Papahānaumokuākea Marine National Monument

RESEARCH Permit Application

NOTE: ***This Permit Application (and associated Instructions) are to propose activities to be conducted in the Papahānaumokuākea Marine National Monument. The Co-Trustees are required to determine that issuing the requested permit is compatible with the findings of Presidential Proclamation 8031. Within this Application, provide all information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Papahānaumokuākea Marine National Monument (Monument).***

ADDITIONAL IMPORTANT INFORMATION:

- Any or all of the information within this application may be posted to the Monument website informing the public on projects proposed to occur in the Monument.

- In addition to the permit application, the Applicant must either download the Monument Compliance Information Sheet from the Monument website OR request a hard copy from the Monument Permit Coordinator (contact information below). The Monument Compliance Information Sheet must be submitted to the Monument Permit Coordinator after initial application consultation.

- Issuance of a Monument permit is dependent upon the completion and review of the application and Compliance Information Sheet.

INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED

Send Permit Applications to:
NOAA/Inouye Regional Center
NOS/ONMS/PMNM/Attn: Permit Coordinator
1845 Wasp Blvd, Building 176
Honolulu, HI 96818
nwhipermit@noaa.gov
PHONE: (808) 725-5800 FAX: (808) 455-3093

SUBMITTAL VIA ELECTRONIC MAIL IS PREFERRED BUT NOT REQUIRED. FOR ADDITIONAL SUBMITTAL INSTRUCTIONS, SEE THE LAST PAGE.

Papahānaumokuākea Marine National Monument
Permit Application Cover Sheet

This Permit Application Cover Sheet is intended to provide summary information and status to the public on permit applications for activities proposed to be conducted in the Papahānaumokuākea Marine National Monument. While a permit application has been received, it has not been fully reviewed nor approved by the Monument Management Board to date. The Monument permit process also ensures that all environmental reviews are conducted prior to the issuance of a Monument permit.

Summary Information

Applicant Name: Amy Baco-Taylor
Affiliation: Florida State University

Permit Category: Research
Proposed Activity Dates: Sept 28, 2020 -Nov 11, 2020
Proposed Method of Entry (Vessel/Plane): RV Kilo Moana
Proposed Locations:
Monument sites: Southeast Hancock Seamount, Acadmician Berg, Ladd, Bank 9, and Pioneer Bank.
High seas sites: Koko Seamount, Yuryaku Seamount, Kammu Seamount, Colahan Seamount. Sites do not include any state waters.

Estimated number of individuals (including Applicant) to be covered under this permit: 25

Estimated number of days in the Monument: 45

Description of proposed activities: (complete these sentences):

a.) The proposed activity would…

Despite expectations that deep-sea scleractinian reefs could not exist under the harsh carbonate chemistry conditions of the N Pacific, reefs were recently discovered in the Northwestern Hawaiian Islands (NWHI) and the Emperor Seamount Chain (ESC), with 4 of 7 sites in waters undersaturated with respect to aragonite (aragonite saturation state (Ωar) range 0.71–1.33; Ωar<1 indicates undersaturation). Building on this discovery, the overarching question we will test with this work is: How is it that deep-sea scleractinian coral reefs can occur in undersaturated water, well below the hypothesized reef development limit of Ωar = 0.9? Although individual corals may be capable of calcifying in undersaturated water, it is unlikely that a three-dimensional reef structure could develop since deep-sea calcification rates are slow and most of the reef matrix is dead skeleton susceptible to dissolution. Therefore the hypotheses are: 1) These deep-sea reefs developed in saturated water and are now in undersaturated water because the aragonite saturation horizon (ASH) has shoaled over the last two centuries due to anthropogenic ocean

acidification; 2) The reefs in undersaturated water are now net dissolving; and 3) Environmental parameters other than Ωar are driving reef distribution.

b.) To accomplish this activity we would ….
To test these 3 hypotheses, 2 research cruises have been funded by NSF to characterize the reefs and environmental parameters of 9 seamounts across an Ωar gradient where reefs exist above and below the ASH. Coral and water samples will be collected, the ROV will conduct video transect surveys, and experimental dissolution blocks and in situ instrumentation will be deployed at the reef sites to investigate carbonate chemistry variability on diel (in situ instruments) to centennial (skeletal boron isotopes as a pH proxy) scales; calcification and dissolution rates; and reef ecology. Further, species distribution modeling will be used to examine the environmental factors that determine the distribution of these deep-sea reefs.

c.) This activity would help the Monument by …
This project will both substantially increase our knowledge of the deep-water communities within the monument as well as provide critical insights into deep-sea reef formation, persistence, distribution, and the effects of changing Ωar due to ocean acidification. Additionally, two key deep-sea reefs sites, SE and NW Hancock, fall into the 2016 expansion area of the PMNM which means they have not been extensively explored. So far in the entire North Pacific, deep-sea reefs are limited to only 7 known locations, 3 of which fall into the PMNM and 4 of which fall into high seas areas. Because of active trawling at all 4 high seas locations, and shoaling aragonite saturation horizons due to ocean acidification, the PMNM sites will be critical for survival of these reefs.

Other information or background:
This work builds on discoveries from the work permitted under PMNM-2014-028, and PMNM-2016-021.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Baco-Taylor, Amy R.

Title: Associate Professor

1a. Intended field Principal Investigator (See instructions for more information):
Amy Baco-Taylor

2. Mailing address (street/P.O. box, city, state, country, zip): [redacted]

Phone: [redacted]

Fax: [redacted]

Email: [redacted]

For students, major professor's name, telephone and email address:

3. Affiliation (institution/agency/organization directly related to the proposed project):
Florida State University

4. Additional persons to be covered by permit. List all personnel roles and names (if known at time of application) here (e.g. John Doe, Research Diver; Jane Doe, Field Technician):
Brendan Roark, Co-PI, Texas A&M University, [redacted];
Kathryn Shamberger, Co-PI, Texas A&M University, [redacted]
Mauricio Silva, Postdoctoral Researcher, Florida State University, [redacted]
Nicole Morgan, Student, Florida State University, [redacted];
Virginia Biede, Student, Florida State University, [redacted]
William Brantley, Student, Florida State University, [redacted]
Tacey Hicks, Student, Texas A&M University, [redacted]
Allison Savoie, Student, Texas A&M University, [redacted]
Makeda Mills, Student, Texas A&M University, [redacted]
Kourtney Higgins, Texas A&M University, [redacted]
Alyssa Schultz, Texas A&M University, [redacted]
Lu'ukai Operations Crew, University of Hawaii

Section B: Project Information

5a. Project location(s):

		Ocean Based	
☐ Nihoa Island	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Necker Island (Mokumanamana)	☐ Land-based	☐ Shallow water	☐ Deep water
☐ French Frigate Shoals	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Gardner Pinnacles	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Maro Reef			
☐ Laysan Island	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Lisianski Island, Neva Shoal	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Pearl and Hermes Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Midway Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Kure Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☒ Other			

☐ Remaining ashore on any island or atoll (with the exception of Midway & Kure Atolls and Field Camp staff on other islands/atolls) between sunset and sunrise.

NOTE: There is a fee schedule for people visiting Midway Atoll National Wildlife Refuge via vessel and aircraft.

