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

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

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: Charles H. Fletcher
Affiliation: Department of Geology and Geophysics, School of Ocean and Earth Science and Technology University of Hawai‘i (UH) at Mānoa

Permit Category: Research
Proposed Activity Dates: May thru September 2018
Proposed Method of Entry (Vessel/Plane): Vessel (M/V Searcher)
Proposed Locations: French Frigate Shoals (FFS)

Estimated number of individuals (including Applicant) to be covered under this permit: 9

Estimated number of days in the Monument: 13

Description of proposed activities: (complete these sentences):

a.) The proposed activity would…

Assess the impacts of past and present sea-level rise upon low lying islands to improve understanding of how future sea-level rise will impact essential habitats for priority species (e.g. sea turtles, monk seals, and various seabirds).

b.) To accomplish this activity we would ….

Develop historical reconstructions of beach erosion and accretion during the recent Holocene (approximately 6,000 years ago to present), and provide managers with predictive models of sea-level rise impacts to nesting and foraging habitats for sea turtles, monk seals, and birds in Papahānaumokuākea. At FFS we propose to visit 2-3 sandy islands. At each island we would assess the interior stratigraphic architecture (layering of sediment) by recovering sediment from a maximum of 12 sites total. . Sediment recovered from the interior of the island will be strategically sampled in small quantities (120 samples total, approx. 2 tbsp/sample). The island surface will subsequently be restored to an undisturbed state by infilling sites with previously extracted sediment and best efforts will be made to avoid existing vegetation, and critical habitat for birds, turtles, and monk seals. Modern sediment will be sampled along the seafloor (120, 2 tbsp size samples) and comparisons will be made to island

sediment to quantify how sediment source and type have changed over time. To interpret historical reef habitat and accretionary response to changes in sea-level we will recover short cores (12 total: 1 m long, and 5-8 cm diameter) from the surrounding fossil reef platform using a small hand held drill.

Predictive modeling of island habitat response to future sea-level requires the acquisition of high-resolution requires topographic (land) and bathymetric (shallow seafloor) elevation data. We will derive digital elevation maps (DEMs) of each island from drone imagery and Structure-from-Motion. Real Time Kinematic Global Positioning System (RTK-GPS) control points will also be collected at the time of the drone survey to ensure that each DEM is adequately georeferenced. A vertical datum will be derived from RTK-GPS control points and a local short-term tide gauge that we will install for the duration of field work at each island. The DEM will be used to assess past changes in island habitat documented in historical imagery and in our predictive model to simulate island response to future sea-level rise.

c.) This activity would help the Monument by …

Sea-level rise is predicted to exceed 1-2 m by the end of the century (Sweet et al., 2017), which threatens the very existence of low lying islands and critical habitats for priority species found throughout Papahānaumokuākea. Ultimately our research will provide Papahānaumokuākea Marine National Monument (PMNM) staff with guidance for responsive management of critical ecosystems and endangered species in a future of elevated sea-level. This will be accomplished by first reconstructing beach erosion and accretion during the recent Holocene as sea-level rose 1-2 m approximately 2,000-4,000 years ago. For example did islands form and persist as sea-level rose, or was island formation triggered as sea-level fell below some perceived critical value? Answering this question will provide a historical basis for the capacity of island evolution and habitat response to anticipated sea-level rise.

Secondly, predictive modeling of sediment transport and wave environment will provide managers insight into how sea-level rise and perturbations to the island's shape and nearshore bathymetry at FFS will affect the convergence or divergence of wave-driven sand transport, causing the islands to accrete or erode, respectively. We strive to determine whether or not sand production from the reef is large enough to support island emergence and growth under static or rising mean sea-level conditions. If island emergence is only possible during falling sea-levels then it may be necessary to begin identifying solutions to the loss of nesting and foraging habitats for sea turtles, monk seals, and birds. Lessons learned at FFS are applicable throughout Papahānaumokuākea.

Other information or background:
Sweet et al., (2017) identifies six scenarios of potential sea-level rise that should be considered for management planning. In all scenarios there is little variation by mid-century. Approximately 30 cm (1 foot) is projected by 2050. In the second half of the

century various scenarios diverge dynamically to a mean of roughly 1.0 m by 2100, extreme of 2.0 m by 2100, and a minimum of less than 1.0 m by 2100. Which scenario plays out is being determined today by the greenhouse gas emissions of our modern society.

Models of paleo sea-level and morphologic evolution, as revealed by the proposed field work, will help to understand the processes that govern the stability of low lying islands as sea-level continues to rise in the future. This study is the first of its kind to model future impacts of sea-level rise using a process-based, shoreline evolution that couples historical geological data, high resolution imagery, and modern sediment dynamics. Considering that island loss has already been documented at FFS and prior assessments predict five of the nine islands at FFS will be entirely inundated at 2.0 m (using a passive inundation model) (Reynolds et al., 2012) it is imperative that improved scientific qualitative data be provided to guide responsive management plans for critical ecosystems and endangered species.

We have successfully implemented our methodologies in similar studies at Kapapa Island, O‘ahu, ‘Upolu Island, Sāmoa, and Bokollap Island, Majuro atoll. At Kapapa Island, Dr. Fletcher’s research has provided the best record of the Mid-Holocene higstand (Fletcher and Jones, 1996), which is the basis for our understanding of the local sea-level record for Hawai‘i over the past 6,000 years. At ‘Upolu, we have successfully employed trench and auger methods to accurately document the evolution of the sandy coastal plain environment in response to changes in Holocene sea-level (Kane et al., 2017). The sedimentological record developed at ‘Upolu shows that as sea-level fell following the mid-Holocene highstand, the coastal plain prograded (grew in the oceanward direction) allowing for increased habitatbility of coastal plain environments, and establishment of initial Sāmoan settlement sites (Cochrane et al., 2016; Kane et al., 2017a). Finally at Majuro we have shown that fossil reefs can be sampled with minimal environmental impact using a handheld drill and that our methods enable accurate reconstructions of habitat change in response to changes in sea-level (Kane et al., 2017b).

