

**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:

Papahānaumokuākea Marine National Monument Permit Coordinator  
6600 Kalaniana'ole Hwy. # 300  
Honolulu, HI 96825  
nwhipermit@noaa.gov  
PHONE: (808) 397-2660 FAX: (808) 397-2662

**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:** Christopher Wall

**Affiliation:** UH Manoa, Hawai'i Institute of Marine Biology (HIMB)

**Permit Category:** Research

**Proposed Activity Dates:** May 1<sup>st</sup> - December 31<sup>st</sup>, 2015 (specific dates TBD)

**Proposed Method of Entry (Vessel/Plane):** R/V Hi'ialakai

**Proposed Locations:** (Shallow water reef (<100 ft depth), TBD, dependent on NOAA field cruise destinations)

**Estimated number of individuals (including Applicant) to be covered under this permit:** 4 Christopher Wall, Dr. Courtney Couch, two TBD UH Manoa Scientific Divers (\* no more than 3 divers will enter the Monument at a time for the purpose of this research plan).

**Estimated number of days in the Monument:** 30

**Description of proposed activities:** (complete these sentences):

a.) The proposed activity would...

assess the bleaching recovery in reef corals from shallow-water reefs throughout the Papahānaumokuākea Marine National Monument. In 2014, extensive and severe coral bleaching occurred across PMNM and the Main Hawaiian Islands. Dr. Courtney Couch and NOAA documented this bleaching event by recording the extent of bleaching along randomly selected sites (RAMP) and permanent transects in PMNM. To better understand how high temperature stress affected bleaching susceptibility and recovery of corals from the physiological to community scale, we propose to use non-destructive field ecology and minimally invasive sampling. This analysis will reveal the coral taxa most vulnerable and resilient to coral bleaching and identify physiological factors contributing to bleaching resilience across reef habitats. Further, these data will contribute valuable baseline data for coral health and bleaching recovery in the PMNM.

b.) To accomplish this activity we would ....

conduct ecological surveys by SCUBA on shallow-water reefs to determine whether changes in coral cover and species diversity at each site and reef habitat can be attributed to the 2014 bleaching. In August and September 2014, bleaching prevalence and severity, as well as benthic community structure (e.g. % cover of benthic taxa), were quantified in PMNM along permanent transects at French Frigate Shoals, Lisianski Island, Midway Atoll, and Pearl and Hermes Atoll. In 2015, we will visit the sites sampled in 2014 to assess post-bleaching recovery using field ecology methods employed in 2014 (i.e., photographs, transects, video). These data will be leveraged with bleaching information collected in 2014 to determine the impacts of bleaching on the PMNM reef coral community. Additionally, we will examine the physiological basis for coral bleaching recovery to test for site-specific traits conferring resilience to bleaching using the coral *Montipora* spp. as a model organism. Physiological assessments will include: examining the diversity of the coral's symbiotic alga community, and the nutritional and energetic status of coral biomass in small fragments (<4cm<sup>2</sup> fragment). *Montipora* spp. is abundant across the Hawaiian archipelago and has been shown to be sensitive to bleaching stress, therefore this coral taxa is an ideal system to explore the dynamics of bleaching and recovery in the PMNM. Finally, to evaluate the contribution of potential nutritional sources to bleaching recovery water samples (10L), seawater samples (10mL), and plankton will be collected and analyzed at the Hawai'i Institute of Marine Biology on O'ahu.

c.) This activity would help the Monument by ...  
examining the ecological outcomes of coral bleaching on Papahānaumokuākea Marine National Monument reef coral communities; identifying reef habitats and coral taxa resilient to bleaching stress; and examining the physiological characteristics conferring resilience to bleaching. This study provides the ideal opportunity to implement the PMNM Climate Change Action Plan by developing a monitoring strategy to survey climate change impacts within the Monument and directly builds from previous PMNM research (PMNM-2014-012 Couch). Through this study, we will augment the invaluable ecological baseline data and conduct the first study on the physiological outcomes of bleaching in the Monument. As a result of anthropogenic climate change, the frequency and magnitude of coral bleaching is expected to increase over the course of this century. Therefore, evaluating the impacts of climate change and bleaching on corals within the PMNM is imperative for the long-term management of this valuable ecosystem.

