3.45	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-01	Farallon de Medinilla 2	486-533	3110	320	3,430	509	6.7	2.48	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L1-14	Pigafetta Seamount	1954-2039	130	2940	3,070	1983	2.1	3.30	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-19	Vogt Guyot	1702-1944	390	2670	3,060	1755	2.3	3.03	High-density communities are defined as having at least 3,000 combined coral and sponge counts per kilometer
EX1605L3-02	Pagan	222-396	400	1810	2,210	319	13.9	5.68	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-02	Santa Rosa South	291-581	190	2010	2,200	368	8.5	3.01	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-17	Farallon de Medinilla	251-484	0	1470	1,470	282	17.0	5.61	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-19	Esmeralda Bank Crater	240-248	0	1430	1,430	244	16.1	5.24	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L1-01	Santa Rosa North	314-619	220	910	1,130	414	8.3	3.09	Moderate-density communities are defined as those with 1,000-2,999 combined counts per kilometer
EX1605L3-07	Chamorro Seamount	859-965	30	920	950	873	4.6	1.85	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-15	Explorer Ridge Shallow	1605-1904	60	750	810	1677	2.5	2.90	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-16	Del Cano Guyot	1797-1928	490	40	530	1868	2.1	3.33	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-08	Northwest Guam Seamount	1159-1343	160	270	430	1234	3.5	2.71	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-22	Romeo and Juliet- B29 Bomber	367-374	30	390	420	**	10.2	4.46	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-17	Fryer Guyot	1925-2127	90	270	360	2000	2.1	3.23	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-13	Kunanaf Hulo Mud Volcano	3673-3702	150	30	180	3680	1.5	4.48	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-08	Eifuku Seamount	312-502	40	140	180	453	11.5	5.47	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-20	Subducting Guyot 2	4014-4427	180	10	180	4230	1.5	4.60	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-06	Fina Nagu C	2524-2752	40	120	160	2614	1.7	3.86	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-11	Northern Forearc Ridge	4206-4229	150	0	150	4209	1.5	4.56	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-05	Fina Nagu D	2659-2973	70	50	120	2820	1.7	3.93	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-04	"Enigma Seamount"	3636-3782	30	70	110	3691	1.5	4.38	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-03	"Sirena Canyon"	4849-4964	80	0	80	4884	1.5	4.83	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-14	Explorer Ridge Deep	2213-2594	40	20	60	2427	1.8	3.57	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-07	Fina Nagu A	2291-2369	10	40	50	2313	2.0	3.62	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-13	Twin Peaks	4798-4835	50	0	50	4811	1.5	4.84	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-10	Stegasaurus Ridge	3083-3201	40	0	40	3097	1.5	4.18	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-11	Hydrothermal Vent	3291-3294	10	0	20	3292	1.7	4.05	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-12	Unnamed Forearc Seamount	3296-3318	20	0	20	3306	1.6	4.07	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-18	Petite-spot Volcano	5561-5686	20	0	20	5612	1.6	4.94	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L3-05	Ahyi Seamount	270-329	0	10	10	285	16.7	6.46	Low-density communities are those with less than 1,000 combined per kilometer.
EX1605L1-10	Potential New Vent Field 1	3864-3868	0	0	-	3866	1.6	4.26	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-04	Hadal Ridge	5894-5894	0	0	-	5894	1.6	4.94	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-21	Hadal Wall	5816-5816	0	0	-	5816	1.6	4.90	A very small number of corals and sponges were observed on the other 3 dives above these however when rounded to a single integer, their counts appear as 0.
EX1605L3-09	Daikoku Seamount	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable
EX1605L3-16	Subducting Guyot 1	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable
EX1605L1-09	Young Lava Flows	N/A	0	0	-	N/A	N/A	N/A	N/A in the last 3 dives indicates that there were no corals or sponges observed during the dives and therefore the environmental data and depths are not applicable

Figure 7. Map and table of deep-sea coral and sponge community densities in the Marianas Archipelago along the SEA-US cable route.

APPENDIX C1. Draft Compatibility Determination for SEA-US Cable Right-of-Way

Draft Compatibility Determination

Title

Right of Way (operating and maintaining the SEA-US submarine telecommunications cable), Mariana Trench National Wildlife Refuge.

Refuge Use Category

Rights-of-way and Rights to Access

Refuge Use Type(s)

Right of Way (landing, operating and maintaining a submarine telecommunications cable).

Refuge

Mariana Trench National Wildlife Refuge.

Refuge Purpose(s) and Establishing and Acquisition Authority(ies)

Mariana Trench NWR:

"… for the development, advancement, management, conservation, and protection of fish and wildlife resources … 16 U.S.C. § 742f(a)(4)

"… for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude …" 16 U.S.C. § 742f(b)(1) (Fish and Wildlife Act of 1956).

"… conservation, management, and … restoration of the fish, wildlife, and plant resources and their habitats … for the benefit of present and future generations of Americans…" 16 U.S.C. § 668dd(a)(2) (National Wildlife Refuge System Administration Act).

"… suitable for— (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species …" 16 U.S.C. § 460k-1

"… the Secretary … may accept and use … real … property. Such acceptance may be accomplished under the terms and conditions of restrictive covenants imposed by donors …" 16 U.S.C. § 460k-2 (Refuge Recreation Act (16 U.S.C. § 460k-460k-4), as amended).

Mariana Trench Marine National Monument:

"…for the purpose of protecting the objects identified above…" "… [Interior Secretary] shall not allow or permit any appropriation, injury, destruction, or removal of any feature of this monument except as provided for by this proclamation or as otherwise provided for by law". (Presidential Proclamation 8335)

"…Regulation of Scientific Exploration and Research…Subject to such terms and conditions as the Secretary deems necessary for the care and management of the objects of this monument, the Secretary of the Interior may permit scientific exploration and research within the monument, including incidental appropriation, injury, destruction, or removal of features of this monument for scientific study…" (Presidential Proclamation 8335)

"…For each of the areas subject to this delegation, the Director of the [USFWS] shall provide for the proper care and management of the monument, including all objects of scientific and historic interest therein; the conservation of fish and wildlife; and the development of programs to assess and promote national and international monument-related scientific exploration and research." (Section 4.a.(2) . . . subject to the provisions of the proclamation [8335] establishing this Monument. . .")." (Secretarial Order 3284).

National Wildlife Refuge System Mission

The mission of the National Wildlife Refuge System, otherwise known as Refuge System, is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans (Pub. L. 105-57; 111 Stat. 1252).

Description of Use

Is this an existing use?

Yes. The Service has previously issued two right-of-way permits for submarine telecommunications cables through the Refuge. This Draft Compatibility Determination has been prepared for a new right-of way permit. NEPA compliance for the operation and maintenance of the SEA-US telecommunications cable is covered under the Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems (USFWS 2023).

What is the use?

The use is issuance of a Right-of-Way Permit, defined as the "right to use and possibly alter the landscape through construction, maintenance, and operation of… powerline, telecommunications line …" on lands under control by the U.S. Fish and Wildlife Service (Service.) The Secretary of the Interior, through his/her authorized representative, the Regional Director, United States Fish and Wildlife Service (Service), in accordance with applicable authorities, and regulations published in 50 CFR 29.21 et. seq., will grant a Right-of- Way Permit to RTI Solutions, Inc. (dba HMB), herein referred to as the Permittee. The permit will grant the Permittee the right to use certain submerged lands within the Mariana Trench National Wildlife Refuge (Refuge) for up to 50 years solely for the purpose of operating, and maintaining a submarine telecommunications cable. The permit includes those activities required to maintain a telecommunications cable on submerged Refuge lands, including, but not limited to post-lay surveys, cable operations, and maintenance and repairs.

Is the use a priority public use?

No

Where would the use be conducted?

The cable route crossed over the Mariana Trench and through the MTMNM for a total linear distance of approximately 70.07 miles (60.89 nautical miles (NM) or 112.77 km). The cable route is the shortest feasible route across the MTMNM. The total cable footprint within the MTMNM is approximately 0.47 acres (20,630.75 square feet (sq. ft)). A summary of cable dimensions within the MTMNM is presented in Table 2-3 of the EA.

The cable was laid flush on the seafloor by a cable-laying ship. Along the cable route, slopes range from 0.90° to 15.20° (1.57% to 27.16%), and water depths range from 6,100 to 9,725 m, spanning the hadal (6,000 to 11,000 m) zone (EA, Appendix B, Figure 5).

When would the use be conducted?

The right-of-way permit would grant the Permittee the right to use certain submerged lands within the Mariana Trench National Wildlife Refuge (Refuge) for up to 50 years solely for the purpose of operating and maintaining a submarine telecommunications cable. The project would have a life of approximately 25 years. The cable would be decommissioned and left in place once it has reached the end of its lifespan.

How would the use be conducted?

A Right-of-Way Permit will be issued by USFWS to RTI Solutions (dba HMB) to authorize the operation and maintenance of the SEA-US fiber-optic communications submarine cable that was laid through a portion of the MTMNM in 2017.

Subsea Fiber-Optic Cable. The SEA-US cable comprises one type of cable, Lightweight (LW) cable, within the MTMNM. The LW cable type is 1.7 cm in diameter (0.67 in), and has inner steel wires surrounding an insulant of natural polyethylene (ICPC, 2014). This cable has a total design capacity of approximately 20 terabits per second (Tbps) of data capacity using 100-gigabit wavelength technology.

Cable Installation. The fiber-optic cable was laid directly on the seabed. Slack was continuously applied at various rates throughout the installation to allow the cable to conform to the contour of the seabed as much as feasible.