Obtaining a better understanding of the fate of reef islands is vital for understading the future of critical habitats at FFS and also for eludicating what impacts we may forsee for cultural, natural, and historic resources of the PMNM as a whole.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Fletcher, Charles, H.

Title: Associate Dean for Academic Affairs and Professor of Geology and Geophysics

1a. Intended field Principal Investigator (See instructions for more information):
Dr. Charles H. Fletcher

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

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

3. Affiliation (institution/agency/organization directly related to the proposed project):
Department of Geology and Geophysics, School of Ocean and Earth Science and Technology University of Hawaiʻi at Mānoa

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):
Sean Vitousek, Coastal Geologist, Modeler
Haunani Kane, Coastal Geologist
Kammie Dominique Tavares, Costal Geologist
Kristian McDonald, Coastal Geologist, Drone operator
Dr. Jade Delevaux, Coastal Geologist, Geospatial technician
Clifford Kapono, Researcher

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
X French Frigate Shoals	X Land-based	X 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			

NOTE: Shallow water is defined by water less than 100 meters in depth.

☐ Remaining ashore on any island or atoll (with the exception of Sand Island,at Midway Atoll 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:
We propose to conduct our analysis at East Island, Trig Island, and if time and weather permits a third island location (e.g. Shark Island, Gin Island, round Island, or Disappearing Island) will be determined. We propose to trench, and collect aerial imagery of the subaerial portion of each island. Within the shallow nearshore environment we propose to survey, and collect sediment samples. Reef coring will occur along shallow (less than 1 m deep, or subaerial) fossil (non living) reefs. We will also install a temporary tide gauge within one of the reef core holes and temporarily deploy current and wave sensors.

5b. Check all applicable regulated activities proposed to be conducted in the Monument:

X Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving Monument resource

X 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

X 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)
X 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:

(a) Purpose of proposed activities

The purpose of our research is to assess the impacts of past and present sea-level rise upon low lying islands to improve understanding of how future sea-level rise will impact essential habitats for priority species (e.g. sea turtles, monk seals, and various seabirds). This information will provide guidance for PMNM managers tasked with developing responsive management plans.

We aim to answer the following specific management questions related to the Kapapa highstand which reached a maximum 2.00 ± 0.35 m sea-level value in Hawai‘i 3,500 years BP: Did the reef islands at FFS form ca. 6,000 to 4,000 years ago as sea-level rose out of the last ice age toward this highstand? Or did they emerge as sea-level fell in the more recent 1,000 to 2,000 years? The objective of the historical analysis is to develop historical reconstructions of beach erosion and accretion during the recent Holocene (approximately 6,000 years ago to present).

We also seek to answer the following specific management question related to the management of priority species in a future of elevated sea-level: How will sea-level rise impact wave driven sand transport and cause islands to accrete or erode? How will changes in island size and configuration affect nesting and foraging habitats for sea turtles, monk seals and birds in Papahānaumokuākea? The objective of this component will be to provide managers with predictive models of sea-level rise impacts to priority species within Papahānaumokuākea.

(b) Need for proposed activities

As global mean sea-level rise continues to accelerate (Chen et al., 2017), administrators of the PMNM are faced with the need to develop responsive management plans for critical ecosystems and endangered species. Central to this is the challenge of improving understanding of how essential habitats will respond to sea-level rise. Reef islands at FFS provide critical habitat to sea turtles, monk seals, and various seabirds. Prior assessments predict using passive inundation models that a 2 m rise in sea-level will result in complete submergence of five of the nine islands at FFS (Reynolds et al., 2012). While passive models provide a good first assessment of sea-level rise impacts, they do not account for sediment dynamics, or sand transport which is inherently captured in the sedimentological record of reef islands and the adjacent reef flat. Here we propose to build upon existing passive sea-level assessments by

using observations from the historical record to guide a predictive model that integrates longshore and cross-shore sediment transport processes by waves and sea-level rise to predict shoreline change on a variety of timescales. Developed by Co-PI Sean Vitousek, this is the only process-based, observation assimilating, shoreline evolution model in the scientific literature.
Low lying reef islands like FFS are geologically-ephemeral sedimentary features composed of carbonate sand and gravel, and are constantly reshaped by tides, waves, and wave-driven currents. These sandy environments are highly responsive to sea-level rise and are likely to undergo significant geomorphic change that will intensify with time (Romine et al., 2016; Vitousek et al., 2017). Understanding and predicting these geomorphic changes will provide managers with the information required to effectively conserve these important habitats at FFS.

Our proposed research will be the first to document reef island history anywhere in the PMNM. The described results are achievable because we are applying proven methodology to a new system and possess the expertise to execute the proposed research activities. The resulting data will be critically valuable for providing historical records to enable modeling of how predicted sea-level rise will impact essential island habitat for sea turtles, monk seals, and various seabirds no only at FFS but throughout PMNM.