**Other information or background:**

In order to understand and manage for the impacts of climate change on marine ecosystems, particularly within marine sanctuaries, long-term monitoring is needed to address the impacts of ocean warming on coral reefs and identify factors contributing to bleaching resistance and recovery. Coral bleaching has contributed to declining coral abundance worldwide and is a leading cause of coral mortality. Ocean warming and climate change is predicted to increase the frequency and magnitude of bleaching events. Since 2002, three widespread bleaching events have occurred in PMNM with

2014 being the most extensive and severe bleaching to date, suggesting that ocean warming is already affecting the remote islands of PMNM. While ecological studies provide invaluable information on the communities-level responses of reef corals to these events, coral physiological assessments provide insight into the underlying mechanisms driving these larger-scale patterns in bleaching response. Lipid biomass and heterotrophic nutrition associate with bleaching resilience. Therefore identifying environmental factors supporting alternative sources of nutrition (e.g., lipid biosynthesis, heterotrophy) will provide insight into bleaching susceptibility and recovery. This research will directly address the science needs specified by the Office of Marine Sanctuaries for the PMNM by determining the ecological impacts of an archipelagic-bleaching event. Additionally, this research will contribute to effective management strategies in the PMNM and other global reef systems by (1) identifying factors affecting bleaching and bleaching recovery and (2) enabling resource managers to identify reef systems resilient or vulnerable to climate change stress in order to support science- and ecosystem-based management in Hawai'i.

## **Section A - Applicant Information**

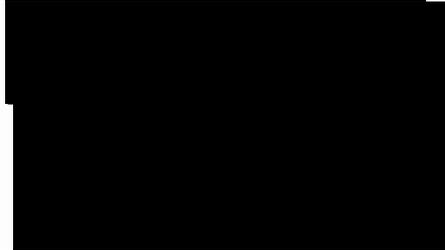
### **1. Applicant**

Name (last, first, middle initial): Wall, Christopher B.

Title: Ph.D. student, UH Manoa, HIMB

**1a. Intended field Principal Investigator (See instructions for more information):**  
Christopher B. Wall

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



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



**3. Affiliation (institution/agency/organization directly related to the proposed project):**  
HIMB, UH Manoa

**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):**

1. Christopher B. Wall, Research Diver & PI, Ph.D. student UH Manoa/HIMB
2. Dr. Courtney Couch, Research Diver & Co-PI, Postdoc at UH Manoa/HIMB
3. TBD Diver (UH Manoa/HIMB)
4. TBD Diver (UH Manoa/HIMB)

**Section B: Project Information**

**5a. Project location(s):**

- |  |                                     |   |                                     |
|--|-------------------------------------|---|-------------------------------------|
| <input checked="" type="checkbox"/> Nihoa Island                 | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Necker Island (Mokumanamana) | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> French Frigate Shoals        | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Gardner Pinnacles            | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Maro Reef                    |                                     |   |                                     |
| <input checked="" type="checkbox"/> Laysan Island                | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Lisianski Island, Neva Shoal | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Pearl and Hermes Atoll       | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Midway Atoll                 | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input checked="" type="checkbox"/> Kure Atoll                   | <input type="checkbox"/> Land-based | <input checked="" type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input type="checkbox"/> Other                                   |                                     |   |                                     |

**Ocean Based**

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:

**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 purpose of our proposed activities is to utilize qualitative field ecological assessments of coral bleaching and bleaching recovery on shallow-water reefs throughout the Papahānaumokuākea Marine National Monument. The significance of this work is two-fold: (1) understanding bleaching recovery in PMNM is essential for managing for the impacts of climate change on the pristine ecosystem of the Monument, specifically, the extent to which these reefs are resilient to increased ocean warming; (2) providing baseline data for coral-symbiont assemblages across atolls/islands and habitats; (3) identifying those species resilient to ocean warming and the physiological characteristics that contribute to coral resilience to environmental stress using the coral *Montipora* spp. as a model organism. Corals are the "ecosystem engineers" of tropical reef systems, central to the construction of reef substrate, providing habitat for a multitude of marine species, and serve as energy transformers taking light energy to produce oxygen and dissolved materials critical to reef ecosystem food webs. Therefore, the health of the coral communities directly affects the health of the reef ecosystem as a whole. Climate change is a leading threat to reef corals, and as global changes progress it is important to study the impacts of environmental stress on the reefs of PMNM to determine which reefs and species will be most vulnerable. As one of the world's few 'near-pristine' coral reef ecosystems, PMNM provides an invaluable system against which to compare regions with high levels of anthropogenic stress. Additionally, as physical conditions and seasonal variance vary across regions of PMNM, it is important for resource managers to have detail on the spatial variance of stress susceptibility and bleaching recovery across PMNM. This will aid in identification of areas threatened by bleaching stress, and conversely, those reefs or habitats more resilient to environmental stress. Furthermore, the analysis of sediment organic matter and suspended particulates will allow for an analysis of potential food sources utilized by corals in these habitats. This information has the potential to inform our understanding of coral nutrition and their reliance on alternative food sources during periods of stress. The proposed methods in this permit will complement and improve upon the current assessments of coral health that utilize permanent survey sites (PMNM-2014-012 Couch) by repeatedly surveying colonies and providing a framework for future studies. Furthermore, continuing these surveys over time will equip managers with the ability to track episodes of coral bleaching within the Monument, and compare bleaching and bleaching recovery in a future of more frequent climate change-driven bleaching events.