Cable Operations and Maintenance. There is no routine monitoring or maintenance associated with the submerged segments of the cable. However, it is possible that emergency repair activities and associated upgrades could occur. Should the permittee need to conduct repairs and/or upgrades to the telecommunications cable, these activities would occur within the ROW. The typical triggers for emergency repair are such things as ship anchors being dragged across the cable route during active anchoring, fishing gear entanglement during active fishing (neither of which would be a concern in the MTMNM due to the great depths), and equipment failure. The Right-of-Way permit will include conditions governing the ability to continue to conduct scientific research using ROVs in proximity to the cable. ROVs are generally not permitted to operate near known sea floor cables. However, the applicant has agreed to conditions in the right-of-way permit that allow the operation of ROVs in proximity of the cable.

Emergency Repair. If the cable needs to be repaired in the MTMNM, it would need to be recovered to the cable ship for repair. Because of the depth of the cable, the operation would take place in several steps. First a flatfish grapnel fitted with a cutting blade would be pulled until it snags and cuts the cable. Then a Gifford grapnel would be used to retrieve one end of the cable to the cable ship. After the cable is recovered, the end would be prepared and the fibers tested using a conventional optical time-domain reflectometer (OTDR). After conducting the necessary tests onboard the cable ship, this end of the cable would be sealed and buoyed off for easy recovery later.

Next, the other cable end would be recovered and similarly tested to locate the fault more precisely. The cable ship would retrieve this end of cable until the fault is aboard. After the fault site (either a cable or repeater section) is removed from the system, the repaired cable would be joined to the fault-free cable end and paid out as the vessel returns to the buoyed end. When the buoy is recovered aboard the ship, the two cable ends would be joined. After final testing, the cable would then be paid out through the stern of the ship to settle on the ocean floor.

Retirement, Abandonment, or Removal of the Cable Systems. The project would have a life of approximately 25 years. After a cable is decommissioned, it is typically abandoned in place. Abandonment in place would cause fewer environmental impacts than recovering the cable from the seafloor.

Why is this use being proposed or reevaluated?

The freedom to lay undersea cables has long been recognized as a lawful use of the sea. The United States recognizes this right under the Convention on the High Seas (1958), Article 2: the Convention on the Continental Shelf (1958), Article 4; and the United Nations Convention on the Law of the Sea (UNCLOS) which provides that within the Exclusive Economic Zone (EEZ) (200 nautical miles (NM)), all states enjoy the "freedoms referred to in Article 87 of navigation and overflight and of the laying of submarine cables and pipelines." (Article 58). The SEA-US cable system will continue to enhance and contribute to the expansion of communications networks between Guam, CNMI, Davao (Philippines), Manado (Indonesia) and the U.S. (Hawaii and California) within the greater SEA-US network. The SEA-US cable system will further enhance and contribute to the expansion of communications networks between Asia and the United States, thereby improving network redundancy, ensuring highly reliable communications, and expanding onward connectivity options in Guam and CNMI.

Availability of Resources

In general, the Refuge will incur no expense except administrative costs for review of applications, issuance of a ROW Permit, and staff time to conduct a literature review and complete a finding of appropriateness (FOA) and compatibility determination (CD). The Permittee will oversee the landing of the submarine cable and will be responsible for maintenance of the cable (EA, Appendix B, Figure 1).

Administrative Costs:
Review request, coordination, and process ROW Permit: 4 staff: 58 hours: $2,250.00
Conduct literature review, process FOA and CD: 1 staff: 20 hours: $1,150.00
Total $3,400.00.

Anticipated Impacts of the Use

The effects and impacts of the proposed use to refuge resources, whether adverse or beneficial, are those that are reasonably foreseeable and have a reasonably close causal relationship to the proposed use. This CD includes the written analyses of the environmental consequences on a resource only when the impacts on that resource could be more than negligible and therefore considered an "affected resource." Water and air quality, geology and soils, floodplains, wilderness, environmental justice, and climate change will not be more than negligibly impacted by the action and have been dismissed from further analyses.

Potential impacts of a proposed use on the refuge's purpose(s) and the Refuge System mission

Most of the possible impacts recognized are over or within the water column, and therefore outside the boundary of the Refuge (The Mariana Trench NWR includes only submerged lands within the Mariana Trench Marine National Monument). Possible impacts to the bottom community of Mariana Trench NWR, including disturbance to benthic marine organisms, are described in Short-term and Long-term Impacts, below. However, these impacts are likely to be minor to negligible, and would not materially interfere with or detract from the Refuge's ability to meet its purposes, or the Refuge System mission.

Short-term impacts

Impacts of laying and maintaining the submarine cable were analyzed in the Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems (USFWS 2022). The cable route was surveyed to ensure safety and to minimize impacts to habitat. Impacts to habitat and wildlife caused by the Permittee's use of the ROW are expected to be short term and minor, as described below.

Cables in deep water environments are generally laid on the surface of the ocean floor, as was performed for the SEA-US Cable. Environmental impacts associated with submarine cables can generally be attributed to either installation, maintenance and repair work, and removal; or the operational phase.

The Refuge consists only of submerged lands. The National Marine Fisheries Service oversees activities that have the potential to affect fish and marine mammals living in the waters above the refuge. Therefore, only effects to the benthic environment are analyzed here. Effects to fish (other than benthic species) and marine mammals from multibeam sonar used during cable route surveys, noise associated with the vessel and any laying machinery, visual disturbance from the vessel, and potential collisions between the vessel and marine mammals, are not analyzed.

Candidate actions potentially responsible for interactions with the benthic environment include laying down the cable on the seafloor, short and long-term interactions of the cable and its environment, and cable retrieval in the event of a fault or at the end of the cable's lifespan.

When placed in waters more than 2,000 meters in depth, cables are generally not buried. They are simply laid across the ocean floor. This is because, at such depths, cables are significantly less susceptible to potentially harmful interactions with living marine resources. The degree of benthic disturbance caused by laying submarine cables depends on the habitat and its associated ecosystem. The underlying geology of the proposed cable route has not been extensively studied or surveyed. Hadal zone researchers Heather Stewart and Alan Jamieson studied areas in the hadal and adjacent abyssal slope zones of the southern MTMNM (Stewart and Jamieson 2018). They classified the basic geologic structure by depth zones. Substrate types were categorized through the analysis of photographic data. Within the water depth range of 4,506 m to 5,641 m, the dominant seabed sediment observed comprised muddy gravel, with one observation each of bedrock, bedrock and fine-grained sediment, and gravelly fine-grained sediment across all fifteen sampling stations (Stewart and Jamieson 2018). Within the water depth range of 6,008 to 7,941 m, gravelly fine-grained sediment was the dominating sediment type; fine-grained sediment, bedrock, slightly gravelly fine-grained sediment, and muddy gravel were also observed within this depth range (Stewart and Jamieson 2018).

Deep sea coral and sponge communities occur in areas of clear water, such as on ridges, seamounts, canyon walls and shelf-edge breaks, where there is hard substratum, sufficient food, and moderate to strong currents (Hourigan et al. 2017). These communities are richest in areas of high slope and terrain roughness (rugosity). The existing SEA-US cable corridor has areas of higher slope and terrain roughness in the western sector. Although there are no known deep-sea coral and sponge communities along the cable route, there is an inferred higher probability for the presence of deep-sea corals and sponges at these locations. The closest mapped deep sea coral or sponge community in the MTMNM is located approximately 115 miles (185 km) southeast of the cable route.

Laying submarine cable, though a relatively short-lived activity, can be disruptive to the area and ecosystem in which it is carried out. There is a low potential for adverse impacts on biological resources within the cable's relatively narrow footprint. Potential impacts from the cable-laying process include laying the cable directly on, damaging, or abrading sessile or slow-moving organisms, although given the 1.7 cm (0.67 in) diameter of the cable, the likelihood of direct adverse impacts was low. Organisms, including deep-sea coral and sponge communities in the vicinity of the cable route, may have also been adversely affected by the temporary disturbance of surface sediments and the associated increase in turbidity. Increases in turbidity and suspended sediments were localized and temporary and were eventually dispersed by benthic currents.

A collaborative study conducted by the Monterey Bay Aquarium Research Institute (MBARI) and the National Oceanic and Atmospheric Administration division of Oceanographic and Atmospheric Research (NOAA-OAR) investigated the potential interactive effects between a fiber-optic submarine cable and its environment (Kogan et al. 2006). Results from this study indicated that the cable had few detectable effects on marine life. Although this was generally the case, in areas with soft sediments, the cable provided an artificial solid substrate that a number of different species sought out. This is known as the 'reef-effect' and results in species inhabiting an area that they typically would not (OSPAR 2009). The 'reef-effect' has been studied extensively and has been found in many cases to lead to the introduction of non-local biota and the alteration of the natural benthic community. The introduction on non-local biota is highly unlikely given the depth of the cable. Localized changes in the benthic community are possible, but would likely be temporary as the cable becomes buried in the sediments over time (Kerchhof et al. 2007, Tyrell and Byers 2007, OSPAR 2009).

Fiber-optic cables primarily transmit light; however, they also use a small amount of electricity to power the repeaters and boost the telecommunications signal, and therefore transmit small amounts of electromagnetic radiation and heat to the surrounding environment. During normal operation, the cable is powered by direct current (DC). DC currents produce the same type of magnetic field as the earth. The magnetic field generated by the cable is hundreds of times smaller than the Earth's magnetic field and thus would not be detectible or distinguishable against the Earth's field. A small amount of electromagnetic radiation may be produced by submarine fiber-optic cables during the rare events when the cable suffers an outage and AC electroding is used to find faulted cables. These would be exceedingly rare, short-term events and would generate very low levels of radiation comparable to background levels naturally produced by the earth. Therefore, it is expected that the weak magnetic fields produced by the SEA-US cable would have a negligible potential effect on marine organisms.

The submarine cable system is designed and manufactured to be electrically isolated from the environment and in the event of an incident resulting in an insulation cable fault, the cable will be automatically grounded to zero as it comes into contact with water. Consequently, there will likely be negligible effects resulting from electricity associated with the cable.