(c) Scope for proposed activities

To interpret the historical reconstructions of beach erosion and accretion during the recent Holocene we propose to visit 2-3 sandy islands within FFS. This will enable us to interpret the response of sandy island reconfiguration and existence as past sea-level rose to max values of 2.0 m and fell to present values. Our research has the potential to quantify the historical record of island response to over 6,000 years of local sea-level change. In order to quantify the evolutionary response of the island environment we propose to sample up to four sites at each island (120 total samples from 12 sites) from geologic trenches. Each geologic trench will have a maximum size of approximately 1 m^3. Sampled sites will be infilled with original sediment. To quantify modern sediment transport and composition, two transects will be established within the nearshore environment and sampled at each island (120 samples total from 6 nearshore survey transects). Comparisons of sediment age and composition will be made amongst island sediment and modern nearshore sediment in order to quantify how sediment source and composition has change over time. To provide understanding of historical reef habitat and accretionary response to changes in sea-level we propose to recover four short cores at each island (12 short cores total) from the surrounding fossil reef platform using a small hand held drill. All sampled material will be taken back to the University of Hawai‘i for subsampling, dating (radiocarbon) and compositional analysis. All samples that are temporarily removed from the monument will be returned to FFS under the guidance PMNM staff including the OHA.

Observations gained from the historical record will enable our predictive model to model future impacts to priority species within Papahānaumokuākea. Predictive modeling

requires the acquisition of high-resolution topographic (elevation) data. We propose to use a drone to collect high resolution imagery of 2-3 islands and their surrounding nearshore environment. Imagery will be post processed at the University of Hawai‘i, where we will derive digital elevation maps (DEMs) of each island from drone imagery and Structure-from-Motion (McDonald et al., 2017). In order to quantify the accuracy of our DEMs will need to establish RTK-GPS control points at each study site at the time of the drone survey. To quantify the vertical accuracy of our DEM, as well as tie sea-level to common vertical datum we propose to establish a local short-term tide gauge (automated water level data logger) at each of the study sites. The tide gauge will occupy a core hole for the duration of time spent at each of the three study sites. The DEM, drone imagery, historical sedimentary record, and wave data will be used by the predictive model to explore how sea-level rise and perturbations to the island will accrete or erode each surveyed island.

References

Chen, X., Zhang, X., Church, J.A., Watson, C.S., King, M.A., Monselesan, D., Legresy, B., Harig, C., 2017. The increasing rate of global mean sea level rise during 1993-2014. Nat. Clim. Chang. 7, 492–495.

Cochrane, E.E., Kane, H., Fletcher, C., Horrocks, M., Mills, J., Barbee, M., Morrison, A.E., Tautunu, M.M., 2016. Lack of suitable coastal plains likely influenced Lapita (~2800 cal. BP) settlement of Sāmoa: Evidence from south-eastern ’Upolu. The Holocene 26, 126–135. doi:10.1177/0959683615596841

Fletcher, C.H., Jones, A.T., 1996. Sea-level highstand recorded in Holocene shoreline deposits on Oahu, Hawaii. J. Sediment. Res. 66, 632–641. doi:10.1306/D42683CE-2B26-11D7-8648000102C1865D

Habel, S., Fletcher, C.H., Barbee, M., Anderson, T.R., 2016. The influence of seasonal patterns on a beach nourishment project in a complex reef environment. Coast. Eng. 116, 67–76. doi:10.1016/j.coastaleng.2016.06.006

Kane, H.H., Fletcher, C.H., Cochrane, E.E., Mitrovica, J.X., Habel, S., Barbee, M., 2017a. Coastal plain stratigraphy records tectonic , environmental , and human habitability changes related to sea-level drawdown , ‘ Upolu , S ā moa 246–257. doi:10.1017/qua.2017.2

Kane, H.H., Fletcher, C.H., Habel, S., McDonald, K., Tavares, K.-D.A., 2017b. The evolution of Majuro atoll in response to sea-level change during the mid-Holocene, in: GSA Annual Meeting in Seattle, Washington. Seattle.

McDonald, K., Fletcher, C.H., Barbee, M., Habel, S.L., Anderson, T., Tavares, K.-D.A., 2017. UAV SURVEYS TO MONITOR VOLUMETRIC BEACH CHANGES OVER AN EXTREME HIGH-TIDE EVENT: WAIKIKI, HAWAII, in: GSA Annual Meeting in Seattle, Washington. Seattle.

Reynolds, M., Berkowitz, P., Courlot, K.N., Krause, C.M., 2012. Predicting Sea-Level Rise Vulnerability of Terrestrial Habitat and Wildlife of the Northwestern Hawaiian Islands.

Romine, B.M., Fletcher, C.H., Frazer, L.N., Anderson, T.R., 2016. Beach erosion under rising sea-level modulated by coastal geomorphology and sediment availability on carbonate reef-fringed island coasts. Sedimentology n/a-n/a.

doi:10.1111/sed.12264
Sweet, W., Kopp, R., Weaver, C., Obesekera, J., Horton, R., Thieler, E., Zervas, C., 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083.
Vitousek, S., Barnar, P.L., Fletcher, C.H., Frazer, N., Storlazzi, C.D., 2017. Doubling of coastal flooding frequency within decades due to sea-level rise 1–9. doi:10.1038/s41598-017-01362-7

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

If so, please list the species you specifically intend to target.
We do not plan to specifically target protected species. However we will be using a drone to collect imagery of the islands, and nearshore environment of FFS. Thus our images may ultimately capture endangered species.

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?
The activities proposed will be conducted with adequate safeguards for the resources and ecological integrity of the Monument. We acknowledge that there are concerns with disturbing sediment from the islands and removing cores from the fossil reef flat. We welcome discussion with PMNM staff including cultural experts to ensure that our research is conducted in a manner that is respectful of the place, and its cultural, natural, and historical resources. As a means to ensure that our research aligns with PMNM best management practices and policies we acknowledge that value of FFS islands for critical habit for the threatened Hawaiian Green sea turtle, endangered Hawaiian habitat and a number of endangered and native seabirds. Special care will be taken to avoid nesting sites and burrows. To minimize impact, we will be using a combination of bucket augering and trenching to extract sediment from the island.