\*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?

As conservation biologists, we study how best to conserve the ecological integrity of marine ecosystems and ensure that our science has the least amount of impact on these ecosystems as possible. We respect the natural and cultural resources around coral reefs and recognize the immense importance of these ecosystems to indigenous peoples. In this work, we will actively employ every precautionary measure to minimize impacts of fieldwork on the reefs of the Monument. We have carefully designed our study to retain a robust scientific nature with minimal collection requirements, and have opted for non-invasive methods when possible. Results produced from this work will be useful for scientists and managers and will contribute to the conservation efforts of the Monument and other reef systems worldwide. We believe that we have implemented every reasonable safeguard for the natural resources and ecological integrity of the Monument in our research, and we do not expect any detectable impact from our research sampling. As outlined in detail below, our sample size and methodologies have all been selected to provide robust and scientifically rigorous information to managers with the least possible impact to the natural and cultural resources of the Monument. No surveys or collections will occur in the vicinity of any known Native Hawaiian or western archaeological sites within the Monument, and thus are unlikely to impact any such resources. If archaeological sites are encountered, Global Positioning System (GPS) coordinates for the sites as well as a general description will be taken and provided to Monument staff.

Field Surveys (Permanent transects):

Surveys in 2015 will return to permanent reef transects sampled in 2014; permanent transects were established by Dr. Jim Maragos, NOAA's CRED and Dr. Courtney Couch. Analysis of coral community bleaching (2014), recovery (2015), and the ecological outcomes of bleaching (changes in % coral cover or % species abundance) is performed using transect tape and photographs. This methodology relies on pre-existing pins and affords the diver very limited contact with the benthos, with the exception of deployment of transect tape, and leaves virtually no trace of the divers presence. The only physical impact is the deployments of transect tape. Transects will be carefully deployed and placed above the substrate in a manner to ensure no harmful contact with any living corals or other organisms. No tape will be wrapped or anchored

in any manner that could damage any living coral or substrate. The methods used to deploy transect tape are nearly identical to those used for CRED research activities and will have the same negligible impact on living substrate. I have experience performing field ecological surveys using SCUBA and have surveyed reefs in Hawai'i (O'ahu and Hawai'i Island) and internationally (Taiwan; Mo'orea French Polynesia). The co-PI on this project (Dr. Courtney Couch) also has substantial experience conducting surveys in this manner and has visited the Monument previously to conduct these surveys. All divers are adequately trained (please see diver qualification descriptions in Question #7-F) in benthic surveys by SCUBA.

#### Coral Sample Collection:

The sampling of coral tissue will be minimal and will not affect the health of the coral colony as a whole. Bleaching in 2014 was characterized at Midway Atoll, Pearl and Hermes Atoll, Lisianski Island, and French Frigate Shoals at 2 depths [shallow (0-30') and moderate (31-60')], 2 reef habitats (backreef and forereef), along 2-3 transects within each depth and habitat. During 2014, *Montipora* spp. was most severely affected by bleaching across all sampled locations. In 2015, we will use *Montipora* spp. to assess factors contributing to bleaching recovery and susceptibility; *Montipora* spp. was selected as a model organism to examine post-bleaching recovery and resilience due to its wide range across the Hawaiian archipelago, abundance in PMNM, and high sensitivity to bleaching stress. Our research plan will consist of collection of 20 4cm<sup>2</sup> fragments of *Montipora* spp. (which could include *M.captitata*, *M.patula*, *M.turgescens/dilatata*, *M.flabellata*) at each depth and habitat (no more than 20/site), for a total sampling effort of 80 fragments collected at each island/atoll (total area equal to 0.03m<sup>2</sup>) and no more than a total of 400 fragments, equalling a total sampling area of 0.16m<sup>2</sup> across the entire Monument (>1000km). These samples will be judiciously collected by carefully removing an apical region of individual plating *Montipora* spp. colonies using metal clippers, hammer and chisel. Collections of this nature are common in coral biology, and can be made without causing damage or mortality risk to the coral colony. The apical regions of corals are the sites of most active growth, and these areas are fastest to recover relative to central regions of the animal. Both Dr. Couch and I have extensive experience in coral sampling and marine ecology. Samples will immediately be placed in whirl pak bags and transported to the surface, where they will be placed in a cooler filled with ice. Once we return to the wetlab on the Hi'ialakai, we will remove a small fragment (~0.5cm<sup>2</sup>) from the sample and place it into DNA extraction buffer (see MSDS for details), which will be placed in an airtight container and stored in the wetlab freezer until we return to Honolulu. At no time will chemicals be released into the Monument. At no point will any live tissue be transported between sites or released back into the marine environment.