Long-term impacts

Once in place—if correctly laid—submarine cables have thus far not been shown to have a significant adverse effect on the surrounding marine environment since they are generally immobile once placed and coated with a layer of polyethylene, which is inert in seawater. Leaching from cables and their repeaters is believed to pose very little risk to the surrounding environment –especially in extremely deep environments (Collins 2007; Andrady 2000). Chemical breakdown processes, such as oxidation, hydrolysis, and mineralization, are extremely slow – largely as a result of low UV penetration at those depths. In a study conducted by Andrady (2000), it was predicted that total conversion of cable-grade polyethylene to carbon dioxide and water would take centuries.

Impacts to the Public: The existing regulated uses within the Mariana Trench NWR would continue after the laying of the cable. These include research and exploration of the Mariana Trench with the proper federal permits, and commercial fishing in compliance with federal regulations.

In summary, the issuance of the ROW Permit to operate and maintain the SEA-US telecommunications cable would result in negligible negative impacts to the benthic habitat and marine life; negligible long-term impacts to the benthic habitat and marine life; and no negative impacts to the public. There would be long-term positive impacts to the public since the SEA-US cable system will further enhance and contribute to the expansion of communications networks between Asia and the United States, thereby improving network redundancy, ensuring highly reliable communications, and expanding onward connectivity options in Guam and CNMI.

Public Review and Comment

This compatibility determination has been prepared concurrently with an Environmental Assessment (EA), which addresses environmental effects associated with the proposed ROW for the subject submarine telecommunications cable. The EA and Draft Compatibility Determination will be available for public review and comment for a period of 15 days in June 2023. The public will be notified of the opportunity to review and comment on the CD and EA through media releases and posting of the EA and CD on the Refuge's webpage. The Permittee and the Service coordinated with the Navy through correspondence with Ms. Catherine Creese, Assistant Director, U.S. Naval Seafloor Cable Protection Office (NSCPO), in Washington, D.C. Concerns expressed during the public comment period will be addressed in the final.

Determination

Is the use compatible?

Yes

Stipulations Necessary to Ensure Compatibility

To ensure compatibility with the National Wildlife Refuge System and the refuge goals and objectives, installation and maintenance of the aforementioned submarine fiber optic cable can only occur under the following conditions:

1. The Service reserves the right to authorize other activities, including research involving remote operated vehicles (ROVs), in the vicinity of the cable. Before permitting activities within 500 meters of the final as-built location of the cable, the Service will consult with the Permittee to establish protocols for communications and operations to minimize the potential for impacts to the cable. The Permittee will ensure that the final coordinates identifying the location of the cable are fully communicated and has agreed to conditions in the right-of-way permit that allow the operation of ROVs in proximity of the cable.
2. The Permittee will produce and share the "as built" legal description describing the accurate location of the cable to the Service, within 180 days after it has been laid on the seafloor.
3. To minimize the risk of introducing contaminants into the marine environment, all instruments and equipment (including small boats) should be checked prior to deployment to ensure that there are no contaminant leaks (oil, fuel, hydraulic fluid, etc.) which could affect marine resources in the project area.
4. If any instruments or equipment is found to not be in good working order, it should be removed from service until all necessary repairs have been made which would prevent a release of contaminants.
5. The crew of the vessel used to lay the cable should try to minimize the amount of detergents and other noxious substances that might be washed

overboard as part of an effort to clean instruments or equipment used during the cruise or in day-to-day operation of the vessel.

6. To prevent the spread of disease or invasive species, all equipment used in the cable laying operation should be rinsed with fresh water when practical.
7. A robust biosecurity plan must be submitted for review prior to cable laying operations to ensure that invasive species will not be inadvertently introduced into the Monument/Refuge.
8. Birds at sea have the potential to be attracted to or confused by lights on the vessel. At night the ship shall use the minimum amount of light necessary for legal and safe transit when underway. Through coordination with the USFWS, the cable ship operators will be briefed on the potential for bird encounters and will follow these protocols:
   A. After putting on gloves, the operators will pick up any downed birds and place them in a clean box to prevent soiling of their feathers .
   B. The birds will be kept in a cool, safe place until daylight.
   C. The birds will then be placed in an open area near the stern of the cable ship where they can take off when ready.
   D. Photographs of any downed birds will be taken to document distribution of species at sea and the USFWS will be notified and provided with these photographs.
9. The Permittee shall notify the Refuge Manager or his/her designee a minimum of 2 weeks prior to commencing with installation of the submarine cable to avoid conflicts with Refuge programs.
10. Any operations to conduct emergency repairs or maintenance of the cable must be coordinated with the Refuge Manager prior to scheduling said repair or maintenance.
11. The Permittee shall notify the Refuge Manager 30 days prior to the cable decommission date.
12. Consistent with regulations at 50 CFR 25.21(h), the Service reserves the right to modify terms and conditions of the ROW permit in the future, as necessary to ensure continued compatibility with the use and occupancy of the land.

Justification

It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of the Refuge will not be measurably lessened during the submarine cable installation, operation and maintenance activities facilitated by the proposed use. The relatively limited number of wildlife individuals expected to be adversely affected during the operation and maintenance of the submarine cable will not cause wildlife populations to materially decline, the physiological condition and production of wildlife species present will not be impaired, alterations to the behavior and normal activity patterns will be minor or nonexistent, and their overall welfare will not be negatively impacted.

The right of way as described is determined to be compatible because potential impacts from the permittee's use of this right of way on wildlife that use this Refuge unit would be minimal and not materially interfere with or detract from achievement of the NWRS mission or from the Service's ability to achieve Refuge wildlife, habitat, or other public-use-related purposes and goals.

Signature of Determination

Refuge Manager Signature and Date

Signature of Concurrence

Assistant Regional Director Signature and Date

Mandatory Reevaluation Date

The reevaluation date will be indicated after this CD is finalized.

Literature Cited/References

Andrady, A.L., 2000. Plastics and their impacts in the marine environment. Proceedings International Marine Debris Conference on Derelict Fishing Gear and the Marine Environment, Hawaii, August.

Collins, K., 2007. Isle of Man cable study – Preliminary material environmental impact studies. Preliminary report, University of Southampton.

Hourigan T.F., P.J. Etnoyer P.J. and S. D. Cairns. 2017. The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. 467 p.

International Cable Protection Committee (ICPC). 2014. Glossary. URL: https://www.iscpc.org/information/learn-about-submarine-cables/glossary/
Kerchhof, F., B. Rumes, T. Jaques, S. Degraer, and A. Norro. 2010. Early development of the subtidal marine biofouling on a concrete offshore windmill foundation on the Thornton Bank (southern North Sea): first monitoring results. Underwater Technology 29: 137-149.

Kogan, I., C. Paull, L. Kuhnz, E. Burton, S. Von Thun, H. G. Greene, J. Barry. 2006. ATOC/Pioneer Seamount cable after 8 years on the seafloor: Observations, environmental impact. Continental Shelf Research 26: 771-787.

NOAA. 2017. Submarine cables: domestic regulation. URL: https://www.gc.noaa.gov/gcil_submarine_cables_domestic.html Accessed September 21, 2018.

OSPAR. 2008. Background Document on potential problems associated with power cables other than those for oil and gas activities. – Publication Number: 370/2008, 50 pp.

Stewart, H. and A. Jamieson. 2018. Habitat Heterogeneity of Hadal Trenches: Considerations and Implications for Future Studies. Progress in Oceanography. Volume 161: 47-65.

Tyrell, M. C. and J. E. Byers. 2007. Do artificial substrates favour non indigenous fouling species over native species? Journal of Experimental Marine Biology and Ecology. 342: 54-60.

USFWS. 2023. Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems.

APPENDIX C2. Draft Compatibility Determination for BIFROST Cable Right-of Way

Draft Compatibility Determination

Title

Right of Way (landing, operating and maintaining a submarine telecommunications cable), Mariana Trench National Wildlife Refuge.

Refuge Use Category

Rights-of-way and Rights to Access

Refuge Use Type(s)

Right of Way (landing, operating and maintaining a submarine telecommunications cable).

Refuge

Mariana Trench National Wildlife Refuge.

Refuge Purpose(s) and Establishing and Acquisition Authority(ies)

"… for the development, advancement, management, conservation, and protection of fish and wildlife resources … 16 U.S.C. § 742f(a)(4)

"… for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude …" 16 U.S.C. § 742f(b)(1) (Fish and Wildlife Act of 1956).

"… conservation, management, and … restoration of the fish, wildlife, and plant resources and their habitats … for the benefit of present and future generations of Americans…" 16 U.S.C. § 668dd(a)(2) (National Wildlife Refuge System Administration Act).

"… suitable for— (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species …" 16 U.S.C. § 460k-1

"… the Secretary … may accept and use … real … property. Such acceptance may be accomplished under the terms and conditions of restrictive covenants imposed by donors …" 16 U.S.C. § 460k-2 (Refuge Recreation Act (16 U.S.C. § 460k-460k-4), as amended).

Presidential Proclamation 8335 (6 Jan 2009) established the Mariana Trench Marine National Monument in an area of 95,216 sq. miles, under the authority of the

Antiquities Act of 1906. The Secretary of the Interior has management responsibility, except that the Secretary of Commerce has primary responsibility for the fishery related activities. Secretary's Order 3284 (16 Jan 2009) directed the Director of the Fish and Wildlife Service to manage the Trench Unit (Mariana Trench NWR) as a unit of the National Wildlife Refuge System.

National Wildlife Refuge System Mission

The mission of the National Wildlife Refuge System, otherwise known as Refuge System, is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans (Pub. L. 105-57; 111 Stat. 1252).

Description of Use

Is this an existing use?