Trenching is necessary in order to observe the stratigraphic architecture of the island which is not otherwise available and is a key element in understanding the island accretion and erosion process. We will ensure that sampled areas on the island are infilled with existing sediment and every attempt will be made to ensure that sampled areas are returned to preexisting conditions.

Efforts will be made to ensure that fossil reef cores are only extracted from non-living coral samples or cemented carbonate pavement. No living corals will be sampled. Our drill is a powered by a gas motor and safety protocols have been established to ensure that fuel and oil are safely contained and stored. These protocols have been tested in the field and have been used during two prior field expeditions at Majuro atoll. Sediment and fossil reef samples will be returned to PMNM staff under the guidance of the OHA to ensure that our efforts are culturally appropriate.

We will be operating a drone to collect high resolution imagery of FFS islands. We will make every effort to follow established drone protocols and best management practices.

Our research group will pay respect and conduct culturally appropriate protocols at each island visited as well as throughout the research to continue to connect to place and stay grounded as a group. As a part of our cultural plan, while at sea we will have group discussions centered around huli ‘ia, a tool developed by Nā Maka ‘o Papahānaumokuākea, to document environmental observations experienced through all of our senses while in Papahānaumokuākea. Researchers participate in discussions contributing their observations sharing noticeable dominant characteristics of lani (sky), honua (earth), and kai (ocean) as a way to characterize that time (season) and space (Papahānaumokuākea). This broader holistic view will support our research team in intimately understanding moods and characteristics of Papahānaumokuākea and through this documentation process, supports the development of best practices enabling communities to adjust and adapt their activities to assist in mālama ‘āina (care for the land). In addition as a part of our cultural plan we will provide data and information to assist the Cultural Working Group’s effort to develop Hawaiian names and descriptions for new species and spaces that may be encountered in the mesophotic zone. Finally, in an effort to create intergenerational capacity building, three native Hawaiian students will be included in the research team, and be mentored in all aspects from research development, field work, and post cruise data analysis.

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?
Our research activities will temporarily disturb island sediment and fossil reef, however the lessons learned from our research has the potential to enable researchers and managers to better plan for the very existence of these sites as sea-level continues to rise into the future. In addition by applying our coring methods on previous research

expeditions on O‘ahu and Majuro atoll we have observed that cored reef flats naturally infill (8 cm max diameter cored hole) with sediment relatively quickly.

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.
There is no practicable alternative to conducting activities in the Monument. We are addressing questions that are directly relevant to the very existence of critical habitat within the Monument in a future of elevated sea-level. Hence the study must be carried out within the Monument. We are limiting our study site to three islands at FFS. Lessons learned from FFS are applicable to low lying sandy islands throughout the PMNM. An important implication of this work is relevant to endangered species management plans and as sandy habitat in PMNM becomes unstable as a result of sea-level rise the main Hawaiian Islands may be considered as future replacement habitat. Therefore it is the specific location of PMNM that is necessary for this research.

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 management value of data produced by our research activities outweighs the impacts upon Monument resources. FFS has already experienced island lost (e.g. Disappearing island), and a preliminary study by the USGS predicts that under 2 m of sea-level rise five of the nine islands at FFS will be completely submerged assuming a passive inundation model. Here we propose to improve upon this study by coupling a historical analysis that extends 1000s of years into the past, as well as high resolution imagery and elevation data sets to model shifts in the sedimentary budget into the future. By coupling all of these components we will produce the first study of its kind that provides guidance for future management of critical habitats based upon lessons learned from the historical record, and allows for an evolving sedimentary budget. Research products produced at FFS are applicable across the PMNM. In addition we will do our best to ensure that our methods have minimal impact upon monument resources. For example, no live samples of coral will be sampled or removed from the monument. Finally we will work with PMNM staff including the OHA to ensure that all samples are returned in a culturally appropriate manner.

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.
The actual fieldwork component of this research involves the minimum time required to reach the desired data required to reconstruct the paleo sea-level record as well as collect topographic data to model future sea-level impacts. We propose to visit and sample 2-3 islands during the 13 day period. The outcome will be a historical record of island evolution that encompasses nearly 6,000 years. From this record we hope to project sea-level impacts upon critical habitat 100+ years into the future.

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

Charles H. Fletcher (UH at Mānoa): Dr. Fletcher has over 100 peer-reviewed publications, and 30 years of experience leading investigations related to island evolution, beach processes, sea-level history and impacts, and carbonate sedimentary processes. Dr. Fletcher serves as the Associate Dean of the School of Ocean and Earth Science and Technology, was recognized in 2011 by the U.S. Environmental Protection Agency with an Environmental Achievement Award in Climate Change Science, in 2018 became a Honolulu city council climate change commissioner, and has worked actively with managers, stakeholders, and policy makers over the past 30 years to determine best practices and adaptive management strategies across the state of Hawaiʻi and in the Republic of the Marshall Islands.

Sean Vitousek (University of Illinois at Chicago): Dr. Vitousek has developed a model that integrates longshore and cross-shore sediment transport processes by waves and sea-level rise to predict shoreline change on a variety of timescales. The model uses an extended Kalman filter data-assimilation technique to auto-tune model parameters and improves confidence in long-range shoreline predictions. This is the only process-based, observation assimilating, shoreline evolution model in the scientific literature. Dr. Vitousek's model will be applied to FFS to model island response to future sea-level rise. Dr. Vitousek is an experienced ocean and coastal modeler who brings extensive quantitative expertise to this project.