#### Sampling of seawater and sediment nutrients

At each atoll ~10L of seawater will be collected from shallow and mid-depth habitat (~20L per atoll or island). This seawater will be used to analyzed dissolved inorganic nutrients and particulate organic matter in seawater adjacent to sampled corals. A small sample of sediment will be taken from the substrate adjacent to the corals

sampled to analyze the composition of organic matter in the sediment. Three sediment sample will be taken at each habitat (~6 samples per atoll or island), and will require collection of only the upper 1cm of sediment with a final volume not to exceed 10mL. Finally, a single vertical plankton tow will be performed at each habitat (total of 2 tows per atoll or island) to sample potential heterotrophic food sources available to corals. Tows will originate at the depth of coral collection and move vertically towards the surface, retaining only those particles >70 um in diameter on a filter. Tows are slow and nondestructive, and do not harm or disturb fish or other marine organisms. The importance of these three parameters pertain to categorizing nutritional sources available to corals, as has been done in other trophic studies in other benthic taxa. These nutrient sources will vary according to habitat type, depth, and location within the Monument, and may relate to the potential for a coral to exploit alternative sources of nutrition during normal and stressed periods. In total this effort will require a total of 80 - 100L of seawater, 1L of sediment, and 10 separate plankton collecting only materials retained on a 70um filter.

Returning to Midway Atoll, Pearl and Hermes Atoll, Lisianski Island, and French Frigate Shoals is dependent upon the logistical support of NOAA and the planned research objectives set forth by NOAA lead scientists. Therefore, we are requesting sampling from the entirety of the Monument in order to plan for uncertainty in the ultimate destination of the research voyage. However, we anticipate the sampling design to be fixed, with the objective of sampling bleaching recovery across habitats in the three regions of the Monument (northern, central, southern).

Our work will not impact historic resources: we do not set foot on land within the Monument, and we report but do not touch any submerged artifacts discovered during our diving activities.

Each participant is required to participate in a Cultural Briefing prior to departure on the Hi'ialakai. In addition, the chief scientist, other appropriate personnel and myself will consult with the Office of Hawaiian Affairs (OHA) and the Monument's Native Hawaiian program coordinator on proper conduct while in the NWHI, and on cultural sensitivities associated with the proposed activities and locations. Our research team is aware of the unique ecological status of the Monument, and this briefing reminds all members of the cultural significance of this place. Stewardship of natural resources is a central theme in the relationship that Hawaiians have with the natural world and, thus, there is no difference between a natural and cultural resource. Papahānaumokuākea is a sacred place to Native Hawaiians; a place that is included in the oral history of chants and mele; a place where native Hawaiians have travelled for hundreds of years. Because of the close relationship between Native Hawaiians and the ocean, the coral reef marine life of Papahānaumokuākea Marine National Monument also constitute a living cultural resource whose well-being is integral to the perpetuation of cultural values and practices. We acknowledge that the corals we will survey hold great cultural significance to Native Hawaiians, in spiritual, religious, nutritional, utilitarian, and other ways. Similar to the RAMP and NOAA CRED program, we aim to characterize and

monitor the Monument's living marine resources, and directly inform traditional managers and Native Hawaiian practitioners of the health of these fragile resources within the Monument. We strive to approach our work in the Monument with the same humility, and regard for the natural world as these people. The significance of this work will contribute to the management of the Monument and will provide information on the health of these ecosystems following an unprecedented archipelagic bleaching event in 2014. We intend that our research in the Monument will give a strong foundation to stewardship practices that best manage and protect the coral reefs ecosystems of Papahānaumokuākea.

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? The research we propose here is the type of research directly mandated by the Proclamation: it is "research designed to further understanding of monument resources and qualities... [and] will assist in the conservation and management of the monument". The genealogical chant, Kumulipo, describes the first life form created was the coral polyp, therefore reef corals hold an important place in Hawaiian culture, as well as in the reef ecosystems that bare their name. This Kumulipo shows a deep respect for corals as the backbone of our productive marine ecosystems. Corals deserve this appreciation as they provide habitat for a plethora of creatures, many of which we depend on for food. Climate change is a threat to all coral ecosystems; regardless of the protection afforded them, all coral reefs will be impacted by climate change. Therefore, we must manage for climate change effects in the hopes of mitigating these impacts on reef corals. In recognition of this threat, PMNM is in the final stages of implementing a Climate Change Action Plan that will improve the management of PMNM's ecological and cultural resources in the face of climate change. Determining the resilience of reefs to environmental stress is an important step in advancing the objective of understanding the impacts of climate change on the Monument. Due to their profound ecological and cultural importance, it is imperative that we work to conserve and protect Hawaiian corals. This research plan will contribute to the effective management of the Monument and predicting how PMNM reefs are affected--and more importantly how reefs recover--from environmental stress and climate change. Our goal is to collect data on the health and structure of coral communities in order to monitor and protect these organisms. Hawaiian corals are regarded as Kupuna that we must care for, as they are the ancestors and backbone of all marine life. Loss of corals will result in loss of habitat and function of the marine ecosystems. We hope our work will provide insight into the health of corals within the Monument as well as what factors may be connected to resilience and vulnerability to environmental stress. Ultimately this work aims to safeguard these culturally and ecologically important organisms. The research methods utilized in this study have no detrimental impacts on the marine ecosystems within the Monument. Our proposed research plan will provide valuable baseline data on physiological metrics that