Yes. The Service has previously issued two right-of-way permits for submarine telecommunications cables through the Refuge. This Draft Compatibility Determination has been prepared for a new right-of way permit. NEPA compliance for the landing, operation, and maintenance of the telecommunications cable is covered under the Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems (USFWS 2023).

What is the use?

The use is issuance of a Right-of-Way Permit, defined as the "right to use and possibly alter the landscape through construction, maintenance, and operation of… powerline, telecommunications line …" on lands under control by the U.S. Fish and Wildlife Service (Service.) The Secretary of the Interior, through his/her authorized representative, the Regional Director, United States Fish and Wildlife Service (Service), in accordance with applicable authorities, and regulations published in 50 CFR 29.21 et. seq., will grant a Right-of- Way Permit to RTI Solutions, Inc. (dba HMB), herein referred to as the Permittee. The permit will grant the Permittee the right to use certain submerged lands within the Mariana Trench National Wildlife Refuge (Refuge) for up to 50 years solely for the purpose of landing, operating, and maintaining a submarine telecommunications cable. The permit includes those activities required to install and maintain a telecommunications cable on submerged Refuge lands, including, but not limited to, cable installation (laying), pre- and post-lay surveys, cable operations, and maintenance and repairs.

Is the use a priority public use?

No

Where would the use be conducted?

The cable route will cross over the Mariana Trench and through the MTMNM for a total linear distance of approximately 98.91 miles (159.18 km). The cable route is the shortest feasible route across the MTMNM. The total cable footprint within the MTMNM is approximately 0.89 acres (38,550 square feet (sq. ft)). A summary of cable dimensions within the MTMNM is presented in Table 2-2 of the EA.

The cable will be laid flush on the seafloor by a cable-laying ship. Along the proposed cable route, slopes range from 0.61° to 8.37° (1.07% to 14.61%), and water depths range from 3,660 to 7,230 m, spanning the abyssal (4,000 to 6,000 m) and hadal (6,000 to 11,000 m) zones, based on a non-intrusive bathymetric survey in 2021 (EA, Appendix A, Figure 5).

When would the use be conducted?

The right-of-way permit would grant the Permittee the right to use certain submerged lands within the Mariana Trench National Wildlife Refuge (Refuge) for up to 50 years solely for the purpose of landing, operating, and maintaining a submarine telecommunications cable. The project would have a life of approximately 25 years. The cable would be decommissioned and left in place once it has reached the end of its lifespan.

How would the use be conducted?

A Right-of-Way Permit would be issued by USFWS to RTI Solutions (dba HMB) to allow the landing of the BIFROST fiber-optic communications submarine cable through a portion of the MTMNM.

Subsea Fiber-Optic Cable. The BIFROST cable will comprise Lightweight Protected (LWP) cable within the MTMNM. The LWP cable type is 2.25 centimeters (cm) in diameter (0.88 inch (in)), and has inner steel wires surrounding an insulant of natural polyethylene (ICPC, 2014). The LWP cable type is needed to ensure the cable is sufficiently protected in the deeper portions of the Mariana Trench.

Cable Installation. The fiber-optic cable will be laid directly on the seabed. The cable laying ship will proceed at approximately 3.7 kilometers per hour (2 knots). Slack will be continuously applied at various rates throughout the installation to allow the cable to conform to the contour of the seabed as much as feasible.

Cable Operations and Maintenance. There is no routine monitoring or maintenance associated with the submerged segments of the cable. However, it is possible that emergency repair activities and associated upgrades could occur. Should the Permittee need to conduct repairs and/or upgrades to the telecommunications cable, these activities would occur within the ROW. The typical triggers for emergency repair are such things as ship anchors being dragged across the cable route during active anchoring, fishing gear entanglement during active fishing (neither of which would be a concern in the MTMNM due to the great depths), and equipment failure. The Right-of-Way permit will include conditions governing the ability to continue to conduct scientific research using ROVs in proximity to the cable. ROVs are generally not permitted to operate near known sea floor cables. However, the Permittee has agreed to conditions in the right-of-way permit that allow the operation of ROVs in proximity of the cable.

Emergency Repair. If the cable needs to be repaired in the MTMNM, it would need to be recovered to the cable ship for repair. Because of the depth of the cable, the operation would take place in several steps. First a flatfish grapnel fitted with a cutting blade would be pulled until it snags and cuts the cable. Then a Gifford grapnel would be used to retrieve one end of the cable to the cable ship. After the cable is recovered, the end would be prepared and the fibers tested using a conventional optical time-domain reflectometer (OTDR). After conducting the necessary tests onboard the cable ship, this end of the cable would be sealed and buoyed off for easy recovery later.

Next, the other cable end would be recovered and similarly tested to locate the fault more precisely. The cable ship would retrieve this end of cable until the fault is aboard. After the fault site (either a cable or repeater section) is removed from the system, the repaired cable would be joined to the fault-free cable end and paid out as the vessel returns to the buoyed end. When the buoy is recovered aboard the ship, the two cable ends would be joined. After final testing, the cable would then be paid out through the stern of the ship to settle on the ocean floor.

Retirement, Abandonment, or Removal of the Cable Systems. The project would have a life of approximately 25 years. After a cable is decommissioned, it is typically abandoned in place. Abandonment in place would cause fewer environmental impacts than recovering the cable from the seafloor.

Why is this use being proposed or reevaluated?

The freedom to lay undersea cables has long been recognized as a lawful use of the sea. The United States recognizes this right under the Convention on the High Seas (1958), Article 2: the Convention on the Continental Shelf (1958), Article 4; and the United Nations Convention on the Law of the Sea (UNCLOS) which provides that within the Exclusive Economic Zone (EEZ) (200 nautical miles (NM)), all states enjoy the "freedoms referred to in Article 87 of navigation and overflight and of the laying of submarine cables and pipelines." (Article 58). The BIFROST cable system will enhance and contribute to the expansion of communications networks between Guam, CNMI, Singapore, Indonesia, Philippines and the U.S. mainland (California) within the greater BIFROST network. The BIFROST cable system will further enhance and contribute to the expansion of communications networks between Asia and the United States, thereby improving network redundancy, ensuring highly reliable communications, and expanding onward connectivity options in Guam and CNMI.

Availability of Resources

In general, the Refuge will incur no expense except administrative costs for review of applications, issuance of a ROW Permit, and staff time to conduct a literature review and complete a finding of appropriateness (FOA) and compatibility determination (CD). The Permittee will oversee the landing of the submarine cable and will be responsible for maintenance of the cable (EA, Appendix A, Figure 1).

<u>Administrative Costs:</u>
Review request, coordination, and process ROW Permit: 4 staff: 58 hours: $2,250.00
Conduct literature review, process FOA and CD: 1 staff: 20 hours: $1,150.00
Total $3,400.00.

Anticipated Impacts of the Use

The effects and impacts of the proposed use to refuge resources, whether adverse or beneficial, are those that are reasonably foreseeable and have a reasonably close causal relationship to the proposed use. This CD includes the written analyses of the environmental consequences on a resource only when the impacts on that resource could be more than negligible and therefore considered an "affected resource." Water and air quality, geology and soils, floodplains, wilderness, environmental justice, and climate change will not be more than negligibly impacted by the action and have been dismissed from further analyses.

Potential impacts of a proposed use on the refuge's purpose(s) and the Refuge System mission

Most of the possible impacts recognized are over or within the water column, and therefore outside the boundary of the Refuge (The Mariana Trench NWR includes only submerged lands within the Mariana Trench Marine National Monument). Possible impacts to the bottom community of Mariana Trench NWR, including disturbance to benthic marine organisms, are described in Short-term and Long-term Impacts, below. However, these impacts are likely to be minor to negligible, and would not materially interfere with or detract from the Refuge's ability to meet its purposes, or the Refuge System mission.

Short-term impacts

Impacts of laying and maintaining the submarine cable were analyzed in the Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems (USFWS 2022). The location of the proposed right of way was surveyed to ensure safety and to minimize impacts to habitat. Impacts to habitat and wildlife caused by the Permittee's use of the ROW are expected to be short term and minor, as described below.

Cables in deep water environments are generally laid on the surface of the ocean floor, as is being proposed for the BIFROST Cable. Environmental impacts associated with submarine cables can generally be attributed to either installation, maintenance and repair work, and removal; or the operational phase.
The Refuge consists only of submerged lands. The National Marine Fisheries Service oversees activities that have the potential to affect fish and marine mammals living in the waters above the refuge. Therefore, only effects to the benthic environment are analyzed here. Effects to fish (other than benthic species) and marine mammals from multibeam sonar used during cable route surveys, noise associated with the vessel and any laying machinery, visual disturbance from the vessel, and potential collisions between the vessel and marine mammals, are not analyzed.

Candidate actions potentially responsible for interactions with the benthic environment include laying down the cable on the seafloor, short and long-term interactions of the cable and its environment, and cable retrieval in the event of a fault or at the end of the cable's lifespan.

When placed in waters more than 2,000 meters in depth, cables are generally not buried. They are simply laid across the ocean floor. This is because, at such depths, cables are significantly less susceptible to potentially harmful interactions with living marine resources. The degree of benthic disturbance caused by laying submarine cables depends on the habitat and its associated ecosystem. The underlying geology of the proposed cable route has not been extensively studied or surveyed. Hadal zone researchers Heather Stewart and Alan Jamieson studied areas in the hadal and adjacent abyssal slope zones of the southern MTMNM (Stewart and Jamieson 2018). They classified the basic geologic structure by depth zones. Substrate types were categorized through the analysis of photographic data. Within the water depth range of 4,506 m to 5,641 m, the dominant seabed sediment observed comprised muddy gravel, with one observation each of bedrock, bedrock and fine-grained sediment, and gravelly fine-grained sediment across all fifteen sampling stations (Stewart and Jamieson 2018). Within the water depth range of 6,008 to 7,941 m, gravelly fine-grained sediment was the dominating sediment type; fine-grained sediment, bedrock, slightly gravelly fine-grained sediment, and muddy gravel were also observed within this depth range (Stewart and Jamieson 2018).