Location Description:
Monument sites: Southeast Hancock Seamount, Acadmician Berg, Ladd, Bank 9, and Pioneer Bank.
High seas sites: Koko Seamount, Yuryaku Seamount, Kammu Seamount, Colahan Seamount.
Sites do not include any state waters.

5b. Check all applicable regulated activities proposed to be conducted in the Monument:
☒ Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving Monument resource
☒ Drilling into, dredging, or otherwise altering the submerged lands other than by anchoring a vessel; or constructing, placing, or abandoning any structure, material, or other matter on the submerged lands
☐ Anchoring a vessel
☐ Deserting a vessel aground, at anchor, or adrift
☒ Discharging or depositing any material or matter into the Monument
☒ Touching coral, living or dead
☐ Possessing fishing gear except when stowed and not available for immediate use during passage without interruption through the Monument
☐ Attracting any living Monument resource
☐ Sustenance fishing (Federal waters only, outside of Special Preservation Areas, Ecological Reserves and Special Management Areas)
☐ Subsistence fishing (State waters only)

☐ Swimming, snorkeling, or closed or open circuit SCUBA diving within any Special Preservation Area or Midway Atoll Special Management Area

6. Purpose/Need/Scope ***State purpose of proposed activities:***
The discovery of deep-sea coral reefs in the far NWHI and ESC, with more than half the sites in undersaturated water, provides an unprecedented opportunity to investigate the potential impact of ocean acidification on these important ecosystems. It is becoming critical to gain a better understanding of the role of Ωar in the distribution of deep-sea scleractinian reefs because it has been documented that the ASH is shoaling throughout the world oceans due to ocean acidification. More deep-sea reefs will experience undersaturation in the near future as Ωar declines and the ASH shoals, making the future of deep-sea reefs and the ecologically and economically valuable ecosystems they support highly uncertain. Recent studies aimed at understanding how Ωar affects the distribution of deep-sea corals are confounded by natural changes in Ωar that occur along a depth gradient and therefore basic questions remain regarding reef development in the deep sea, including: Can scleractinian reefs develop in undersaturated water? What is the fate of reefs that developed in saturated water once they experience undersaturation? How long can reefs persist in undersaturated water? The NWHI and ESC provide a natural gradient in Ωar along a longitudinal/latitudinal transect while controlling for depth, thus the proposed research will be able to answer these questions and disentangle the environmental factors controlling reef distribution.

To address these questions and test our hypotheses, 2 research cruises have been funded by NSF to characterize the reefs and environmental parameters of 9 seamounts across an Ωar gradient where reefs exist above and below the ASH. Coral and water samples will be collected, the ROV will conduct video transect surveys, and experimental dissolution blocks and in-situ instrumentation will be deployed at the reef sites to investigate carbonate chemistry variability on diel (in-situ instruments) to centennial (skeletal boron isotopes as a pH proxy) scales; calcification and dissolution rates; and reef ecology. Further, species distribution modeling will be used to examine the environmental factors that determine the distribution of these deep-sea reefs. We will also use multibeam to further map the seamounts to target our studies.

Related to photography below, we are not targeting any federally protected species with our work, however, we have previously observed Hawaiian Monk Seals within precious coral beds. Therefore we may incidentally photograph these federally protected animals while the ROV is doing its video transects, however there will be no effort made to approach or endanger them. Scleractinian corals are protected by CITES but we will not be transporting any samples internationally.

*Considering the purpose of the proposed activities, do you intend to film / photograph federally protected species? Yes ☐ No ☒

For a list of terrestrial species protected under the Endangered Species Act visit:
http://www.fws.gov/endangered/
For a list of marine species protected under the Endangered Species Act visit:

http://www.nmfs.noaa.gov/pr/species/esa/
For information about species protected under the Marine Mammal Protection Act visit:
http://www.nmfs.noaa.gov/pr/laws/mmpa/

7. Answer the Findings below by providing information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Monument:

The Findings are as follows:

a. How can the activity be conducted with adequate safeguards for the cultural, natural and historic resources and ecological integrity of the Monument?

While we do not anticipate the multibeam activities will impact marine species in the area, we will follow standard mitigation techniques including using a "soft start" or "ramp up" to the maximum noise output of the multibeam (Barlow and Gisner 2006). The main hypothesis with stranding related to anthropogenic noise is that animals will be startled by the noise and swim to the surface too rapidly and thereby experience barotrauma. A slow start up will provide a warning for these species, if present. We will also scan the area for marine mammals before starting the system and wait until any that might be present have left the area before starting the multibeam system. Finally, we are able to host a NOAA observer(s) if the monument chooses to provide one. We've used these mitigation techniques during previous multibeam activities in the Monument.

The ROV carries disposable ballast called drop shot which is composed of mild steel ballast made from the middle punchings of washers. This is the same ballast which has been used by the Pisces submersible in the PMNM on previous dives. It is biodegradable in 1-3 years, and has an advantage over elevator weights or train wheels that persist much longer. It is deployed in a cotton bag or cotton sock (each weighing ~5 pounds) that is also biodegradable. The weights are carried on the sample basket and are put down by the manipulator as the sample basket is filled. Because they are put down by the manipulator we can be selective in placement, i.e. make sure they are a minimum distance from any benthic fauna or reefs. To ballast the ROV we anticipate the ROV carrying 3-5 weights (~15-25 pounds) of drop shot. Since we are primarily collecting corals, which are farily light-weight, we do not anticipate dropping more than 2-4 weights per dive, (~10-20 pounds) with an expected maximum of 12 weights per seamount and a maximum of 60 weights left in the monument. The ~10-25 pounds of drop shot per ROV dive is significantly less than the 240-350 pounds the HURL submersibles dropped per dive.

We will also be collecting deep-sea corals at each of the seamounts as outlined in Question 9. Although the sample numbers are not insignificant, we are taking several measures to minimize the number of samples collected and therefore our impacts to the deep-sea coral communities in the Monument.

1. All samples collected for genetics will be taken as a small subsample of the colony, leaving the remaining colony intact on the seafloor (as carried out on previous permits). Whole coral samples will be collected for aging, skeletal boron isotope pH proxy work, mineral identification, and for measuring calcification rates. To minimize the number of whole coral samples collected, coral skeletal measurements for age, boron isotopes, mineral identification, and calcification rates will be performed on the same samples. In other words, additional samples are not needed to enable these four different skeletal analyses.

Ideally, ~25 specimens of each species of interest would be collected across the entire depth range 500-900m ((Ωar) range 0.71–1.33) at each site in the Monument where there are sufficient individuals to do so. Previous permitted work was not focused on reef-forming scleractinian corals (Solenosmilia sp., Madrepora sp, and Enalopsammia sp), which will be the principal focus of our collections with this permit. (We will generally be deeper than precious coral depths, but where they occur, we will also sample Hemicorallium laauense or Pleurocorallium secundum. We will limit our collections of these species to only those needed to fill gaps in our current specimen archive to bring our totals to 25 per site.) While we need to collect enough live specimens to correlate coral skeletal measurements with the water column chemistry measurements we've been making in the PMNM over the last 6 years, we will also focus on collecting dead specimens, as these are just as valuable to reconstructing longer term environmental variability and reduces the impact of our collections (see question 9).