contribute to bleaching tolerance and recovery (e.g., lipid biomass, symbiont genotype), and will work in combination with field ecology to better understand the ecological outcomes of bleaching in PMNM. These results will allow managers to identify sites of concern, for instance, where coral bleaching was severe and recovery was low. Our proposed methods directly complement the annual Reef Assessment and Monitoring Program (RAMP) by providing supplemental data on coral health, bleaching, and coral ecology within the standardized monitoring program for future surveys. Additionally, this dataset can be leveraged in future reef assessments and will contribute to an understanding of the effects of ocean warming within the Monument. To date, few studies have examined bleaching recovery in the PMNM and little information exists on coral reef resilience following bleaching in the PMNM, with the exception of general characteristics of dominant coral taxa from other regions. Therefore, this research plan will provide the first account of valuable physiological and ecological data for bleaching recovery, as well as the factors contributing the physiological resilience of corals across spatial scales. This data is urgently needed and has the potential to significantly contribute to the management and protection of the PMNM ecosystem.

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.

In order to understand how the corals of the Monument are affected by climate change, we must conduct research on the corals from these unique habitats. To accomplish this, the most care and respect must be afforded to these unique and pristine habitats. Therefore, sampling efforts must balance a rigorous design and judicious, well-thought out sampling plan. In this research plan the majority of activities are non-invasive and will contribute to the understanding of reef recovery and resilience following a widespread bleaching event. The biological sampling will be performed to couple the ecological outcomes—both the extent of bleaching and bleaching recovery—with coral physiology to evaluate biological mechanisms contributing to bleaching and recovery. It is important that these research activities be conducted and will provide useful data for monitoring and assessing coral health within the Monument. There is no practical alternative as the goal is to develop a robust dataset pertaining to coral health dynamics within the Monument itself. However, the dataset from this research plan will be used to its full potential and archived for longevity and historical reference. Furthermore, findings of this study will be used to formulate hypotheses regarding bleaching recovery that will be experimentally tested by myself at HIMB using corals collected from reefs across O'ahu. Our proposed survey methodology will complement and enhance the current coral health data being collected in the Monument, and contribute to the knowledge of the physiology of reef corals across this unique ecosystem.

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

The sampling outlined in this research plan is informative for the management and conservation of coral reefs within the Monument and is vital in our understanding of the ecological and physiological outcomes of environmental stress in the Monument. For instance, three bleaching events have been recorded in the Monument since 2002, and

the reefs of the northern and central region of Monument are consistently most severely bleached. While this may represent physical factors, including high temperature water retained in these areas due to stratification of seawater, it is uncertain whether these corals show any physiological signs of acclimation to increased frequency of thermal stress, or if there is a physiological or genetic basis for the vulnerability of these reefs to thermal stress. Further, the dynamics of bleaching recovery are not well described, specifically: what environmental conditions favor bleaching recovery, and what determines the physiological mechanisms used by corals to recover from bleaching? Results from this research will inform these important aspects of coral ecology and physiology. The sampling outlined in this research plan relies heavily on non-invasive metrics of assessing the coral community. Also, the research offers a unique chance to evaluate coral recovery along permanent transects where long term data collected by NOAA and CRED has already been obtained. Ecological sampling and biological sampling will be collected with minimal impact on the reefs of the Monument, and no coral colonies will be adversely affected by the actions detailed in this research plan. Protection, management, and kokua for the reefs of Hawai'i and the PMNM is a central theme to the research of Dr. Couch and myself, and we will respect the cultural value of this habitat at all times.

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.

The duration of our activities is dependent on the planned NOAA research cruises. We will use the allotted time efficiently to maximize our data collection, therefore needing no time outside that planned by the PMNM research coordinators.