Deep sea coral and sponge communities occur in areas of clear water, such as on ridges, seamounts, canyon walls and shelf-edge breaks, where there is hard substratum, sufficient food, and moderate to strong currents (Hourigan et al. 2017). These communities are richest in areas of high slope and terrain roughness (rugosity). The bathymetry of the proposed cable corridor indicates there are areas of higher slope and terrain roughness. Although there are no known deep-sea coral and sponge communities along the cable route, there is an inferred higher probability for the presence of deep-sea corals and sponges at these locations. The closest mapped deep sea coral or sponge community in the MTMNM is located approximately 20 miles (33 km) north of the cable route.

Laying submarine cable, though a relatively short-lived activity, can be disruptive to the area and ecosystem in which it is carried out. There is a low potential for adverse impacts on biological resources within the cable's relatively narrow footprint. Potential impacts from the cable-laying process include laying the cable directly on, damaging, or abrading sessile or slow-moving organisms, although given the 2.25 cm (0.88 in) diameter of the cable, the likelihood of direct adverse impacts is low. Organisms, including deep-sea coral and sponge communities in the vicinity of the cable route, could also be adversely affected by the temporary disturbance of surface sediments and the associated increase in turbidity. Increases in turbidity and suspended sediments would be localized and temporary, and eventually dispersed by benthic currents.

A collaborative study conducted by the Monterey Bay Aquarium Research Institute (MBARI) and the National Oceanic and Atmospheric Administration division of Oceanographic and Atmospheric Research (NOAA-OAR) investigated the potential interactive effects between a fiber-optic submarine cable and its environment (Kogan et al. 2006). Results from this study indicated that the cable had few detectable effects on marine life. Although this was generally the case, in areas with soft sediments, the cable provided an artificial solid substrate that a number of different species sought out. This is known as the 'reef-effect' and results in species inhabiting an area that they typically would not (OSPAR 2009). The 'reef-effect' has been studied extensively and has been found in many cases to lead to the introduction of non-local biota and the alteration of the natural benthic community. The introduction on non-local biota is highly unlikely given the depth of the cable. Localized changes in the benthic community are possible, but would likely be temporary as the cable becomes buried in the sediments over time (Kerchhof et al. 2007, Tyrell and Byers 2007, OSPAR 2009).

Fiber-optic cables primarily transmit light; however, they also use a small amount of electricity to power the repeaters and boost the telecommunications signal, and therefore transmit small amounts of electromagnetic radiation and heat to the surrounding environment. During normal operation, the cable is powered by direct current (DC). DC currents produce the same type of magnetic field as the earth. The magnetic field generated by the cable is hundreds of times smaller than the Earth's magnetic field and thus would not be detectible or distinguishable against the Earth's field. A small amount of electromagnetic radiation may be produced by submarine fiber-optic cables during the rare events when the cable suffers an outage and AC electroding is used to find faulted cables. These would be exceedingly rare, short-term events and would generate very low levels of radiation comparable to background levels naturally produced by the earth. Therefore, it is expected that the weak magnetic fields produced by the BIFROST cable would have a negligible potential effect on marine organisms.

The submarine cable system is designed and manufactured to be electrically isolated from the environment and in the event of an incident resulting in an insulation cable fault, the cable will be automatically grounded to zero as it comes into contact with water. Consequently, there will likely be negligible effects resulting from electricity associated with the cable.

Long-term impacts

Once in place—if correctly laid—submarine cables have thus far not been shown to have a significant adverse effect on the surrounding marine environment since they are generally immobile once placed and coated with a layer of polyethylene, which is inert in seawater. Leaching from cables and their repeaters is believed to pose very little risk to the surrounding environment –especially in extremely deep environments (Collins 2007; Andrady 2000). Chemical breakdown processes, such as oxidation, hydrolysis, and mineralization, are extremely slow – largely as a result of low UV penetration at those depths. In a study conducted by Andrady (2000), it was predicted that total conversion of cable-grade polyethylene to carbon dioxide and water would take centuries.

Impacts to the Public: The existing regulated uses within the Mariana Trench NWR would continue after the laying of the cable. These include research and exploration of the Mariana Trench with the proper federal permits, and commercial fishing in compliance with federal regulations.

In summary, the issuance of the ROW Permit to install, operate and maintain the telecommunications cable would result in minor, short term negative impacts to the benthic habitat and marine life; negligible long-term impacts to the benthic habitat and marine life; and no negative impacts to the public. There would be long-term positive impacts to the public since the BIFROST cable system will further enhance and contribute to the expansion of communications networks between Asia and the United States, thereby improving network redundancy, ensuring highly reliable communications, and expanding onward connectivity options in Guam and CNMI.

Public Review and Comment

This compatibility determination has been prepared concurrently with an Environmental Assessment (EA), which addresses environmental effects associated with the proposed ROW for the subject submarine telecommunications cable. The EA and Draft Compatibility Determination will be available for public review and comment for a period of 15 days in June 2023. The public will be notified of the opportunity to review and comment on the CD and EA through media releases and posting of the EA and CD on the Refuge's webpage. The Permittee and the Service coordinated with the Navy through correspondence with Ms. Catherine Creese, Assistant Director, U.S. Naval Seafloor Cable Protection Office (NSCPO), in Washington, D.C. Concerns expressed during the public comment period will be addressed in the final.

Determination

Is the use compatible?

Yes

Stipulations Necessary to Ensure Compatibility

To ensure compatibility with the National Wildlife Refuge System and the refuge goals and objectives, installation and maintenance of the aforementioned submarine fiber optic cable can only occur under the following conditions:

1. The Service reserves the right to authorize other activities, including research involving remote operated vehicles (ROVs), in the vicinity of the cable. Before permitting activities within 500 meters of the final as-built location of the cable, the Service will consult with the Permittee to establish protocols for communications and operations to minimize the potential for impacts to the cable. The Permittee will ensure that the final coordinates identifying the location of the cable are fully communicated and has agreed to conditions in the right-of-way permit that allow the operation of ROVs in proximity of the cable.
2. The Permittee will produce and share the "as built" legal description describing the accurate location of the cable to the Service, within 180 days after it has been laid on the seafloor.
3. To minimize the risk of introducing contaminants into the marine environment, all instruments and equipment (including small boats) should be checked prior to deployment to ensure that there are no contaminant leaks (oil, fuel, hydraulic fluid, etc.) which could affect marine resources in the project area.
4. If any instruments or equipment is found to not be in good working order, it should be removed from service until all necessary repairs have been made which would prevent a release of contaminants.
5. The crew of the vessel used to lay the cable should try to minimize the amount of detergents and other noxious substances that might be washed overboard as part of an effort to clean instruments or equipment used during the cruise or in day-to-day operation of the vessel.
6. To prevent the spread of disease or invasive species, all equipment used in the cable laying operation should be rinsed with fresh water when practical.
7. A robust biosecurity plan must be submitted for review prior to cable laying operations to ensure that invasive species will not be inadvertently introduced into the Monument/Refuge.
8. Birds at sea have the potential to be attracted to or confused by lights on the vessel. At night the ship shall use the minimum amount of light necessary for legal and safe transit when underway. Through coordination with the USFWS, the cable ship operators will be briefed on the potential for bird encounters and will follow these protocols:

   A. After putting on gloves, the operators will pick up any downed birds and place them in a clean box to prevent soiling of their feathers .

   B. The birds will be kept in a cool, safe place until daylight.

C. The birds will then be placed in an open area near the stern of the cable ship where they can take off when ready.

D. Photographs of any downed birds will be taken to document distribution of species at sea and the USFWS will be notified and provided with these photographs.

9. The Permittee shall notify the Refuge Manager or his/her designee a minimum of 2 weeks prior to commencing with installation of the submarine cable to avoid conflicts with Refuge programs.
10. Any operations to conduct emergency repairs or maintenance of the cable must be coordinated with the Refuge Manager prior to scheduling said repair or maintenance.
11. The Permittee shall notify the Refuge Manager 30 days prior to the cable decommission date.
12. Consistent with regulations at 50 CFR 25.21(h), the Service reserves the right to modify terms and conditions of the ROW permit in the future, as necessary to ensure continued compatibility with the use and occupancy of the land.

Justification

It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of the Refuge will not be measurably lessened during the submarine cable installation, operation and maintenance activities facilitated by the proposed use. The relatively limited number of wildlife individuals expected to be adversely affected during the operation and maintenance of the submarine cable will not cause wildlife populations to materially decline, the physiological condition and production of wildlife species present will not be impaired, alterations to the behavior and normal activity patterns will be minor or nonexistent, and their overall welfare will not be negatively impacted.

The right of way as described is determined to be compatible because potential impacts from the permittee's use of this right of way on wildlife that use this Refuge unit would be minimal and not materially interfere with or detract from achievement of the NWRS mission or from the Service's ability to achieve Refuge wildlife, habitat, or other public-use-related purposes and goals.

Signature of Determination

Refuge Manager Signature and Date

Signature of Concurrence

Assistant Regional Director Signature and Date

Mandatory Reevaluation Date

The reevaluation date will be indicated after this CD is finalized.

Literature Cited/References

Andrady, A.L., 2000. Plastics and their impacts in the marine environment. Proceedings International Marine Debris Conference on Derelict Fishing Gear and the Marine Environment, Hawaii, August.

Collins, K., 2007. Isle of Man cable study – Preliminary material environmental impact studies. Preliminary report, University of Southampton.

Hourigan T.F., P.J. Etnoyer P.J. and S. D. Cairns. 2017. The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. 467 p.