2. We will take as many of our samples for genetics as possible from the colonies collected for aging and geochemistry work, to reduce the number of total colonies impacted by our project.

3. We are using AUV images collected on previous cruises to these sites to target areas with high concentrations of our target species. We will only take samples from areas where there are more than 8 individuals of a species living in the area. Sampling individuals from a large population will have less of an impact than sampling individuals from less dense populations.

4. Where at all possible we will collect dead deep-sea corals (remaining skeletons that have already fallen over) in lieu of live collected samples. These samples can be utilized for some of the sclerochronology work and for the paleoceanographic pH work (For more detail see question 9).

b. How will the activity be conducted in a manner compatible with the management direction of this proclamation, considering the extent to which the conduct of the activity may diminish or enhance Monument cultural, natural and historic resources, qualities, and ecological integrity, any indirect, secondary, or cumulative effects of the activity, and the duration of such effects?

We have designed our sampling efforts to have as minimal impact as possible while still obtaining the data needed to address our questions. Although this requires sampling of deep-sea corals, we anticipate that ultimately this work will enhance the Monument because it will provide greater knowledge of the deep-sea community that falls within the Monument's waters and enable predictions about the persistence of deep-sea scleractinian reefs under ocean

acidification. It is through previously permited research activities very similar to this request that these deep-sea reefs were discovered, enhancing our understanding of the Monument's resources and the threat ocean acidification poses to the Monument.

c. Is there a practicable alternative to conducting the activity within the Monument? If not, explain why your activities must be conducted in the Monument.

The targeted sites for this project are unique as the only known sites in the entire North Pacific that have been found to harbor accumulations of deep-sea scleractinian coral reefs and the only known sites globally where deep-sea scleractinian coral reefs exist in undersaturated water ($\Omega ar<1$) corrosive to aragonite coral skeletons. The water chemistry of this region does not fit within the known parameters to support reef formation. Thus the PMNM and adjacent seamounts are by far the best location in the North Pacific to study scleractinian reefs and the best, and perhaps the only, location in the world to understand the impacts of ocean acidification on deep-sea reef corals.

d. How does the end value of the activity outweigh its adverse impacts on Monument cultural, natural and historic resources, qualities, and ecological integrity?

We have designed our sampling efforts to have as minimal impact as possible while still obtaining the data needed to address our questions. This specific work will contribtue to the PMNM's understanding as well as to the broader scientific, conservation and management communities' understanding of how deep-sea corals deal with waters that are understaurated with respect to aragonite. Development of boron isotope ratios (d11B) as a proxy for seawater pH will improve our understanding of long-term pH changes that may have impacted reef development within the PMNM and ocean acidification impacts beyond the instrumental record. This increased knowledge will directly help in the conservation and management of not only the PMNM, but other monuments, sanctuaries and ocean resources.

In addition we are making every effort to maximize the utility of the samples and data we collect to address research questions beyond our immediate project. For example, every effort is made to fully utilize each sample taken to its maximum benefit as evidence by the paleoceanographic and paleoclimate work and the histology and life cycle work that will be done on the samples collected by the PIs as well as a broader group of researchers and collaborators. The unexpected discovery of these scleractinian reefs and documentation of the adverse water chemistry in their vicinity is a prime example of how we have utilized samples to their full potential on previous expeditions in the PMNM.

This kind of interdisciplinary work that combines research and exploration in equal parts defines and highlights PMNM natural resources, their qualities, and their ecological importance. It also demonstrates the importance of the PMNM to the surronding ecosystems. We have an extensive K-12 education and outreach program in collaboration with Ruth Musgrave of WhaleTimes, Inc. (whaletimes.org) as part of our project. These efforts include School Visit Programs, which include developing a curriculum and classroom presentations on deep-sea corals, seamounts and related topics. These workshops will incorporate activities and information from the STEM

curriculum and end with an “ask a scientist” session shared with classrooms in Hawaii, Florida, and Texas. In addition, we are collaborating with Andy Collins at Mokupāpapa Discovery Center to incoporate the impact of ocean acidification on coral reef ecosystems in the Monument. These activites will highlight the importance of PMNM cultural, natural and historic resources to new audiences.

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.
The locations of our study sites require extensive transit from Honolulu and between sites. Additionally, both multibeam mapping and ROV video collections require extended time periods to provide high quality data. The duration of the cruise and time at each site is determined by the endurance capability of the R.V. Kilo Moana, not the purpose of the research, which takes longer than one cruise to accomplish because of the vast area of study. To optimize this valuable time on station, data from previous cruises, and habitat suitability modeling using data from previous cruises have been used to refine the science station locations for 2020.

f. Provide information demonstrating that you are qualified to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

Baco-Taylor and Roark have extensive field experience including 20+ years each of work with a variety of submersibles, ROVs and the AUV Sentry. Participating in numerous cruises and serving as Chief Scientist on several occasions, they have collectively led nearly 200 submersible dives, 50+ ROV dives, and 25+ Sentry dives working in deep-sea ecosystems off Hawaii, Alaska, New Zealand, Antarctica, the Bahamas, the Gulf of Mexico, California, and the US East Coast. Most importantly Baco-Taylor and Roark have led multiple expeditions working in several of the Pacific Marine Monuments and protected areas. Shamberger’s research has focused primarily on shallow water tropical coral reef carbonate chemistry and metabolism rates on reefs in Hawaii, Palau, American Samoa, Taiwan, the Great Barrier Reef, and the Gulf of Mexico, with 15+ years of field experience. Shamberger has been collaborating with Baco-Taylor and Roark to characterize seawater carbonate chemistry (including Ωar) at deep-sea coral sites in the NWHI and ESC since 2014.

Baco-Taylor’s research has largely focused on the seamounts and deep-sea corals of the Hawaiian Archipelago, including exploration of many seamounts in this region, documentation of distributions of benthic fauna on these seamounts, population genetics and phylogenetics of precious coral species, and understanding the effects of trawling and process of recovery. Baco-Taylor also has extensive experience with multivariate statistics. Roark has been responsible for all the radiocarbon dating of precious corals in the Hawaiian Islands that has illustrated their extreme longevity (Roark et al., 2009, 2011, Roark and Parrish 2009, Houlbreque et al. 2010) and biogeochemistry proxy development work in deep-sea corals. Shamberger has been characterizing the carbonate chemistry at deep-sea coral sites in the NWHI and ESC since 2014, revealing that 4 of 7 recently discovered deep-sea scleractinian reef sites are currently found in undersaturated water that is corrosive to aragonite coral skeletons (Baco et al. 2017). Further, Shamberger's work comparing our NWHI and ESC carbonate chemistry data to those of the

international repeat hydrography program (WOCE, CLIVAR, GO-SHIP) collected in the North Pacific supports our hypothesis that these reefs developed in saturated water and are now in undersaturated water due to ocean acidification-induced declines in Ωar. Thus, the PIs have the required experience in the field, the lab, and in data analyses to make the proposed project a success. Please see the attached CV's for additional details.

g. Provide information demonstrating that you have adequate financial resources available to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.
This project is supported by the National Science Foundation (NSF) grant to Baco-Taylor, Roark and Shamberger. NSF has supplied the ship-time and also funding to Baco-Taylor, Roark, Shamberger, a post-doc, and several graduate students to complete this project through to publication of results.

h. Explain how your methods and procedures are appropriate to achieve the proposed activity's goals in relation to their impacts to Monument cultural, natural and historic resources, qualities, and ecological integrity.
The methods we plan to use on this cruise are identical to those we have used previously throughout the NWHI and other geographic locations. Baco-Taylor and Roark have been working with deep-sea corals for most of their careers (over 20 years each) and have well-honed sampling approaches intentionally designed to minimize the impact to these long-lived, slow growing coral communities by taking the smallest number of samples and smallest size of samples necessary to address the questions at hand. For population genetics, the publication standard is ideally at least 30 individuals per population (e.g. Hale et al 2012).