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

Dr. Couch and I have extensive experience working on coral reefs in the field and in the laboratory, and we share a long history of conducting coral health surveys throughout Hawai'i and reefs around the world. Beyond our professional expertise and training as coral scientists, we have a deep respect and kokua for coral reefs and appreciate the value of these cultural resources to indigenous cultures, especially here in Hawai'i. Separately, our work has resulted in many peer-reviewed scientific publications, and presentations of our research has been exhibited at scientific conferences, community events, educational outreach activities, and the Monument Management Board (MMB)

Dr. Courtney Couch is a postdoctoral research fellow at the Hawaii Institute of Marine Biology. She is co-funded by NOAA/PMNM and The Nature Conservancy and tasked with standardizing coral health and disease monitoring across the Indo-Pacific, addressing the role of land-based pollution in coral health in Hawai'i, and building a capacity with marine resource managers to address coral disease. She has a decade of scientific diving experience, is a NAUI Rescue Diver with Nitrox certifications, a member

of the American Academy of Underwater Sciences and an active UH Manoa Lead Scientific Diver. She was also the lead diver on a 3-year coral health disease project on Hawai'i Island, a 2-year project in Indonesia through Cornell University, has conducted coral disease assessments in the Caribbean, Philippines and Indonesia, and has extensive experience in managing and analyzing large datasets. Dr. Couch also led the coral bleaching response in 2014, participated in both the RAMP and Biogeography cruise in 2014 and is familiar with the nuances of working in the PMNM.

Christopher Wall is a Ph.D. student in the Marine Biology Program at the UH Manoa, and performs the majority of his research at the Hawai'i Institute of Marine Biology. Christopher has 18 years of diving experience, and is a certified NAUI Master Diver and Rescue Diver, a member of the American Academy of Underwater Sciences and an active UH Manoa Lead Scientific Diver. Christopher has conducted extensive ecological surveys on the reefs of O'ahu, Hawai'i Island, Mo'orea French Polynesia, and southern Taiwan, and is trained as a coral reef physiological ecologist. He has 5 years experience performing coral physiology assessments, and his masters thesis was on the impacts of ocean warming and ocean acidification on reef corals.

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. The research labs of Drs. Ruth Gates (HIMB) and Megan Donahue (HIMB) are well funded by several federal and private grants and are equipped with all the analytical software necessary for disseminating the collected data. Due to the un-invasive nature of our survey methods we would be capable of mitigating any potential impacts if they occurred. There are no anticipated deleterious impacts of this work.

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.

Methods employed are designed to produce a robust dataset describing the ecology of reef corals with non-invasive field ecology, including videography, photography, and first-hand observations. Biological sampling has been designed to be minimal in scope while retaining a robust nature adequate to address the scientific questions on bleaching recovery. At no time with these activities compromise the health of these reefs, or the individual corals, and will not impact the cultural or historic resources of these reef. Following the sampling in 2014, returning in 2015 to sample bleaching recovery will allow us to non-invasively evaluate the recovery of these reefs. Building on this dataset, collections for host (animal) and symbiont (animal) analysis will allow for a comparison of observed ecological outcomes with the physiology and genetics of the coral-algal symbiosis. Our methods make use of a large historical dataset of coral reef ecology obtained by NOAA and CRED, and supplementing this with information of organismal biology and trophic ecology. The combination of field sampling and biological sampling will contribute to evaluating climate change effects, and recovery from these effects, in a near-pristine coral reef ecosystem. Results from this work will be

leveraged with other research projects being undertaken at HIMB addressing bleaching recovery at nine patch reefs at a human-impacted reef in Kāneʻohe Bay, Oʻahu. Results from both projects will advance the understanding of environmental factors contributing to bleaching and recovery and will aid in identifying the physical and biotic factors contributing to coral resilience to climate change.

i. Has your vessel been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?  
Our work will be conducted in conjunction with the planned NOAA summer field cruises; we will therefore operate on NOAA vessels and be in compliance with all marine vessel requirements.

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.  
Our activities in PMNM will be restricted to those explicitly described in this permit application.

#### **8. Procedures/Methods:**

Surveys will be conducted using SCUBA, transport to the sites will be facilitated by NOAA research vessels. Two divers will descend on the shallow-water coral reef sites (~10-80ft) chosen for surveys. Divers will deploy three 15-20m transect at a pre-determined location in the direction of a pre-determined bearing. Transect locations will be established by utilizing a random stratified sampling design in order to objectively survey all study sites. Working in unison, divers will investigate all corals underneath the deployed transect tape. Divers will record multiple parameters, such as colony size, bleached area (proportional surface area; if bleaching observed), coral species, percent cover, and dead coral for each surveyed colony and visible health affliction. All observed colonies will also be photographed to facilitate digital image analyses. Divers will also conduct an overlapping photo and video survey so the transect can be digitally reconstructed and archived for future use. The analyzed data will be used to determine coral bleaching recovery dynamics across spatial and temporal scales for all surveyed reefs within the Monument.