International Cable Protection Committee (ICPC). 2014. Glossary. URL: https://www.iscpc.org/information/learn-about-submarine-cables/glossary/

Kerchhof, F., B. Rumes, T. Jaques, S. Degraer, and A. Norro. 2010. Early development of the subtidal marine biofouling on a concrete offshore windmill foundation on the Thornton Bank (southern North Sea): first monitoring results. Underwater Technology 29: 137-149.

Kogan, I., C. Paull, L. Kuhnz, E. Burton, S. Von Thun, H. G. Greene, J. Barry. 2006.

ATOC/Pioneer Seamount cable after 8 years on the seafloor: Observations, environmental impact. Continental Shelf Research 26: 771-787.

NOAA. 2017. Submarine cables: domestic regulation. URL: https://www.gc.noaa.gov/gcil_submarine_cables_domestic.html Accessed September 21, 2018.

OSPAR. 2008. Background Document on potential problems associated with power cables other than those for oil and gas activities. – Publication Number: 370/2008, 50 pp.

Stewart, H. and A. Jamieson. 2018. Habitat Heterogeneity of Hadal Trenches: Considerations and Implications for Future Studies. Progress in Oceanography. Volume 161: 47-65.

Tyrell, M. C. and J. E. Byers. 2007. Do artificial substrates favour non indigenous fouling species over native species? Journal of Experimental Marine Biology and Ecology. 342: 54-60.

USFWS. 2023. Programmatic Environmental Assessment (EA) for the Issuance of Right-of-Way Permits for Telecommunications Cable-Laying Activities within the Mariana Trench National Wildlife Refuge and Mariana Trench Marine National Monument Including the BIFROST and SEA-US Cable Systems.

APPENDIX D. Summary of EFH and HACP Designations

Table 1. Essential Fish Habitat and Habitat Areas of Particular Concern for the Mariana Archipelago Applicable to Guam

Management Unit	Species Complex	EFH	HAPC
Bottomfish and Seamount Groundfish	**Shallow-water species (0-50 fm):** uku (*Aprion viriscens*), thicklip trevally (*Pseudocarancx dentex*), lunartail grouper (*Variola louti*), blacktip grouper (*Epinephelus fasciatus*), ambon emperor (*Lethrinus amboinensis*), redgill emperor (*Lethrinus rubrioperculatus*), giant trevally (*Caranx ignoblis*), black trevally (*Caranx lugubris*), amberjack (*Seriola dumerili*), taape (*Lutjanus kamsira*)	**Eggs and larvae:** the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fm) **Juvenile/Adult:** the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fm)	All slopes and escarpments between 40-280 m (20 and 140 fm)
	Deep-water species (50-200 fm): ehu (*Etilis carbunculus*) onaga (*Etelis coruscans*), opakapaka (*Pristipomoides filamentosus*), yellowtail kalekale (*P. auricilla*), yelloweye opakapaka (*P. flavipinnis*), kalekale (*P. sieboldii*), gindai (*P. zonatus*), hapuupuu (*Epinephelus quernus*), lehi (*Aphareus rutilans*)	**Eggs and larvae:** the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fm) **Juvenile/Adult:** the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fm)	All slopes and escarpments between 40-280 m (20 and 140 fm)
	Seamount groundfish species (50-200 fm): amorhead (*Pseudopentaceros richardsoni*), ratfish/butterfish (*Hyperglyphe japonica*), alfonsi (*Beryx splendens*)	**Eggs and larvae:** the (epipelagic zone) water column down to a depth of 200 m (100 fm) of all EEZ waters bounded by latitude 29° – 35° N **Juvenile/adults:** all EEZ waters and bottom habitat bounded by latitude 29° - 35° N and longitude 171° E – 179° W between 200 and 600 m (100 and 300 fm)	No HAPC designated for seamount groundfish

Management Unit	Species Complex	EFH	HAPC
Crustaceans	**Spiny and slipper lobster:** Spiny lobster (*P. penicillatus*, P. spp.), ridgeback slipper lobster (*Scyllarides haanii*), Chinese slipper lobster (*Parribacus antarcticus*) **Kona crab:** Kona crab (*Ranina ranina*)	**Eggs and larvae:** the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m **Juvenile/adults:** all of the bottom habitat from the shoreline to a depth of 100 m	All banks with summits less than or equal to 30 m (15 fm) from the surface
	Deepwater shrimp (*Heterocarpus* spp.)	**Eggs and larvae:** the water column and associated outer reef slopes between 550 and 700 m **Juvenile/adults:** the outer reef slopes at depths between 300 and 700 m	No HAPC designated for deepwater shrimp
Precious Corals	**Deep-water precious corals (150-750 fm)** **Shallow-water precious corals (10-50 fm)**	No EFH for precious corals on Guam.	No HAPC for precious corals on Guam
Coral Reef Ecosystems (CRE)	**All Currently Harvested Coral Reef Taxa (CHCRT)** **All Potentially Harvested Coral Reef Taxa (PHCRT)**	EFH for CRE-MUS includes the water column and all benthic substrate to a depth of 100 m from the shoreline to the outer limit of the EEZ.	Cocos Lagoon, Orote Point Ecological Reserve Area, Haputo Point Ecological Reserve Area, Ritidian Point, and Jade Shoals
Pelagic	**Temperate species:** striped marlin (*Tetrapurus audax*), bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), albacore (*Thunnus alalonga*), mackerel (*Scomber* spp.) bigeye (*Thunnus obesus*), pomfret (family Bramidae). **Tropical species:** yellowfin (*Thunnus albacares*), kawakawa (*Euthynnnus affinis*), skipjack (*Kastuwonus pelamis*), frigate and bullet	**Eggs and larvae:** the (epipelagic zone) water column down to a depth of 200 m (100 fm) from the shoreline to the outer limit of the EEZ. **Juvenile/adults:** the water column down to a depth of 1,000 m (500 fm)	The water column from the surface down to a depth of 1,000 m (500 fm) above all seamounts and banks with summits shallower than 2,000

Management Unit	Species Complex	EFH	HAPC
	tunas (*Allothunnus fallai*), black marlin (*Makaira indica*), dogtooth tuna (*Gymnosarda unicolor*), spearfish (*Tetrapturus* spp.), sailfish (*Istiophorus platypterus*), mahimahi (*Coryphaena hippurus*, *C. equiselas*), ono (*Acanthocybium solandri*), opah (*Lampris* spp.). **Sharks:** pelagic thresher shark (*Alapias pelagicus*), bigeye thresher shark (*Alopias*), common thresher shark (*Alopias vulpinus*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*), blue shark (*Prioace glacuca*), shortfin mako shark (*Isurus oxyrinchus*), longfin mako shark (*Isurus paucus*), salmon shark (*Lamna ditropis*); **Squid:** neon flying squid (*Ommastrephes bartamii*), diamondback squid (*Thysanoteuthis rhombus*), purple flying squid (*Sthenoteuthis oualaniensis*)	from the shoreline to the outer limit of the EEZ	m (1,000 fm0 within the EEZ

APPENDIX E. Predictive Model for Deep-Sea Cnidarian and Poriferan Communities

I. Background

Benthic surveys of cnidarian and poriferan abundance were conducted in 2016 in the Mariana Archipelago. These surveys were performed by the *Deep Discoverer* (D2) remotely operated vehicle launched from the *R/V Okeanos Explorer*. Cnidarian and poriferan abundances were derived from the incidence of invertebrates along benthic transects at depths greater than 200 m. Areas that were surveyed included a variety of macrohabitats, including guyots, seamounts, and mesophotic reefs. Additionally, the surveys recorded maximum, minimum and average depth (Appendix A).

Because of the availability of depth and cnidarian and poriferan abundance data from the 2016 *Okeanos* surveys, we explored the feasibility of modeling abundance as a function of depth for these two invertebrate groups. We specifically applied both general linear models (GLM) and general additive models (GAM) to derive a predictive model of abundance in response to depth.

II. Methods

We evaluated both cnidarian abundance (cnidaria·km^{-1}) and poriferan abundance (porifera·km^{-1}) as a function of average depth (m), where depth was treated as an independent variable. A plot of abundance versus depth for both taxonomic groups indicated the need to transform the data in order to minimize heteroscedasticity and to meet the assumption of normality of the residuals (Figure 1a and b).

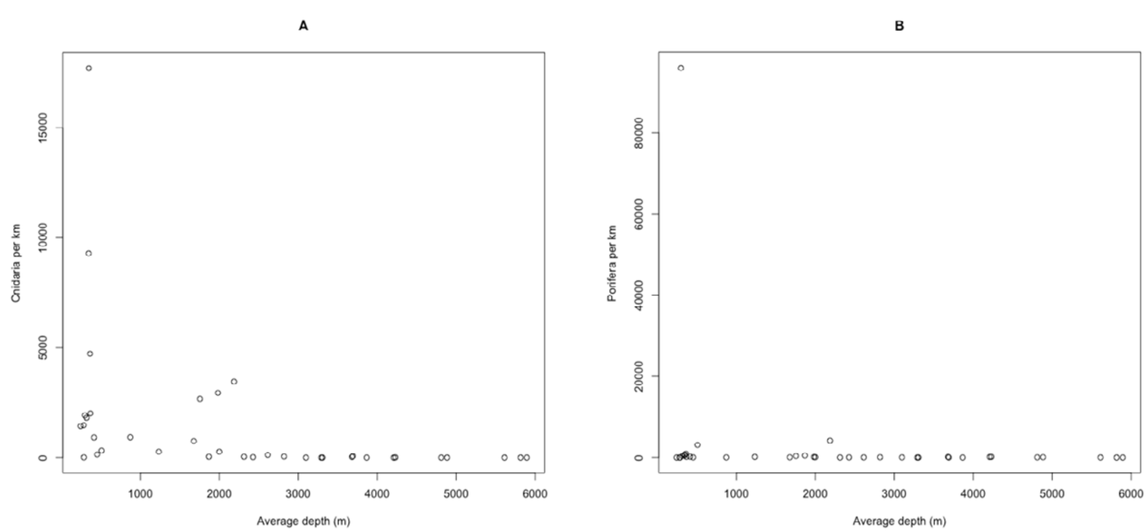


Figure 1. Plot of taxa per km versus average depth of a ROV dive for A) cnidaria and B) porifera. Data are from the 2016 *Okeanos* survey of the Mariana Islands. Note the range of densities for both taxonomic groups.