In this project we will apply the dual d13C-d11B measurements method in deep-sea coral skeletons to reconstruct seawater pH (pHsw) by determining ΔpH from d13C and subtracting it from the d11B-derived calcifying fluid pH (pHcf). This approach quantifies and corrects for vital effects improving the accuracy of pHsw estimates in deep-sea corals (Martin el al., 2015). By being able to collect deep-sea corals from across a latitudinal/longitudal range, within a limited depth range, that includes saturated to undersaturated waters (Ωar range 0.71–1.33) we will be able to substantially improve the d11B-pH calibrations. The ability to sample mutiple species across a large (Ωar) range is a unique aspect of this project. Ideally we would like 5-8 specimens of each species of interest sampled across a depth range that encompasses the Ωar range 0.71–1.33 at each site. We will use specimens already collected during previous work as a starting point and will only utilize the proposed collections to fill in the gaps with a focus on deep-sea scleractinians (Solenosmilia, Madrepora and Enalopsammia) that were not heavily sampled previously because they were not the primary focus of previous work. To minimize the number of whole coral samples collected, coral skeletal measurements for age, boron isotopes, mineral identification, calcification rates, and genetics will be performed on the same samples, maximizing the work done while minimizing the impacts.

Ideally, ~25 specimens of each species of interest would be collected across the entire depth range 500-900m (Ωar range 0.71–1.33) at each site in the Monument where there are sufficient individuals to do so. Where possible we will use our previous collections that focused on Hemicorallium laauense or Pleurocorallium to reach the 25 specimen goal and will only collect

these species to fill gaps in our current specimen archive. The previous work was not focused primarily on reef-forming scleractinian corals (Solenosmilia sp., Madrepora sp, and Enalopsammia sp), which will be the dominant focus of our collections with this permit.

Instruments and carbonate blocks (see Question 8 for details) will be deployed using the ROV to ensure they are placed on the bottom without damaging coral or other ecologically and economically important species.

i. Has your vessel been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?
It is the applicant's understanding that the R.V. Kilo Moana has a VMS as we used this ship in the Monument previously.

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.
We are not aware of any other factors that need to be considered.

8. Procedures/Methods:
The target depth range for all operations will be the range of occurrence of the scleractinian reefs, ~400-900m. We will conduct multibeam surveys, CTD casts and ROV Lu'ukai Dives at each seamount. We anticipate spending ~72 hrs working on station at each of our target seamounts.

Multibeam and Backscatter - We will conduct minimal multibeam surveys with backscatter to fill in gaps from previous cruises. Data will be used to assess the terrain and bottom type using the shipboard multibeam system on the RV Kilo Moana. We conservatively estimate surveys of approximately 11km^2/hr. at a rate of 6 knots and 300m water depth. The multibeam system will be run 24/7 during both transits and on station, except when it needs to be shut off to allow for accurate tracking of the ROV. In deep operating mode the EM302 multibeam system is 237 dB while the EM710 is 229 dB. In shallow mode the EM302 is 232 dB and the EM710 is 225 dB. The frequency of the EM302 is 30kHz and the EM 710 is 70 to 100kHz. We are not aware of any studies that indicate that these frequencies have an impact on marine mammals and these systems are identical to those operated by the Falkor and RV Sikuliaq within the Monument in 2014 and by the RV Kilo Moana in 2015.

Further Information on Anthropogenic Noise and its Effects on Marine Species:
The main concerns with anthropogenic noise are at low and mid-frequencies (10Hz-25kHz). At these and lower frequencies, there is a range of decibels that are considered dangerous to marine mammals and fishes, but higher than 25 kHz (the ship systems are 30kHz+) is considered background noise and will not propagate far enough from the source to affect outside animals (Hildebrand 2009). Studies of possible acoustic sources of known beak whale strandings concur with this (Cox et al 2006) finding, that all possible culprits are low or mid frequency. While we do not anticipate the multibeam activities will impact marine species in the area, we will follow standard mitigation techniques including using a "soft start" or "ramp up" to the maximum noise

output of the multibeam (Barlow and Gisner 2006). The main hypothesis with stranding related to anthropogenic noise is that animals will be startled by the noise and swim to the surface too rapidly and thereby experience barotrauma. We will also scan the area for marine mammals before starting the system and wait until any that might be present have left the area before starting the multibeam system. Finally, we are able to host a NOAA observer(s) if the monument chooses to provide one.

Water Sampling - 5 CTD casts will be conducted at each site, including the 5 sites within the monument, for a maximum of 25 CTD casts within the monument. At each site, one CTD cast will be conducted directly over the seamount and one each over the N, S, E, and W flanks of the seamount. During each cast we collect 240 liters (24 bottles * 10 liters/bottle) of water, for 1200 liters per site, weather permitting. From each lowering of the CTD, a suite of standard water samples will be taken from the niskin bottles off of the CTD rosette for the following analyses: radiocarbon (250ml), dissolved inorganic nutrients (20ml), dissolved inorganic carbon and total alkalinity (250 ml), oxygen (100 ml), stable isotope of oxygen and deuterium (25ml), trace elements (250ml), and with remaining water filtered for particulate organic matter (POC)(3-5 L). Each analysis is an individual specimen but samples for each analyses will not be collected on each CTD cast. For example we anticipate only doing one radiocarbon profile at each of the 9 sites. The primary focus of the water sampling is for the dissolved inorganic carbon and total alkalinity samples used to calculate ocean pH, Ωar, and ASH depth. These samples will extend the temporal range of our dataset that extends back to 2014 with mutiple sites being reoccupied 3-5 times from 2014-2020. This is another unique aspect of our work, especially for such a remote region and may be unique to PMNM among all U.S. Marine Monuments.

ROV Dives and Video- On this cruise we have set aside 24 of the 72 hours at each site for ROV operations, this amounts to 9 24-hour dives (with 5 sites falling into the Monument for a total of ~120 hours of bottom time in the Monument). The primary goal of these dives will be to deploy carbonate dissolution blocks at each site and instruments at Colohan (outside the Monument). Coral specimens will be collected at all reef sites with two goals in mind. The first will be to obtain vouchers specimens for validation of identifications of specimens observed in the video. Collected specimens will be photographed in-situ and on shipboard to aid in identifications. The second goal will be collection of corals for aging, mineral composition, calcification rates, and boron isotopes.

Remaining dive time will be used for ROV Video Transects to determine the area and height (from bottom) of the reefs; the percent cover of live coral, dead coral with exposed calcium carbonate, and dead coral with Mn coatings; full depth range of reef at each site; coral species forming the reefs; and coral species composition across each site. To accomplish this in a quantitative manner, we will conduct a combination of video transects at the same depth on each seamount, as well as focused transects within reef sites. During transects, the HD video camera will be in a fixed position and zoom, with parallel laser beams visible in the field of view.