At each atoll/islands, transects (n=2-3) at two depths [shallow (0-30') and moderate (31-60')] and two reef habitats (backreef and forereef) will be used for coral collections. 20 4cm<sup>2</sup> fragments of *Montipora* spp. (which could include *M.captitata*, *M.patula*, *M.turgescens/dilatata*, *M.flabellata*) will be collected at each depth and habitat (no more than 20/site). These samples will be judiciously collected by carefully removing an apical region of individual plating *Montipora* spp. colonies using metal clippers, hammer and chisel. Samples will immediately be placed in whirl pak bags and transported to the surface, placed in a cooler filled with ice, and transported to the wetlab on the Hiʻialakai. A small fragment (~0.5cm<sup>2</sup>) will be excised from each sample and place into DNA extraction buffer (see MSDS for details) in an airtight container and stored in the wetlab freezer Sampling of seawater and sediment nutrients.

If observed, a few filter-feeding invertebrates (molluscs or arthropods) and epibionts will be collected at each atoll and habitat type near the bethos (a maximum of 15 organisms at each atoll). Since these organisms are non-symbiotic, they will incorporate the signal of available food (particles/plankton) that are also available to the coral. This requirement is not taxa specific, but in general, small bivalves are found near coral colonies or growing at the base of the coral, and these would be the organisms collected. These organisms would be transported to the surface in a plastic falcon tube, transported to the surface, and frozen on the Hi'ialakai.

Seawater collection by Niskin bottle will require ~10L of seawater to be collected from shallow and mid-depth habitat (~20L per atoll or island). Samples will be transported to the surface, and stored in Nalgene bottles. The upper 1cm of sediment adjacent to the corals sampled will be carefully placed into Falcon centrifuge tubes and transported to the surface. The vertical plankton tow will be performed at each habitat (total of 2 tows per atoll or island) by descending the weighted tow apparatus to the depth of collection and pulling the tow back toward the surface boat; only suspended materials will be retained. All samples will be transported back to the wetlab of Hi'ialakai and frozen.

**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:

Coral: Rice coral, ringed rice coral, pore coral/blue coral, sandpaper rice coral

Plankton: planktonic organisms (mix of phytoplankton, zooplankton)

Sand: inorganic and organic carbon sample

Assorted epibiont filter feeders: either bivalve molluscs (date mussel, ark clam, tree oysters, thorny oyster), or gastropods (worm snail, worm shell)

Scientific name:

Coral: *Montipora capitata*, *Montipora patula*, *Montipora turgescens/dilatata*, *Montipora flabellata*

Assorted epibionts: either bivalve molluscs (Genus: *Litophaga*, *Arca*, *Isognomon*, *Spondylus*), or gastropods (Genus: *Serpulorbis*, *Dendropoma*)

# & size of specimens:

Coral: up to a total of 400 coral fragments, with a maximum fragment size of 4cm<sup>2</sup> each

Other: 1L of sand (upper 1 cm only, <10mL per sample), particles retained from plankton tow (10 tows), 100L seawater (unfiltered)

Assorted epibionts (<2cm): 50 maximum samples collected across entire PMNM

Collection location:

a maximum of 80 fragments per island region at up to 5 regions (tentative locations: Midway Atoll, French Frigate Shoals, Lisianski Island, Pearl and Hermes Atoll). A maximum of 15 filter feeders would be collected at each island/atoll.

Whole Organism  Partial Organism

**9b. What will be done with the specimens after the project has ended?**

Preserved samples remain the property of the Monument and will be made available to others requesting access to these materials through the appropriate permit process. PI Wall will maintain a database of samples and provide for the storage of all samples collected at HIMB until such time as the Monument co-trustees request that they be returned to them.

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

All samples will be frozen at -20C or preserved in DNA extraction buffer immediately following collection. This will be conducted by placing samples in pre-filled watertight specimen jars with DNA extraction buffer. These jars will be transported in an air and watertight container to prevent chemical pollution into PMNM waters.

• General site/location for collections:

Collections will be stored in the wetlab on the Hi'ialakai after field collection and then kept at Dr. Ruth Gates' lab at HIMB.

• Is it an open or closed system?  Open  Closed  
N/A

• Is there an outfall?  Yes  No

• Will these organisms be housed with other organisms? If so, what are the other organisms?  
N/A

• Will organisms be released?

At no point will any live samples be transported between locations or released back into Monument waters. We will also follow PMNM Best Management Practice 011 (Disease and Introduced Species Prevention Protocol for Permitted Activities in the Marine Environment). This BMP recommends equipment is disinfected between uses at each dive site.