We chose to apply a $\log_{10}(Y+1)$ transformation to the abundance data because the abundances varied by several orders of magnitude and there were several locations in which no taxa were observed at depth. Transformation also resolved both the non-normality and heteroscedasticity of the residuals for cnidaria but was slightly less effective for porifera. Nevertheless, the transformations improved the linearity response of abundance to depth for both Cnidaria (Figure 2) and Porifera (Figure 3).

For each taxonomic group, we evaluated 1) a general linear model in which abundance was modeled as a function of depth and 2) a general additive model in which depth was a main effect and cnidarian and poriferan abundances were fitted with a spline function using the mgcv package (v. 1.8-40; Wood, 2022). The basis function was specified as k=30, allowing for a substantial amount of fitting or wiggliness. All analyses were conducted in RStudio (RStudio Team, 2020).

To select between the two competing models (i.e., GLM vs GAM), we compared Akaike's Information Criterion (AIC) values. Generally, models with lower AIC values are considered as having a better fit to the data when ΔAIC is > 2 for a pair of competing models (Burnham and Anderson, 2002). Analysis of Variance tests of the two models using the Chi-square distribution also yielded similar inferences (data not shown).

III. Cnidarian abundance

The GLM revealed a significant inverse relationship between depth and cnidarian abundance (t=-8.64; $p < 0.01$; Table 1). The relationship explained 67% of the variance (r^2=0.67). The GAM also indicated a significant inverse relationship between depth and cnidarian abundance explaining approximately 70% of the variance (r^2=0.70; Table 2).

A comparison of AICs for the linear versus additive model of cnidarian abundance revealed a slightly higher AIC for the linear model (97.27) compared to the additive model (94.03; Table 3). While a lower AIC may indicate a better fit of a model to the data, models that differ by less than 2 AICs are generally considered as informationally equivalent (Burnham and Anderson 2002). We therefore selected the GLM to model cnidarian abundance as a function of depth because it had equivalent performance to the GAM but could be easily modeled using linear predictors.

The coefficients from the general linear model (Table 1) were used to develop the following predictive model:

$$\hat{Y}_i = 3.390 - 6.501 \times 10^{-4} \cdot Depth_i$$

where $\hat{Y}_i$ is the expected $\log_{10}$ (cnidarian abundance +1) at a particular depth (i). A plot of the least-squares line is shown in Figure 2.

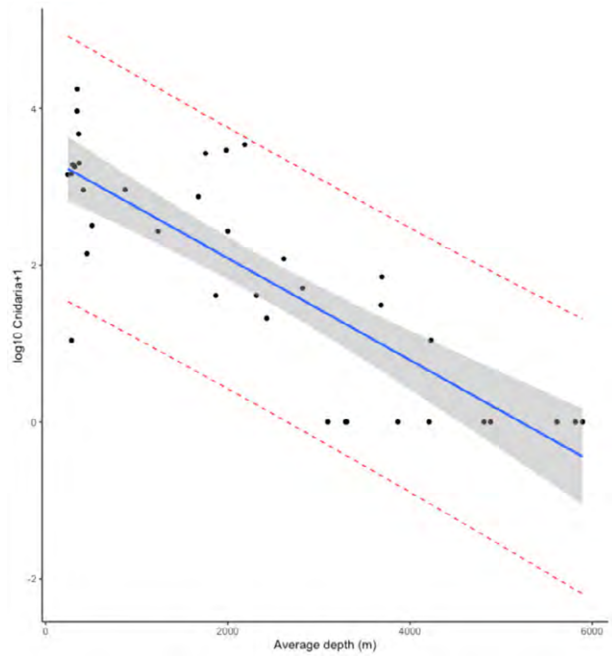


Figure 2. Plot of log_{10}-transformed cnidaria+1 per km versus maximum depth with least squares line (blue) and 95% confidence interval (shaded gray). Dashed red lines represent the 95% prediction interval.

Table 1. Results from a general linear model of cnidarian abundance in response to maximum survey depth from the 2016 *Okeanos* survey of the Mariana Islands. There was a significant relationship between cnidarian abundance and depth (t=-2.291; p<0.001).

Coefficients	Estimate	Standard error	t-value	P
Intercept	3.390	0.2171	15.61	<0.001
AvgDepth	-6.501×10^{-4}	7.524×10^{-5}	-8.64	<0.001

Table 2. Results from a generalized additive model of cnidarian abundance in response to maximum survey depth from the 2016 *Okeanos* survey of the Mariana Islands. There was a significant relationship between cnidarian abundance and depth (r^2=0.70; effective degrees of freedom=3.157; F=21.86; p<0.001).

Smooth terms	Effective Degrees of Freedom	Ref. Degrees of Freedom	F	p
AvgDepth	3.157	3.859	21.86	<0.001

Table 3. AIC indices for the general linear and generalized additive models of cnidarian abundance in response to depth.

Model	Df	AIC
GLM	3.00	93.30
GAM	5.16	92.10

IV. Poriferan abundance

The GLM revealed a weakly significant inverse relationship between depth and poriferan abundance (t=-2.291 p<0.05; Table 4). However, the proportion of the variance explained by the model was low (r^2=11). The GAM also indicated a marginally significant inverse relationship between depth and cnidarian abundance (r^2=0.13; p<0.05; Table 5).

A comparison of AICs for the linear versus additive models of poriferan abundance revealed identical AICs for both the linear model and additive models (Table 6). Therefore, we selected the GLM to model the relationship between poriferan abundance and depth because it had equivalent performance to the GAM but could be easily modeled using linear predictors.

Thus, the coefficients from the linear model (Table 4) were used to develop the following predictive model:

$$\hat{Y}_i = 2.236 - 2.239 \times 10^{-4} \cdot Depth_i$$

Where $\hat{Y}_i$ is the expected $\log_{10}$ (poriferan abundance +1) at a particular depth (i). A plot of the least-squares line is shown in Figure 3.

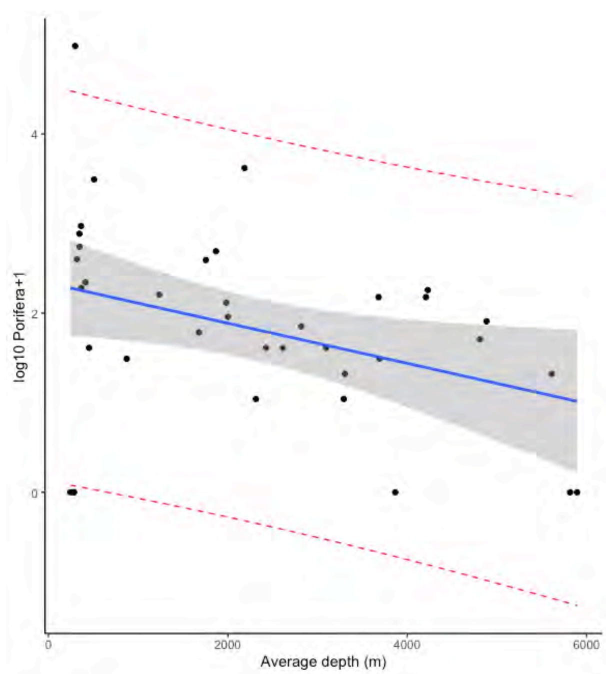


Figure 3. Plot of $\log_{10}$-transformed porifera+1 per km versus maximum depth with least squares line (blue) and 95% confidence interval (shaded gray). Dashed red lines represent the 95% prediction interval.

Table 4. Results from a general linear model of poriferan abundance in response to maximum survey depth from the 2016 *Okeanos* survey of the Mariana Islands. There was a weakly significant relation between poriferan abundance and depth (t=-2.291; p<0.05).

Coefficients	Estimate	Standard error	t-value	p
Intercept	2.336	0.281	8.279	<0.001
AvgDepth	-2.239×10^{-4}	9.776×10^{-5}	-2.291	<0.05

Table 5. Results from a generalized additive model of poriferan abundance in response to maximum survey depth from the 2016 *Okeanos* survey of the Mariana Islands. There was a weak relationship between poriferan abundance and depth (r^2=0.13; effective degrees of freedom=1; F=5.248; p<0.05).

Smooth terms	Effective Degrees of Freedom	Ref. Degrees of Freedom	F	p
AvgDepth	1	1	5.248	<0.05

Table 6. AIC indices for the general linear and generalized additive models of poriferan abundance in response to depth.

Model	Degrees of Freedom	AIC
GLM	3.00	112.67
GAM	3.00	112.67

Appendices

Appendix A. 2016 *Okeanos* Survey Data from the Mariana Archipelago. Note that log_{10}Porifera and log_{10}Cnidaria are transformed variables from the original cnidarian and poriferan abundance data and are generally calculated as $log_{10}(Y+1)$ where Y is the linear coverage of a particular taxon per km. One site (Dive ID L3_22: Romeo and Juliet B-29 Bomber) was excluded from the analyses because depth data were not available.