The ROV carries disposable ballast called drop shot which is composed of mild steel ballast made from the middle punchings of washers. This is the same ballast which has been used by the Pisces submersible in the PMNM on previous dives. It is biodegradable in 1-3 years, and has

an advantage over elevator weights or train wheels that persist much longer. It is deployed in a cotton bag or cotton sock which is also biodegradable. The weights are carried on the sample basket and are put down by the manipulator as the sample basket is filled. Because they are put down by the manipulator we can be selective in placement, i.e. make sure they are a minimum distance from any benthic fauna or reefs. To ballast the ROV we anticipate the ROV carrying 3-5 weights (~15-25 pounds) of drop shot. Since we are primarily collecting corals, which are farily light-weight, we do not anticipate dropping more than 2-4 weights per dive, (~10-20 pounds) with an expected maximum of 12 weights per seamount and a maximum of 60 weights left in the monument. The ~10-25 pounds of drop shot per ROV dive is significantly less than the 240-350 pounds the HURL submersibles dropped per dive.

Carbonate Dissolution Blocks:
To determine whether reefs in undersaturated water ($\Omega ar<1$) are net growing or net dissolving, calcification rates of live corals and dissolution rates of dead corals, along with percent coverage of live and dead corals, must be measured. Dissolution of aragonitic coral skeletons is thermodynamically favored in undersaturated water, but the rate of dissolution depends on local factors including seawater composition, biogeochemical processes occuring on the reef, and flushing time of water on the reef. To estimate dissolution rates at our sites, we will deploy aragonite dissolution blocks at each site, using aragonite produced by corals (rather than synthetic aragonite), to ensure our results are applicable to the reefs at our site. Because it is difficult to obtain enough deep-sea coral-sourced aragonite, dissolution blocks will be cut from shallow water reef-building corals (Porites) with a density within the range of densities previously measured for deep-sea scleractinians. Dissolution blocks will be prepared following Silbiger et al. (2014). Briefly, coral pieces will be cut into 5 × 5 × 2 cm blocks, soaked in fresh water, and then autoclaved to remove any living organisms. Dissolution blocks will be bolted and epoxied to individual weighted PVC frames that will be placed on the bottom and recovered a year later on an NSF funded cruise in 2021. Dissolution blocks will be dry weighed (affected by non-calcifying tissue), buoyant weighed (unaffected by noncalcifying tissue), and CT scanned (to obtain precise densities and for detailed analyses of dissolution processes) by collaborators at NOAA's Atlantic Oceanographic and Meteorological Laboratory before the blocks are deployed on the 2020 cruise and after they are recovered on the 2021 cruise. At each site, 5 dissolution blocks will be deployed at 3 depths each, within the depth range of the reefs (400-900 m): above the ASH in saturated water, below the ASH in undersatured water, and one intermediate depth; for a total of 15 blocks per site and 75 blocks within the monument. Dissolution blocks will be placed on the bottom (and recovered the following year) with the ROV. For sites with reefs, blocks will be placed as close as possible to the reefs without damaging the reef.

ROV Collections - We will be using the mainpulators and bioboxes of the ROV to collect samples for the following objectives.
1. To obtain voucher specimens for morphological and genetic identifications of species observed by the ROV. This will involve collecting where possible, partial specimens of the dominant species of deep-sea corals and sponges at each site, with a maximum of 1-2 individuals of each species. Samples will be placed in bioboxes for return to the surface where they will be

subsampled for genetics. The remainder of each colony will be donated to the Smithsonian Natural History Museum for archiving and morphological taxonomy.

2. To obtain specimens of the dominant reef-forming scleractinians and precious corals for population genetics, a total of up to 30 individuals of each species present at a given site will be collected per dive for a maximum of 60 individuals per species per seamount. These are the sample sizes required to achieve sufficient statistical power for population genetic statistics. We will subsample each of the colonies collected for aging, boron isotope, and calcification studies (obj 3 below) to reduce the impact to the community. Additionally, since we only need a small piece for genetics, we will primarily be taking small pieces off of each colony that is sampled, rather than the whole colony (see attached image for example). These samples are placed in labeled jars in a biobox, which allows us to tie collected fragments to images of colonies.

3. To obtain specimens of corals for biogeochemistry proxy development and reconstruction requires the collection of whole specimens, as it is the base of the colony which provides the data for aging and the longest time series. Whole coral skeletons will be used for aging, boron isotopes, mineral identification, and calcification rates measurements. The primary goal of this portion of the project is to develop boron isotope ratio measurements (d11B) in DSC skeletons as a proxy for seawater pH in order to reconstruct longer term pH variability. The critical element is collecting multiple specimens across a depth range that includes saturated to undersaturated waters ((Ωar) range 0.71–1.33) in order to develop more precise calibration equations correlating d11B and seawater pH . These calibration equations are species specific which means collection multiple specimes of the same species across a depth range to develop the best calibration equations. There are few, if any other places in the world with the diversity of deep-sea corals living across such a large Ωar range at one location. The benefit of sampling from one seamount is that other environmental variables are more likely to be held constant.

To determine the age, radial growth rates and age estimates of the collected specimens we will use radiocarbon (14C) measurements following standard techniques detailed in Roark et al. (2005, 2006). With younger faster growing species we make use of the time varying transient of ‘bomb 14C’ in the oceanic total dissolved CO2 pool (the reason why we’ve been collecting radiocarbon water samples) and develop age models using discretely milled samples extending from the outermost edge to the center of cross-sections cut through the colony base. We anticipate ~25 of the specimens will be 14C dated, and an additional 25-50 specimens dated by the appropriate sclerochronology methods.

Ideally, ~25 specimens of each species of interest would be collected across the entire depth range 500-900m (Ωar range 0.71–1.33) at each site in the monument where there are sufficient individuals to do so. Where possible we will use our previous collections that focused Hemicorallium laauense or Pleurocorallium to reach the 25 specimen goal and will only collect these species to fill gaps in our current specimen archive. The previous work was not focused on reef-forming scleractinian corals (Solenosmilia sp., Madrepora sp, and Enalopsammia sp). so those species will be the dominant focus of our collections with this permit. See section 9a for more specific numbers of individual specimens to be collected.

We will primarily collect medium to larger samples, but leaving the largest/oldest samples. We typically follow the rule that more than 8 individuals of one species must seen at the site before any individuals of that species can be sampled. This ensures the remaining populations continues to be viable.

Hazmat material will be used in the processing of some of the samples. The mercuric chloride is used in some water samples to stop biological processes from continuing by adding 100 µl to the radiocarbon, alkalinity, and DIC samples and then sealing the containers. All the water samples and all the unused hazmat will be removed from the ship and returned to Texas A&M in order to conduct the analyses. For preservation of samples to be used for age dating, tissue is mechanically removed from the skeleton and dried in an oven and once dried, tissues are stored in centrifuge vials. Deep-sea coral skeletons are allowed to air dry after removing tissue.