Haunani Kane (SOEST, UH Mānoa): Haunani has nearly a decade of experience in assessing past, present, and future impacts of sea-level rise upon Pacific Islands. Haunani has spent the past four years interpreting the sedimentological record of Pacific Islands and reefs (e.g. Sāmoa, Majuro atoll, Hawaiʻi) so that Island communities can better understand the role of the mid to late Holocene sea-level change played in the reconfiguration of coastal environments and habitats. Haunani has visited the PMNM twice before as a part of the 2016 intertidal monitoring cruise, and as a crew member and apprentice navigator aboard Hikianalia in 2013.

Kammie Tavares (SOEST, UH Mānoa): As a part of the NOAA educational partnership program, Kammie conducted a sea-level rise assessment that will assist PMNM managers in prioritzining future impacts upon the Hawaiian monk seal. Kammie's research also looks at the impacts of sea-walls upon beach stability and degradation of critical habitat.

Kristian McDonald (SOEST, UH Mānoa): Kristian's research focuses upon the use of unmanned aerial vehicles (e.g. drones) to image and develop digital elevation models that are used to assess changes in beach volume and shape. Kristian has developed such products for Waikiki beach, and Majuro atoll both of which have applications for assessments of future sea-level rise impacts.

Jade Delevaux (SOEST, UH Mānoa): Dr. Delevaux is a geospatial analyst and is currently updating the historical shoreline database for the Kauaʻi, Maui and Oʻahu.

Jade is also experienced in developing spatially-explicit linked land-sea models coupled with scenario planning to quantify the impact of land cover change on coral reefs.

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.
Our research will be supported by resources from the University of Hawaiʻi. Four members of the field team come to the project at no cost. We are also optimistic about receiving the National Fish and Wildlife Foundation funding. These resources will be adequate to conduct and complete the proposed activities and mitigate any potential impacts resulting from its conduct.

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 and procedures that we are proposing are ideal for achieving our goals while attempting to minimize impacts to Monument resources, qualities, and ecological integrity. We have successfully implemented our methodologies in similar studies at Kapapa Island, Oʻahu, ʻUpolu Island, Sāmoa, and Bokollap Island, Majuro atoll. At Kapapa Island, Dr. Fletcher's research has provided the best record the of Mid-Holocene higstand (Fletcher and Jones, 1996), which is the basis for our understanding of the local sea-level record for Hawaiʻi over the past 6,000 years. At ʻUpolu, we have successfully employed the trench and auger method to accurately document the evolution of the sandy coastal plain environment in response to changes in Holocene sea-level (Kane et al., 2017). Finally at Majuro we have shown that fossil reefs can be sampled with minimal environmental impact using a handheld drill and we have worked

with the USGS to develop a high resolution DEM from drone imagery (Kane et al., 2017b).

i. Has your vessel been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?
Yes the private vessel will be equipped with appropriate mobile transceiver units. The vessel and the captain of the M/V Searcher have accessed the PMNM on multiple occasions, including FFS and will comply with all Monument BMPs and vessel requirements. The M/V Searcher will be applying for their own permit.

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.
There are no other factors that would make the issuance of a permit for our proposed activities inappropriate.

8. Procedures/Methods:
FFS will be accessed using the M/V Searcher. Small boats will be used for the daily transport of researchers and equipment to each island. The vessel and the captain of the M/V Searcher have accessed the PMNM on multiple occasions, including FFS and will comply with all Monument BMPs and vessel requirements.

Historical assessment:
(i) Collecting island sediment
We propose to interpret the subsurface island stratigraphy at East Island, Trig Island, and a third island (e.g. Shark Island, Gin Island, round Island, or Disappearing Island) will be determined based upon weather and time availability. A total of 12 sites will be identified from the 2-3 islands using a combination of island trenching and bucket augering (Figure 1). A total of 120 (approximately 2 tbsp volume/sample) sediment samples will be strategically selected in the same manner in both the trenched and the augered sites. The number of samples taken from island will vary depending upon island size, depth of sampling site, and complexity of island stratigraphy. Samples will be taken back to UH Mānoa for compositional analyses under the microscope, and radiocarbon dating. Upon completion of analyses, samples will be returned to PMNM under the guidance of PMNM staff including the OHA. A detailed description of sampling methods is provided below.

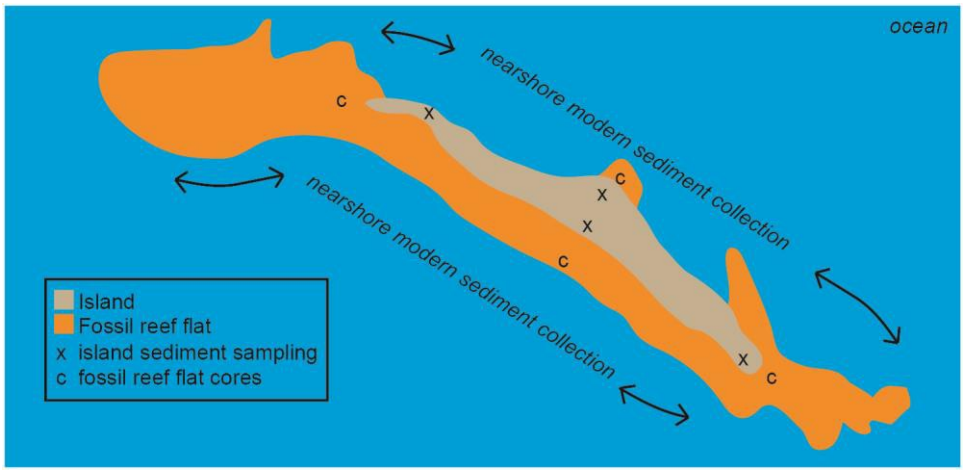

Figure 1. Generalized island sampling layout. The number of island sediment sampling sites and fossil reef flat coring sites will vary based upon island size and accessibility. In total we propose to sample 12 island sediment sites (trench and/or bucket auger), and 12 fossil reef coring sites on 2-3 islands.