**10. If applicable, how will the collected samples or specimens be transported out of the Monument?**

Specimen jars will be transported in an air and watertight container to prevent chemical or biological pollution into or among waters of the Monument. These will be transported back to HIMB aboard the R/V Hi'ialakai. See attached MSDS sheets.

**11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:**

All HIMB researchers working on similar species have coordinated to share samples and avoid duplicate sampling. This project reflects this coordination, as a joint effort between Drs. Couch and Aeby at HIMB, PMNM and the RAMP program, and NOAA CRED. We will coordinate with Dr. Aeby and NOAA CRED to ensure no sampling interferes with or impacts permanent sampling sites in the Monument. Bleaching surveys will also be conducted alongside the RAMP divers to ensure that the data augment ongoing benthic monitoring efforts and minimize overlap.

**12a. List all specialized gear and materials to be used in this activity:**

Coral bleaching surveys: SCUBA gear (BCD, regulator, mask, fins, snorkels, weights, computers, compass, dive knife), slates, rulers, underwater cameras, transect tape

Coral tissue collection: whirl pak bags, clippers, specimen bottles, air/watertight bins, DNA extraction buffer.

Seawater and sediment sampling: Niskin bottles, forceps, planktonic mesh and plankton tow apparatus

**12b. List all Hazardous Materials you propose to take to and use within the Monument:**

Tissue preservation solutions include DNA extraction buffer (4L) CTAB buffer (Cetyltrimethyl ammonium bromide, 3%), consisting of NaCl (28%), EDTA salt buffer (4%), TRIS HCl buffer (10%),  $\beta$ -Mercaptoethanol (0.2%), and Polyvinylpyrrolidone (3%), and water (25%). At no point will the buffer leave the Hi'ialikai, and buffers will be in air and water tight containers. Tissue preservation for lipid and stable isotope analysis will consist of freezing samples at -20C. Sediment and seawater samples will be frozen at -20C.

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

No permanent or fixed installations are deemed necessary for this study.

**14. Provide a time line for sample analysis, data analysis, write-up and publication of information:**

Photo analyses, data analyses, sample processing and a report write-up will be completed within a year of the field surveys. We anticipate processing of coral samples for algal symbiont DNA to be completed within a few years. We hope to complete several publications and a Ph.D. dissertation utilizing this coral dataset within a few years of data collection.

**15. List all Applicants' publications directly related to the proposed project:**

- Couch, C. S. 2014. Intrinsic host and extrinsic environmental factors of coral health and disease. PhD Dissertation, Dept. of Ecology and Evolutionary Biology, Cornell University.
- Couch, CS, J Garriques, C Barnett, L Preskitt, S Cotton, J Giddens, W Walsh (in review). Spatial and Temporal Patterns of Coral Health and Disease along Leeward Hawai'i Island. Coral Reefs.
- Edmunds PJ, Burgess SC, Putnam HM, Baskett ML, Bramanti L, Fabina NS, Han X, Lesser MP, Wall CB, Yost DM, Gates RD (2014) Evaluating the causal basis of ecological success within the Scleractinia: An integral projection model approach. Marine Biology. DOI: 10.1007/s00227-014-2547-y
- Edmunds PJ, Wall CB (2014) Evidence that high pCO<sub>2</sub> affects protein metabolism in tropical reef corals. Biological Bulletin 227:68-77
- Wall CB, T-Fan, Edmunds PJ (2013) Ocean acidification has no effect on thermal bleaching in the coral *Seriatopora caliendrum*. Coral Reefs 33:119-130
- Wall CB, Edmunds PJ (2013) In situ effects of low pH and elevated HCO<sub>3</sub><sup>-</sup> on juvenile *Porites* spp. in Moorea, French Polynesia. Biological Bulletin 225:92-101
- Wall CB (2012) Effects of temperature and ocean acidification on juvenile scleractinian corals. MSc Thesis, Dept of Biology, California State University-Northridge

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.

**Christopher B. Wall**

Digitally signed by Christopher B. Wall  
DN: cn=Christopher B. Wall, o, ou, email=cbw0047@gmail.com, c=US  
Date: 2015.05.18 13:58:25 -10'00'

Signature

Date

**SEND ONE SIGNED APPLICATION VIA MAIL TO THE MONUMENT OFFICE  
BELOW:**

Papahānaumokuākea Marine National Monument Permit Coordinator  
6600 Kalaniana'ole Hwy. # 300  
Honolulu, HI 96825  
FAX: (808) 397-2662

**DID YOU INCLUDE THESE?**

- Applicant CV/Resume/Biography
- Intended field Principal Investigator CV/Resume/Biography
- Electronic and Hard Copy of Application with Signature
- Statement of information you wish to be kept confidential
- Material Safety Data Sheets for Hazardous Materials