For preservation of samples for genetics we freeze samples at -80C and also place a small piece in a 15ml centrifuge tube filled with 95-100% non-denatured ethanol. Larger specimens for the Smithsonian are preserved in larger jars or large ziploc bags with ethanol. For preservation of non-coral samples for morphological taxonomy we preserve the animal whole in 10% buffered formalin - composed of 10% volume of 37.7% formaldehyde buffered with borax, and the remaining 90% volume filtered seawater. We will also opportuistically subsample corals for reproductive histology, where excess tissue is available, by preserving fragments in 10% buffered formalin. All frozen samples, ehtanol-preserved samples and formalin-preserved samples as well as unused preservatives will be removed from the ship and returned to the Baco-Taylor laboratory or the Smithsonian.

Note we are planning to deploy an instrumented deep-sea coral lander at a site outside the Monument (Colahan) and will recover it a year later during an NSF funded cruise in 2021. We include the lander here in case weather or other unforseen circumstances prevent its deployment outside the monument, in which case we will likely deploy at a site in the monument. This is the same deep-sea coral lander that has been deployed two different times for 1 year during previous work in the Monument. However, we are reconfiguring the lander by adding two new sensors to characterize seawater carbonate chemistry (SAMI CO2 and SAMI pH sensors) and making it much smaller so that it can be deployed and recovered using the ROV only leaving behind a small stack of weights (~50 pounds). This is less risky and allows full control on where it is placed. See question 13 for a complete description of the lander and its instrumentation.

NOTE: If land or marine archeological activities are involved, contact the Monument Permit Coordinator at the address on the general application form before proceeding, as a customized application will be needed. For more information, contact the Monument office on the first page of this application.

9a. Collection of specimens - collecting activities (would apply to any activity): organisms or objects (List of species, if applicable, attach additional sheets if necessary):

Common name:
Primarily Reef-Forming Scleractinian Corals - likely Solenosmilia sp., Madrepora sp, and Enalopsammia sp.

With opportunistic collections of other corals we regularly study including:
Red Coral
Pink Coral
Gold Coral
Black Coral
Bamboo Corals
Other corals (and sponges as observed)

Scientific name:
Solenosmilia sp
Madrepora sp.
Other deep-sea Scleractinian corals

Hemicorallium (formerly Corallium) laauense - most likely to encounter
Pleurocorallium (formerly Corallium) secundum
Kulumanamana haumeeae (formerly Gerardia sp)
Leiopathes sp
Isididae

& size of specimens:
- For genetics collections, small fragment from the target species listed above. No more than 60 individuals of each species per each location below.

For the whole coral skeletal measurements for age, boron isotopes, mineral identification, and calcification rates, whole coral samples will be collected across the entire depth range 500-900m ((Ωar) range 0.71–1.33). We will primarily collect medium to larger samples, but leaving the largest/oldest samples.

At each dive site we will collect no more than the following maximum number of specimens
- Maximum 25 whole live individuals of scleractinians corals (Solenosmilia, Madrepora and Enalopsammia)
- Maximum 8 whole live Hemicorallium laauense or Pleurocorallium
- Maximum 2 whole live Kulumanamana haumeeae (formerly Gerardia sp).
- Maximum 5 whole live bamboo corals.
- Maximum 5 whole live miscelaneous other corals
For Leiopathes no more than 1 live whole samples per each location below.
For other corals and sponges - no more than 3-5 whole individuals per species per location

For dead samples (deep-sea coral skeletons that have already fallen over) no more than:
- 25 individual scleractinians corals (Solenosmilia, Madrepora and Enalopsammia) per site, or 70 total from the monument.

- 40 Hemicorallium laauense and Pleurocorallium secundum taken from within the monument.
- No more than 15 individuals of Kulumanamana haumeeae (formerly Gerardia sp).,
- No more than 25 individual bamboo corals total from the monument.
- No more than 20 miscelaneous other corals taken from within the monument.

Collection location:
Southeast Hancock
Academician
Ladd
Bank 9
Pioneer Bank

☒ Whole Organism ☒ Partial Organism

9b. What will be done with the specimens after the project has ended?
Samples will remain archived in the labs or Smithsonian indefinitely for future use as outlined in #10 below.

9c. Will the organisms be kept alive after collection? ☐ Yes ☒ No

• General site/location for collections:
na

• Is it an open or closed system? ☐ Open ☐ Closed
na

• Is there an outfall? ☐ Yes ☐ No
na

• Will these organisms be housed with other organisms? If so, what are the other organisms?
na

• Will organisms be released?
na

10. If applicable, how will the collected samples or specimens be transported out of the Monument?
All samples will be transported onboarrd the Kilo Moana to Honolulu, where they will be shipped to Florida State University or Texas A&M University. Water samples will be housed in the laboratory of Dr. Brendan Roark at Texas A&M University where most of the water sample analyses will be conducted. Total alkalinity and dissolved inorganic carbon analyses will be

performed in Shamberger's lab at Texas A&M. The radiocarbon water samples will be analyzed at the Center for Accelerator Masspectrometry Lawrense Livermore National Laboratory with unused material being returned to Texas A&M University. Coral samples collected for aging will be dried and archived in the laboratory of Dr. Roark in the Geography Department at Texas A&M University. Each sample is curated with individual accession numbers and appropriate metadata to facililate sharing samples with other researchers. Currently more that 100 deep-sea coral specimens from around the world are archived in the laboratory. Excess material not needed for geochemical, age and growth rate studies are made available for others researchers to utilize and incorporate into their research.

For radiocarbon water samples CO2 will be extracted from water samples at Texas A&M University (TAMU), and taken to the Center for Accelerator Masspectrometry Lawrense Livermore National Laboratory (CAMS-LLNL) to be processed for AMS 14C dating by B Roark or one of his graduate students. For age dating corals, 5-10 mg samples will be milled at TAMU from the deep-coral specimens and the resulting powder will processed for AMS 14C dating by B Roark or one of his graduate students. This work is done under a long standing (~15 years) collaboration between B. Roark and researchers at CAMS-LLNL. Aliquots will be taken for carbon and boron isotopic analyses to be analyzed at the Stable Isotope Geosciences Facilty and the Ken Williams Radiogenenic Facilty at Texas A&M University (TAMU). Water samples will be analzed with the same facilites or in Dr. Shambegers laboratory (TA and DIC samples) or at Geochemical and Environmental Research Group TAMU (nutrient samples).

Coral samples for genetics will be housed in the laboratory of Dr. Baco-Taylor at FSU and will be stored at -80 C or in ethanol. After subsampling at sea, larger specimens not used for aging, after subsampling for genetics, will be shipped directly to the Smithsonian Natural History Museum when we reach port, to be added to their invertebrates collection archive.

Baco-Taylor Lab:
Amy Baco-Taylor
EOAS/Oceanography
Florida State University
[redacted]

Roark Lab:
Department of Geography
[redacted]

Center for Accelerator Masspectrometry Lawrense Livermore National Laboratory:

[redacted]

Smithsonian Institution:
Stephen D. Cairns
Research Scientist/Curator
[redacted]

11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:
This is a collaborative effort between 3 scientists A. Baco-Taylor, B. Roark and K. Shamberger, who have previously worked together to publish the discovery of deep-sea scleractinian reefs in the Hawaiian Archipelago. They are sharing this project and associated specimens to prevent duplication of effort and duplication of sampling. A. Baco-Taylor is also incorporating previously collected samples and data from the NWHI into the analyses to avoid having to resample many additional sites. Roark is utilizing data and samples collected in the NWHI and Hawaiian Islands during previous projects to avoid having to collect additional samples and to bolster this study.