Island trenching:
Trenching is necessary in order to observe the stratigraphic architecture of the island which is not otherwise available by bucket augering alone. Interpreting the composition and age of island sediment is a key element in understanding the island's historical accretion and erosion processes.

1. 1 m x 1 m areas will be excavated using shovels (Figure 2A). The depth of the trench will vary depending upon the composition of the island, however we estimate approximately 1 m trench depth. Typically the depth of the trench is limited by cemented substrate or the height of the water table, which causes the base of the trench to cave in.
2. The trench wall will be cleaned of sediment that may have fallen from above, and changes in sediment (e.g. of texture, depth of sediment horizons, and presence of datable material will be recorded) in relation to depth will be described (Figure 2B).
3. The wall face will be photographed and sub sampled. Samples taken from the wall of the trench will be approximately 2 tbsp in volume and will be placed in plastic sample bags. Upon completion of compositional analysis and dating at UH Mānoa, all samples will be returned to PMNM.
4. The 1 m x 1 m trench will be infilled with existing sediment and every attempt will be made to ensure that sampled areas are returned to preexisting conditions. Special consideration will be given to the presence of endangered and protected species.

Figure 2. Island trench. The trench shown above (2A) is larger than what we propose in this project.

Bucket augering:
1. A t-handle bucket auger will be used to recover successive units of sediment until refusal, typically at 1 m or so (Figure 3A-C).
2. Each successive bucket full of sediment (Figure 3C) will be laid out, photographed, and field descriptions of texture, depth of sediment horizons, and presence of datable material will be recorded (Figure 3D).
3. Bucket auger samples will be approximately 2 tbsp in volume and will be placed in plastic sample bags. Upon completion of compositional analysis and dating at UH Mānoa, all samples will be returned to PMNM.
4. The auger hole (Figure 3E) will be infilled with existing sediment and every attempt will be made to ensure that sampled areas are returned to preexisting conditions. Special consideration will be given to the presence of endangered and protected species.

The size of the sampled area is reduced with the bucket auger and as such limits our ability to accurately describe the sedimentary architecture of the island and ultimately our understanding of the islands erosional and accretional history. However to limit our impact to the natural and culture resources of each island we propose to do a combination of island trenching and bucket augering at each island.

Figure 3. Bucket auger.

(ii) Modern sediment collection
We propose to compare island sediment samples to 120 modern sediment samples (approximately 2 tbsp volume/sample) taken from the nearshore environment. Sampling the shallow seafloor will require a small team (at least 2 people) to enter the nearshore marine environment with snorkel gear to recover sediment. Modern sediment samples will be taken back to UH Mānoa for compositional analysis under the microscope, and radiocarbon dating. Upon completion of analyses, samples will be returned to PMNM under the guidance of PMNM staff including the OHA.

(iii) Reef cores
We propose to collect a total of 12 fossil reef flat cores from the 2-3 islands using a hand-held gas powered drill attached to 5.08 cm and 7.62 cm diameter diamond core bits. This will be accomplished by establishing shore perpendicular transects extending from one side of each island to the other. We hope to quantify the age and rate of lateral accretion of the fossil reef in relation to changes in historical sea-level. Cored

samples will be taken back to UH Mānoa for compositional analyses under the microscope, and radiocarbon dating. Upon completion of analyses, samples will be returned to PMNM under the guidance of PMNM staff including the OHA.

(b) Predictive model
(i) Acquisition of topographic data
The predictive sea-level model that will be employed in this study requires topographic (land) and bathymetric (shallow seafloor) elevation data. Topographic or island elevations will be acquired from unmanned aerial vehicle (UAV) imagery. We propose to collect high resolution imagery of 2-3 islands and the surrounding nearshore environment at FFS using an UAV equipped with an internal GPS and a camera. Canvas targets (1 m x 1 m) will be laid out on the island at the time that imagery is collected and later surveyed with an RTK-GPS for ground control. The RTK-GPS includes a fixed base station that will sit on a tripod during the duration of the survey. The rover system is attached to a pole, and the surveyor will transport the rover to each survey site (corners of trenches, bucket auger sites, and reef core sites). UAV imagery and GPS control points will be post processed at the University of Hawaiʻi. A topographic DEM of each island will be derived from UAV imagery using Structure-from-Motion (McDonald et al., 2017).

Bathymetric elevation data will be collected using beach profile methodology that we have successfully employed across the state of Hawaiʻi (Habel et al., 2016). Using a Leica Total Station, beach profiles will be surveyed by tracking a swimmer moving a rod-mounted prism across nearshore waters. The swimmer will follow shore perpendicular transect lines collecting measurements every 3–5 m and at pertinent geomorphic features.

(ii) Installing sensors
To quantify the vertical accuracy of our DEM, as well as tie sea-level to a common vertical datum we propose to establish a local short-term tide gauge (automated water level data logger) at each of the study sites. The tide gauge will occupy a reef core hole for the duration of time spent at each of the three study sites.

To explore how sea-level rise and perturbations to the island will accrete or erode each surveyed island, the predictive sea-level model also requires wave and current information. We propose to temporarily deploy 1-2 PUV-type wave gauges, and 3-10 pressure sensors. Like the tide gauge, the wave gauges and pressure sensors will only record data during the duration of our field expedition. Sensors will be attached to weighted supports and placed on sandy patches of the seafloor. Prior to our departure from FFS all temporary sensors will be collected and taken back to UH Mānoa for data retrieval and analysis.