DiveID	Location	PoriferaKM	log10Porifera	CnidariaKM	log10Cnidaria	Avg Depth	Min Depth	Max Depth
L3_06	Supply Reef	95970	4.98214	1920	3.283527	298	279	364
L1_12	Zealandia	550	2.741152	17710	4.248243	347	278	655
L3_03	Maug	770	2.887054	9290	3.968062	345	321	475
L1_15	Enrique Guyot	4180	3.62128	3460	3.539202	2186	2165	2269
L1_18	Esmeralda Bank	940	2.97359	4720	3.674034	363	245	530
L3_01	Farallon de Medinilla 2	3110	3.4929	320	2.506505	509	486	533
L1_14	Pigafetta.Seamount	130	2.117271	2940	3.468495	1983	1954	2039
L3_19	Vogt.Guyot	390	2.592177	2670	3.426674	1755	1702	1944
L3_02	Pagan	400	2.603144	1810	3.257918	319	222	396
L1_02	Santa Rosa South	190	2.281033	2010	3.303412	368	291	581
L1_17	Farallon de Medinilla	0	0	1470	3.167613	282	251	484
L1_19	Esmeralda Bank Crater	0	0	1430	3.15564	244	240	248
L1_01	Santa Rosa North	220	2.344392	910	2.959518	414	314	619
L3_07	Chamorro Seamount	30	1.491362	920	2.96426	873	859	965
L3_15	Explorer Ridge Shallow	60	1.78533	750	2.87564	1677	1605	1904
L1_16	Del Cano Guyot	490	2.691081	40	1.612784	1868	1797	1928
L1_08	Northwest Guam Seamount	160	2.206826	270	2.432969	1234	1159	1343
L3_22	Romeo and Juliet B-29 Bomber	30	1.491362	390	2.592177	NA	367	374
L3_17	Fryer Guyot	90	1.959041	270	2.432969	2000	1925	2127
L1_13	Kunanaf Hulo Mud Volcano	150	2.178977	30	1.491362	3680	3673	3702
L3_08	Eifuku Seamount	40	1.612784	140	2.149219	453	312	502
L3_20	Subducting Guyot 2	180	2.257679	10	1.041393	4230	4014	4427
L1_06	Fina Nagu C	40	1.612784	120	2.082785	2614	2524	2752
L3_11	Northern Forearc Ridge	150	2.178977	0	0	4209	4206	4229
L1_05	Fina Nagu D	70	1.851258	50	1.70757	2820	2659	2973
L1_04	Enigma Seamount	30	1.491362	70	1.851258	3691	3636	3782
L1_03	Sirena Canyon	80	1.908485	0	0	4884	4849	4964

DiveID	Location	PoriferaKM	log10Porifera	CnidariaKM	log10Cnidaria	Avg Depth	Min Depth	Max Depth
L3_14	Explorer Ridge Deep	40	1.612784	20	1.322219	2427	2213	2594
L1_07	Fina Nagu A	10	1.041393	40	1.612784	2313	2291	2369
L3_13	Twin Peaks	50	1.70757	0	0	4811	4798	4835
L3_10	Stegasaurus Ridge	40	1.612784	0	0	3097	3083	3201
L1_11	Hydrothermal Vent	10	1.041393	0	0	3292	3291	3294
L3_12	Unnamed Forearc Seamount	20	1.322219	0	0	3306	3296	3318
L3_18	Petite-Spot Volcano	20	1.322219	0	0	5612	5561	5686
L3_05	Ahyi Seamount	0	0	10	1.041393	285	270	329
L1_10	Potential New Vent Field 1	0	0	0	0	3866	3864	3868
L3_04	Hadal Ridge	0	0	0	0	5894	5894	5894
L3_21	Hadal Wall	0	0	0	0	5816	5816	5816

Appendix B. R Script used in this analysis.

```
####General Linear and Generalized Additive Models of Okeanos Data######

#Load mgcv and ggplot2 packages
library(mgcv)
library(ggplot2)

###Examined Cnidarian index of abundance vs depth

#Plot Cnidarian density in response to maximum depth of the survey

plot(CnidariaKM~AvgDepth, data=MarOkeanos1605,
   xlab="Average depth (m)",
   ylab="Cnidaria per km",
   main="A")

#Plot log10Cnidarian density+1 in response to maximum depth of the survey
plot(log10Cnidaria~AvgDepth, data=MarOkeanos1605,
   xlab="Average depth (m)",
   ylab="log10 Cnidaria+1 per km",
   main="A")

#Run a general linear model

okeanos.cnidaria.lm1<-lm(log10Cnidaria~AvgDepth, data=MarOkeanos1605)
```

summary(okeanos.cnidaria.lm1)

#Run a generalized additive model
okeanos.cnidaria.gam1<-gam(log10Cnidaria~s(AvgDepth, k=30),data=MarOkeanos1605)

summary(okeanos.cnidaria.gam1)

gam.check(okeanos.cnidaria.gam1)

#Compare models using AIC
AIC(okeanos.cnidaria.lm1, okeanos.cnidaria.gam1)

#Compare models using ANOVA
anova(okeanos.cnidaria.lm1, okeanos.cnidaria.gam1, test="Chisq")

####Check residuals for heteroscedasticity and normality

#Plot histogram of residuals to assess normality
hist(residuals(okeanos.cnidaria.lm1))

#Plot Q-Q Plot to assess normality
qqnorm(MarOkeanos1605$log10Cnidaria)
qqline(MarOkeanos1605$log10Cnidaria)

#Plot residuals vs fitted to assess homoscedasticity
plot(lm(log10Cnidaria~AvgDepth, data=MarOkeanos1605))

###Examined Poriferan index of abundance vs depth

#Plot Poriferan density in response to maximum depth of the survey
```
plot(PoriferaKM~AvgDepth, data=MarOkeanos1605,
    xlab="Average depth (m)",
    ylab="Porifera per km",
    main="B")
```

#Plot log10Poriferan+1 density in response to maximum depth of the survey

```
plot(log10Porifera~AvgDepth, data=MarOkeanos1605,
    xlab="Average depth (m)",
    ylab="log10 Porifera+1 per km",
    main="B")
```

#Run a general linear model

```
okeanos.porifera.lm1<-lm(log10Porifera~AvgDepth, data=MarOkeanos1605)

summary(okeanos.porifera.lm1)
```

#Run a generalized additive model

```
okeanos.porifera.gam1<-gam(log10Porifera~s(AvgDepth, k=30),data=MarOkeanos1605)

summary(okeanos.porifera.gam1)

gam.check(okeanos.porifera.gam1)
```

#Compare models using AIC

```
AIC(okeanos.porifera.lm1, okeanos.porifera.gam1)
```

#Compare models using ANOVA

```
anova(okeanos.porifera.lm1, okeanos.porifera.gam1, test="Chisq")
```

####Check residuals for heteroscedasticity and normality

#Plot histogram of residuals to assess normality

```
hist(residuals(okeanos.porifera.lm1))
```

#Plot Q-Q Plot to assess normality

```
qqnorm(MarOkeanos1605$log10Porifera)
qqline(MarOkeanos1605$log10Porifera)
```

#Plot residuals vs fitted to assess homoscedasticity

```
plot(lm(log10Porifera~AvgDepth, data=MarOkeanos1605))
```

####Plot a 95% Confidence Interval for the Regression and 95% Prediction Interval for new Xs for these data

#95% CI and PI for Cnidaria

```
temp.var.cnidaria<-predict(okeanos.cnidaria.lm1, interval="prediction")

new.dataframe.cnidaria<-cbind(MarOkeanos1605, temp.var.cnidaria)

ggplot(MarOkeanos1605, aes(x=AvgDepth, y=log10Cnidaria), xlab="Average Depth (m)")+
  geom_point()+
```

```
 geom_smooth(method=lm, se=TRUE)

ggplot(new.dataframe.cnidaria, aes(AvgDepth, log10Cnidaria), xlab="Average Depth (m)",
    ylab="log10 (Cnidaria +1)")+geom_point()+
 geom_line(aes(y=lwr), color="red", linetype="dashed")+
 geom_line(aes(y=upr), color="red", linetype="dashed")+
 geom_smooth(method=lm, se=TRUE)+
 labs(x="Average depth (m)", y="log10 Cnidaria+1")+
 theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
     panel.background = element_blank(), axis.line = element_line (colour = "black"))
```

#95% CI and PI for Porifera

```
temp.var.porifera<-predict(okeanos.porifera.lm1, interval="prediction")

new.dataframe.porifera<-cbind(MarOkeanos1605, temp.var.porifera)

ggplot(MarOkeanos1605, aes(x=AvgDepth, y=log10Porifera))+
 geom_point()+
 geom_smooth(method=lm, se=TRUE)

ggplot(new.dataframe.porifera, aes(AvgDepth, log10Porifera))+
 geom_point()+
 geom_line(aes(y=lwr), color="red", linetype="dashed")+
 geom_line(aes(y=upr), color="red", linetype="dashed")+
 geom_smooth(method=lm, se=TRUE)+
 labs(x="Average depth (m)", y="log10 Porifera+1")+
 theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
     panel.background = element_blank(), axis.line = element_line (colour = "black"))
```

####Estimate 95% Prediction Interval for the number of profieran intercations at a specific depth.

#First create a dataframe with the vector containing the X-variables. In this case, we can have multiple depths.

```
depth.ranges<-data.frame(AvgDepth=c(5000, 6000, 7000))
```

#Then run the "predict" script to get the mean and upper and lower 95% prediction limit

cnidaria.log10predict<-predict(okeanos.cnidaria.lm1, depth.ranges, interval="predict") **#95% prediction interval for cnidaria**

cnidaria.log10predict **#Call on the object to get the values in log10 scale**
cnidaria.antilog.predict<-(10^(cnidaria.log10predict))-1 **#Apply antilog to convert the log10 abundances to scale of original data**
cnidaria.antilog.predict **#Call on the object to get the values in scale of original data**

porifera.log10predict<-predict(okeanos.porifera.lm1, depth.ranges, interval="predict") **#95% prediction interval for porifera**
porifera.log10predict **#Call on the object to get the values in log10 scale**
porifera.antilog.predict<-(10^(porifera.log10predict))-1 **#Apply antilog to convert the log10 abundances to scale of original data**
porifera.antilog.predict **#Call on the object to get the values in scale of original data**