12a. List all specialized gear and materials to be used in this activity:
ROV Lu'ukai - operated by the University of Hawaii
Kilo Moana shipboard Multibeam
Kilo Moana shipboard CTD
Deep-sea coral lander with Aanderaa Seaguard II CTD and ADCP Platform, SAMI CO2, SAMI Ocean pH sensors, and data recorder. Note we are planning to deploy an instrumented deep-sea coral lander at a site outside the Monument (Colahan) and will recover it a year later during an NSF funded cruise in 2021. We include the lander here in case weather or other unforseen circumstances prevent its deployment outside the monument, in which case we will likely deploy it at a site in the monument. This is the same deep-sea coral lander that has been deployed two different times for a year during previous work in the Monument. However we are reconfiguring the lander by adding two new sensors to characterize seawater carbonate chemistry (SAMI CO2 and SAMI pH sensors) and making it much smaller so that it can be deployed and recovered using the ROV. This is less risky and allows full control on where it is placed.

12b. List all Hazardous Materials you propose to take to and use within the Monument:
2-5 ml mercuric chloride to poison water samples
95-100% non-denatured ethanol
10% buffered foramlin

Borax
RNA Later

13. Describe any fixed installations and instrumentation proposed to be set in the Monument:

Carbonate Dissolution Blocks:
Dissolution blocks will be cut from shallow water reef-building corals (Porites) with a density within the range of densities previously measured for deep-sea scleractinians. Dissolution blocks will be prepared following Silbiger et al. (2014). Briefly, coral pieces will be cut into 5 × 5 × 2 cm blocks, soaked in fresh water, and then autoclaved to remove any living organisms. Dissolution blocks will be bolted and epoxied to individual weighted PVC frames that will be placed on the bottom and recovered a year later on an NSF funded cruise in 2021. At each site, 5 dissolution blocks will be deployed at 3 depths each, within the depth range of the reefs (400-900 m): above the ASH in saturated water, below the ASH in undersatured water, and one intermediate depth; for a total of 15 blocks per site and 75 blocks within the monument. Dissolution blocks will be placed on the bottom (and recovered the following year) with the ROV. For sites with reefs, blocks will be placed as close as possible to the reefs without damaging the reef.

Deep-sea Coral Lander
The original version of this lander was deployed in the Monument on two separate occasions for 1 year each. The lander was dropped from the ship to the seafloor using weights and after a one year deployment recovered by floatation to surface with ROV/submersible release of weights. This year we are redesigning the lander and substantially reducing its footprint to make it compact enough to deploy and recover from the ROV as we want to place the lander within or at the edge of the deep-sea scleractinian coral reefs without damaging any of the corals. The only items left on the seafloor after recovery will be one stack of soft steal plates (~50 pounds).

Key Elements
-- 2000 m capable lander.
-- Deployed and recovered from the ROV
-- 12 months deployment.
-- Likely depths of deployment 500 to 900 m.
-- Build for potential expansion.

Instrumentation on the lander

1) Aanderaa Seaguard II Platform with a multi-group recorder including 4 analog and 20 AiCaP sensor inputs with 2 GB SD storage card and Lithium Battery (7V/35Ah) (1 year deployment is not a problem in terms of battery power and memory). This instrument serves as a data logger and power source for a series of smart sensors that are connect directly or by cable to the Seaguard II Platform housing. Sensors are detailed below.

1a) Deepwater DCPS 600 kHz 3D Broadband or Narrowband selectable acoustic doppler current profiler sensor. Measurement range 2 to 100 meters, measurement bins size 0.5 – 5 m, Velocity resolution 0.1 cm/s ± 0.5 % (3000m depth rating). This is active sensor with important specifications listed below.

-- Acoustic Frequency: 600 kHz

-- Typical profiling range: Broadband 30-70m, Narrowband 35-80m. We will likely operate using the Broadband profiling across a depths 3-70 m above the seafloor.

-- Ping rate: up to 10Hz. Depending on configuration choices and battery life calculations we anticipate doing active measurement using the acoustic Doppler every 1-6 hours (longer time intervals are more likely) for 1-3 minutes per measurement with the instrument going into sleep mode in between measurements and not emitting any noise.

-- Number of columns: 3 simultaneous columns.

-- Number of beams: 4

-- Beam Angle: 25°

-- Beam width: 2.5°

-- Echo intensity; Dynamic Range;>50dB: resolution <0.01dB; Precision <0.01dB

The rest of these sensors are passive sensors
1b) Conductivity and temperature Sensor – AiCaP smart sensor that plugs directly into the Seaguard II Platform housing. Conductivity, Signal Range 0- 7.5 S/m, Accuracy: 0.0018 S/m, Temperature Output: Range: -5 to 40 Deg.C., Accuracy: 0.1 Deg.C., 3000m rated
1c) Oxygen Optode MkII IW AiCaP smart sensor that plugs directly into the Seaguard II Platform housing. Range 0-500uM, Accuracy +/-8 uM/l or 5% of reading, 3000m rated .

1d) Depth Sensor – AiCaP smart sensor that plugs directly into the Seaguard II Platform housing. Non AP compensated Tide or depth, averaging absolute pressure & water temperature. Pressure range 0-20,000kPa (2km), 2 or 4 Hz sampling, pressure accuracy 0.01%, resolution 0.0001%; Water temperature: Range: -5 to 40 Deg.C., Accuracy: 0.1 Deg.C.; 3000m rated .
1d) WET Labs Environmental Characterization Optics (ECO) fluorometer with an optical scattering measurement at 700 nm for simultaneous determination of fluorescence and turbidity (ECO FLNTU). Sensor will connect to the Seaguard II Platform housing with an RS232 cable.

2) Deep Marker Beacon Sonardyne Type 7835 (2000 m rating). This is a positioning transponders that passively listens to be interrogated at a user defined frequency and then responds allowing the determination of the of range and direction. We will use an ROV-Homer installed on the ROV Jason II to find the lander and recover it in one dive on our return visit to the site. Sound emissions should be limited to the duration of ROV activities to recover the lander; 1 dive lasting 10-12 hours

Operating Frequency Range: HF 35-55kHz
Transmit Source Level >183dB re 1µPa @ 1m

3) SAMI-pH - Ocean pH sensor from Sunburst Sensors
pH range 7-9
Salinity range* 25-40

Response time 3 minutes
Accuracy (based on CRM intercomparison) +/- 0.003 pH units
Precision <0.001 pH units
Long term drift <0.001 pH units over 6 months
Thermistor accuracy, precision 0.1° C, +/- 0.01º C
Dimensions (housing length, diameter - single battery) 55 cm, 15.2 cm
Weight in air/seawater 7.6 kg / 1.1 kg

4) SAMI-CO2 - Ocean CO2 Sensor from Sunburst Sensors
Deployment duration ~10,000 measurements
Response time ~5 minutes
Accuracy** +/- 3 µatm
Precision <1 µatm
Long term drift <1 µatm units over 6 months
Thermistor accuracy, precision 0.1° C, +/- 0.01º C
Dimensions (housing length, diameter) 55 cm, 15.2 cm
Weight in air/seawater 7.6 kg / 1.1 kg

Each of the Sunburst Sensors come with their own internal battery package and recorders.