Post processing data at UH Mānoa
(i) To determine the age of the island and surrounding fossil reef we will submit samples of island sediment and coral (40 mg of carbonate sample) to a commercial laboratory.

All remaining sample material will be returned to PMNM under the guidance of PMNM staff including the OHA.
(ii) Compositional analysis of sediment and cores will require that a small sample size be used to create thin sections so that the samples can be viewed under the microscope. All remaining sample material will be returned to PMNM under the guidance of PMNM staff including the OHA.
(iii) Maps will be created that depict historical changes in critical habitat as sea-level changed in the recent Holocene. All maps, figures, and data will be made publically available.
(iv) Predictive modeling will be used to assess changes in critical habitat under future sea-level scenarios. All maps, figures, and data will be made publically available.

NOTE: If land or marine archeological activities are involved, contact the Monument Permit Coordinator at the address on the general application form before proceeding.

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

It is difficult to anticipate the exact types of specimens that will be collected in our reef cores or to determine whether or not modern coral abundance has persisted as sea-level changed over the past 6,000 years. However from our experience in it is possible that we will recover grainstone (cemented beach sand), fossil coral (genus Porites, Acropora, Pocillopora, etc), and fossil intertidal mollusks. Because this study is the first of its kind being employed in PMNM there is a lot of uncertainty associated with the historical composition of the fossil reef flats and islands. Reducing this uncertainty and quantifying the age and composition of these environments is a priority of this study.

Common name:

Scientific name:

& size of specimens:
120, 2 tbsp size samples of island sediment
120, 2 tbsp size samples of lagoon sediment
12 reef cores 5.08-7.62 cm diameter, approximately 1 m long

Collection location:
Figure 4 shows the potential field location sites. These sites include East Island, Trig Island, and Site 3 will be determined based upon weather/if time permits. Site 3 may take place at Shark Island, or Gin Island, but if weather does not permit access to either of these two sites then we may look into working at Round Island or Disappearing island. Samples will be collected from the island, fossil reef flat and nearshore environment.

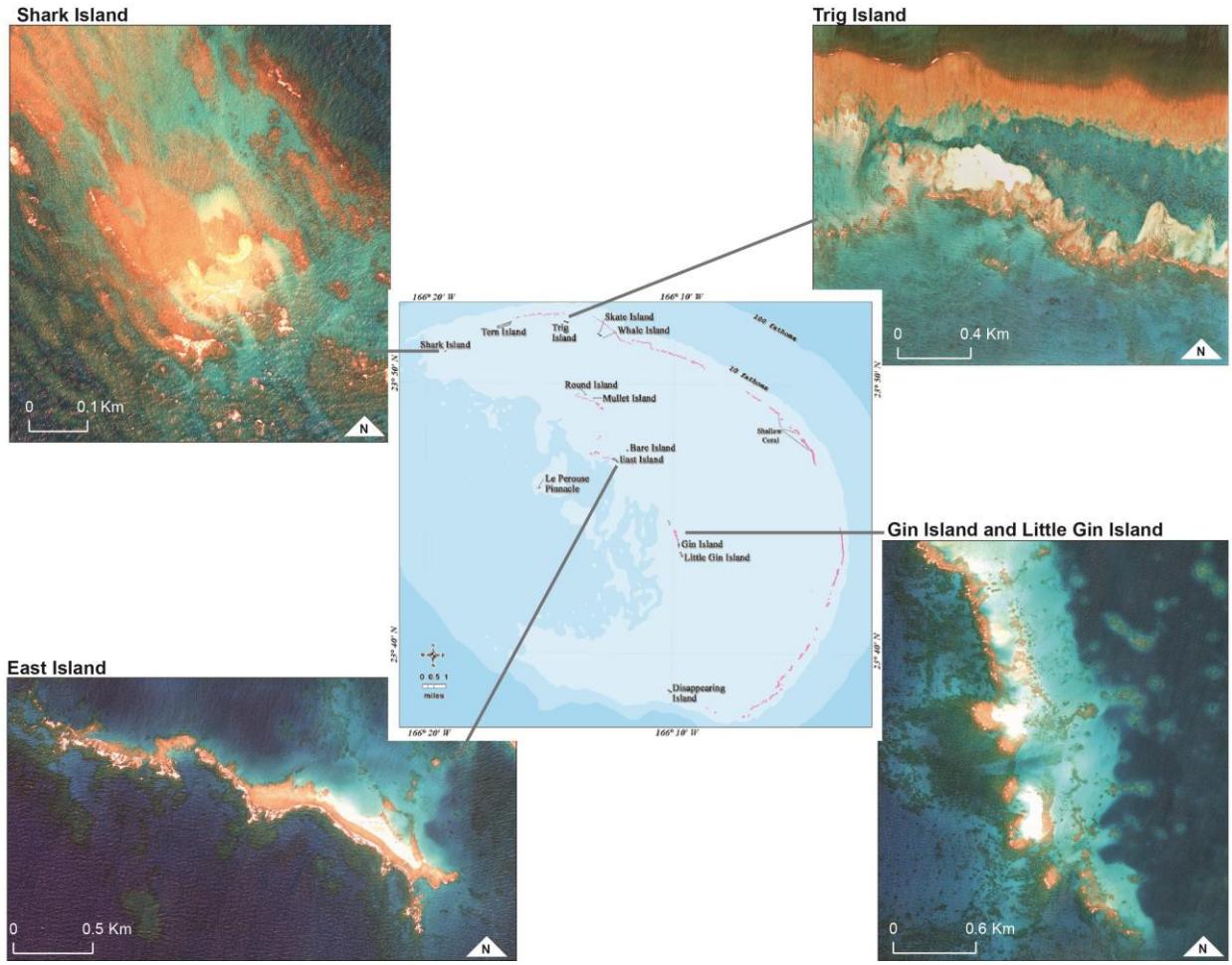

Figure 4. Potential collection sites at French Frigate Shoals.