Lander Frame Construction
Frame configuration and construction is being finalized pending Sunburst sensor order being fulfilled and approval from the ROV operator. Materials used in the previous lander and likely to be used in the new frame or modification of the existing frame.
-- Galvanized steel framing has better corrosion resistance than zinc-plated steel framing and is the minimum acceptable material.
-- 304 stainless steel framing offers the best corrosion resistance
Platform material – molded fiberglass grating.

14. Provide a time line for sample analysis, data analysis, write-up and publication of information:
2-3yrs
We anticipate at least 3 publications developing from this phase of the project. There will also be presentations at scientific meetings to present these findings. We would be happy to work with the Monument if specific outreach products are desired related to the findings of the cruise. We are open to a Monument outreach person participating in the cruise. We also have included Whale Times Inc. to develop outreach and education products in Hawaii, Texas and Florida, and are collaborating with Andy Collins at Mokupāpapa Discovery Center to incoporate the impact of ocean acidification on coral reef ecosystems in the Monument.

Time line for aging studies and geochemistry analyses of coral samples is that 80% of the analytical work will be completed in the year after the cruise. In year 2 the remaining 20% of the analytical work will be completed and the results of the aging study and biogeochemistry

incorporated into the genetics and coral survey work. All of the water samples will be analyzed within 1 year of the completion of the cruise.

15. List all Applicants' publications directly related to the proposed project:
*indicates student author; Shamberger previously published as Fagan

Baco, A.R., *N.B. Morgan, and E. B Roark. 2020. Observations of Vulnerable Marine Ecosystems and Significant Adverse Impacts on High Seas Seamounts of the Northwestern Hawaiian Islands and Emperor Seamount Chain. Marine Policy. 115: 103834. https://doi.org/10.1016/j.marpol.2020.103834

Baco, A.R., E. B Roark, *N.B. Morgan. 2019. Amid Fields of Rubble, Scars, and Lost Gear, Signs of Recovery Observed on Seamounts on 30-40 year Time Scales. Science Advances. 5: eaaw4513.

*Morgan, N.B. and A.R. Baco. 2019. Observation of a High Abundance Aggregation of the Deep-sea Urchin Chaetodiadema pallidum (Agassiz and Clark 1907) on Mokumanamana. Deep-Sea Research I. 150: 103067. https://doi.org/10.1016/j.dsr.2019.06.013.

*Morgan, N.B., **S. Goode, E.B. Roark, A.R. Baco. 2019. Fine scale benthic invertebrate megafaunal assemblage structure on the North Pacific seamount Mokumanamana. Frontiers in Marine Science. Special volume on Pacific Discoveries. 6: 715. doi: 10.3389/fmars.2019.00715 .

*Mejia-Mercado, B., B. Mundy and A.R. Baco. 2019. Variation in the structure of the deep-sea fish assemblages on Necker Island, Northwestern Hawaiian Islands. Deep-Sea Research I. 152: 103086. https://doi.org/10.1016/j.dsr.2019.103086. With cover image.

Baco, A.R., *N.B. Morgan, E.B. Roark, M. Silva, K. Shamberger, K.M., Miller, K. 2017. Defying dissolution, discovery of deep-sea scleractinian coral reefs in the North Pacific. Scientific Reports. 7: 5436 | DOI:10.1038/s41598-017-05492-w

Baco, A.R., R. Etter, P. Beerli, P. Ribeiro, S. von der Heyden, and B. Kinlan. 2016. A synthesis of genetic connectivity in deep-sea fauna and implications for marine reserve design. Molecular Ecology in press.

Morrison, C.L., Baco, A.R., Nizinski, M.S., Coykendall, D.K., Demopoulos, A.W.J., Cho, W., Shank, T.M. 2015. Population Connectivity of Deep-Sea Corals. In: Hourigan TF, Etnoyer PJ, Cairns SD, Tsao C-F (eds) State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum. NOAA, Silver Spring, MD. p 12-1 to 12-30

Parrish, F., A.R. Baco, C. Kelley, and H. Reiswig. 2015. State of Deep Coral and Sponge Ecosystems of the United States Pacific Islands Region: 2015. In: Hourigan TF, Etnoyer PJ, Cairns SD, Tsao C-F (eds) State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum. NOAA, Silver Spring, MD. p 7-1 to 7-38.

*Morgan, N.B., S. Cairns, H. Reiswig, A.R. Baco. 2015. Benthic megafaunal community structure of cobalt-rich manganese crusts on Necker Ridge, North Pacific Ocean. Deep-Sea Research I. 104: 92-105. doi: 10.1016/j.dsr.2015.07.003.

*Figueroa, D. and A.R. Baco. 2014. Octocoral mitochondrial genomes provide insights into the phylogenetic history of gene order rearrangements, order reversals, and also into the use of mitochondrial genomes for cnidarian phylogenetics. Genome Biology and Evolution doi:10.1093/gbe/evu286

*Figueroa, D. and A.R. Baco. 2014. Complete mitochondrial genomes elucidate the phylogenetic relationships of the deep-sea octocoral Families Coralliidae and Paragorgiidae. Deep-Sea Research II, doi:10.1016/j.dsr2.2013.06.001.

*Long, D. and A.R. Baco. 2014. Rapid change with depth in megabenthic structure-forming communities in the Makapu'u deep-sea coral bed. Deep-Sea Research II, doi:10.1016/j.dsr2.2013.05.032.

Schlacher, T., A.R. Baco, A. Rowden, T. O'Hara, M. Clark, C. Kelley, and J. Dower. 2014. Seamount benthos in a cobalt-rich crust region of the central Pacific: conservation challenges for future seabed mining. Diversity and Distributions 20(5): 491-502. doi: 10.1111/ddi.12142

Sinniger, F., O. Ocana, and A. Baco. 2013. Diversity of Zoanthids (Anthozoa: Hexacorallia) on Hawaiian Seamounts: Description of the Hawaiian Gold Coral and Additional Zoanthids. PLoS ONE 8(1): e52607. doi:10.1371/journal.pone.0052607

Baco, A.R. and S.D. Cairns. 2012. Comparing molecular variation to morphological species designations in the deep-sea coral genus Narella reveals new insights into seamount coral ranges. PLoS ONE 7(9): e45555. doi:10.1371/journal.pone.0045555

Yesson, C., M. Taylor, D. Tittensor, A. Davies, J. Guinotte, A.R. Baco, J. Black, J. Hall-Spencer, A. Rogers. 2012. Global habitat suitability of cold water octocorals. Journal of Biogeography 39(7): 1278-1292.

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With knowledge of the penalties for false or incomplete statements, as provided by 18 U.S.C. 1001, and for perjury, as provided by 18 U.S.C. 1621, I hereby certify to the best of my abilities under penalty of perjury of that the information I have provided on this application form is true and correct. I agree that the Co-Trustees may post this application in its entirety on the Internet. I understand that the Co-Trustees will consider deleting all information that I have identified as "confidential" prior to posting the application.

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Honolulu, HI 96818
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