☐ Whole Organism **X** Partial Organism

9b. What will be done with the specimens after the project has ended?
Specimens will be returned to PMNM staff under the guidance of PMNM. The Office of Hawaiian Affairs will be consulted for cultural guidance.

9c. Will the organisms be kept alive after collection? ☐ **Yes X No**
No live organisms will be sampled.

• General site/location for collections:
East island
Trig Island
Site 3 TBD based upon weather/if time permits

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

• Is there an outfall? ☐ Yes ☐ No
N/A

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

• Will organisms be released?
N/A

10. If applicable, how will the collected samples or specimens be transported out of the Monument?
Sediment and fossil reef samples will be stored in sample bags and core boxes and transported out of the monument on the chartered vessel.

11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:
All results, imagery, and products will be made publically available, and provided to PMNM.

12a. List all specialized gear and materials to be used in this activity:
Coring equipment (gas powered drill, bucket auger, core bits, extension rods)
Water pump
Shovel
Elevation survey equipment (total station, tripod, survey rod, survey ribbon, survey prism, canvas targets, water level, brunton compass, RTK GPS base station and rover, etc.)
Phantom drone (lithium batteries, ipad)
Miscellaneous tools (hammer, wrench, electrical tape, tephlon tape, rubber mallot, etc.)
Snorkeling gear (mask, fins)
Sample bags and vials

12b. List all Hazardous Materials you propose to take to and use within the Monument:
Gasoline, and 2 stroke oil to power drill and water pump, lithium batteries for the drone. Safety sheets have been attached in our permit application.

13. Describe any fixed installations and instrumentation proposed to be set in the Monument:
A temporary tide gauge within a PVC pipe will be temporarily placed within a core hole to capture a 24 hour tidal cycle. To capture wave and current information, 1-2 PUV-type wave gauges, and 3-10 pressure sensors will be attached to weighted supports and placed on sandy patches of the seafloor at each island. Prior to our departure from FFS all temporary sensors will be collected and taken back to UH Mānoa for data retrieval and analysis.

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

Photo analyses, data analyses, a report write-up, and at least one publication will be completed within a year of the field surveys. We hope to complete several publications utilizing island and fossil reef composition and age within a few years of data collection.

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

Fletcher, CH, Jones AT. 1996. Sea-level highstand recorded in Holocene shoreline deposits on Oahu, Hawaii. Journal of Sedimentary Research 66.3: 632-641.

Grossman, E., Fletcher, C., and Richmond, B. (1998) The Holocene sea-level highstand in the Equatorial Pacific: Analysis of the insular paleosea-level database. Coral Reefs. Special Issue on Holocene and Pleistocene coral reef geology 17: 309-327.

Grossman, EE, Fletcher, CH. 1998. Sea level 3500 years ago on the Northern Main Hawaiian Islands. Geology 26:363-366.

Habel, S, Fletcher, CH, Rotzoll, K, El-Kadi, A. 2017. Development of a model to simulate groundwater innundation induced by sea-level rise and high tides in Honolulu, Hawaii. Water Research 114: 122-134.

Habel, S, Fletcher, CH, Barbee, M, Anderson, TR. 2016. The influence of seasonal patterns on a beach nourishment project in a complex reef environment. Coastal Engineering 116: 67-76.

Kane, HH, Fletcher, CH, Cochrane, EE, Mitrovica, JX, Habel, S, Barbee, M. 2017a. Coastal plain stratigraphy records tectonic, environmental, and human habitability changes related to sea-level drawdown, 'Upolu, Samoa. Quaternary Research 87: 246-257.

Kane, HH, Fletcher, CH, Habel, S, McDonald, K, Tavares, K.-D.A., 2017b. The evolution of Majuro atoll in response to sea-level change during the mid-Holocene, in: GSA Annual Meeting in Seattle, Washington.

Kane, HH, Fletcher, CH, Romine, BM, Anderson, TR, Frazer, NL, Barbee, MM. 2012. Vulnerability Assessemtne of Hawai'i's Cultural Assests Attributable to Erosion Using Shoreline Trend Analysis Techniques. Journal of Coastal Research 28: 533-539.

McDonald, K, Fletcher, CH, Barbee, M, Habel, SL, Anderson, T, Tavares, K-DA. 2017. UAV SURVEYS TO MONITOR VOLUMETRIC BEACH CHANGES OVER AN EXTREME HIGH-TIDE EVENT: WAIKIKI, HAWAII, in: GSA Annual Meeting in Seattle, Washington.

Romine, BM, Fletcher, CH, Frazer, LN, Anderson, TR. 2016. Beach erosion under rising sea-level modulated by coastal geomorphology and sediment availability on carbonate reef-fringed island coasts. Sedimentology. 63: 1321-1332.

Tavares, K-DA, Fletcher, CH, Barbee, M, Anderson, T, Burstein, J. 2017. Will seawalls damage critical habitat for endangred species in Hawaii as sea level rises? in: GSA Annual Meeting in Seattle, Washington.

Vitousek, S, Barnar, PL, Fletcher, CH, Frazer, LN, Erikson, L, Storlazzi, CD. 2017. Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific Reports 7: 1399.

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.

_____

Signature Date

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

NOAA/Inouye Regional Center
NOS/ONMS/PMNM/Attn: Permit Coordinator
1845 Wasp Blvd, Building 176
Honolulu, HI 96818
FAX: (808) 455-3093

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