

Papahānaumokuākea Marine National Monument
RESEARCH Permit Application

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

ADDITIONAL IMPORTANT INFORMATION:

- Any or all of the information within this application may be posted to the Monument website informing the public on projects proposed to occur in the Monument.
- In addition to the permit application, the Applicant must either download the Monument Compliance Information Sheet from the Monument website OR request a hard copy from the Monument Permit Coordinator (contact information below). The Monument Compliance Information Sheet must be submitted to the Monument Permit Coordinator after initial application consultation.
- Issuance of a Monument permit is dependent upon the completion and review of the application and Compliance Information Sheet.

INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED

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

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

**Papahānaumokuākea Marine National Monument
Permit Application Cover Sheet**

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

Summary Information

Applicant Name: Russell E. Brainard, Ph.D.

Affiliation: National Oceanic and Atmospheric Administration (NOAA), Pacific Islands Fisheries Science Center Chief (PIFSC), Ecosystem Sciences Division (ESD), Coral Reef Ecosystem Program (CREP)

Permit Category: Research

Proposed Activity Dates: 30 August 2016 to 30 September 2016

Proposed Method of Entry (Vessel/Plane): Vessel

Proposed Locations: Shallow water reefs (<30m) of the Papahānaumokuākea Marine National Monument (Monument) including the reefs associated with: Kure Atoll, Pearl & Hermes Atoll, French Frigate Shoals, and Lisianski Island.

Estimated number of individuals (including Applicant) to be covered under this permit: 23

Estimated number of days in the Monument: 32

Description of proposed activities: (complete these sentences):

a.) The proposed activity would...
conduct reef assessment and monitoring activities throughout the islands and atolls of the Monument. These efforts would contribute to continuing research providing scientific information needed to support ecosystem approaches to the management of coral reef systems of the Monument and areas across the Pacific region. The primary focus of the multi-institutional team of scientists, led by NOAA Pacific Islands Fisheries Science Center's Coral Reef Ecosystem Program, would focus on implementing the Pacific Reef Assessment and Monitoring Program (RAMP).

b.) To accomplish this activity we would
use monitoring efforts including rapid ecological assessments of corals, macro-invertebrates, fish, and algae using multiple methods; towed-diver surveys of benthic composition and the abundance and distribution of ecologically and economically important macroinvertebrate taxa and large fish; and multi-platform oceanographic and water quality monitoring using shipboard surveys and moored instrument arrays.

c.) This activity would help the Monument by ...
the use of consistent interdisciplinary methods across this vast region allowing for an opportunity to perform biogeographic and ecological comparative analyses of diverse ecological, environmental, and oceanographic gradients. Patterns of variability of fish biomass, coral disease, diversity, demographics and other reef metrics are paramount to assessing an ecological system as unique and valuable as the one found in the Monument.

Other information or background:

CREP conducts integrated, multidisciplinary, ecosystem research, habitat mapping, and long-term monitoring of coral reef ecosystems throughout American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, the Hawaiian Archipelago and the Pacific Remote Island Areas. This work is part of the NOAA Coral Reef Conservation Program's (CRCP) broad-scale Pacific RAMP surveys. RAMP efforts focus on several priority research themes: 1) ocean and climate change; 2) benthic communities (with emphasis on hard corals); and 3) non-coral invertebrates; and 4) reef-associated fish communities. CREP's efforts under RAMP have involved extensive benthic habitat mapping, ecological and environmental assessment and monitoring, and applied research to support improved ecosystem-based management and conservation. Monitoring of ocean and climate change focuses on thermal structure and water chemistry and is achieved by means of sustained, remotely sensed and in situ observations of ocean temperature, autonomous discrete water sampling for analyses of carbonate chemistry, and distinct biological installations designed to provide integrated, ecosystem-wide response data (e.g., biodiversity, calcification, and bioerosion) in the context of climate change. Biological monitoring for benthic and fish communities is conducted at Rapid Ecological Assessment (REA) sites using a two-stage stratified random sampling design throughout shallow-water (0–30 m), hard-bottom coral reef habitats. The knowledge gained from these methods is shared with resource managers and various public stakeholders to improve decision-making for long-term conservation and management of coral reef resources.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Brainard, Russell E., Ph.D.

Title: Chief, Coral Reef Ecosystem Program, NOAA Pacific Islands Fisheries Science Center

1a. Intended field Principal Investigator (See instructions for more information):

Schumacher, Brett D., Ph.D.

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

[REDACTED]

Phone: [REDACTED]

Fax: [REDACTED]

Email: [REDACTED]

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

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

NOAA Pacific Islands Fisheries Science Center, Ecosystem Sciences Division, Coral Reef Ecosystem Program

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):

Staffing for has not been finalized yet, but the following list reflects our current plan. We will provide an updated list when our roster is confirmed.

Ocean and Climate Change

1. Tom Oliver
2. Chip Young
3. TBD

Benthic Monitoring

4. Dione Swanson
5. Hatsue Bailey
6. Brett Schumacher
7. Joao Garriques
8. TBD (PMNM Partner)

Non-coral Invertebrates

9. Kerry Reardon
10. James Morioka
11. ARMS/Instrumentation - TBD
12. Microbial Biologist - TBD

Reef Fish Monitoring

13. Adel Heenan
14. Tate Webster
15. Kelvin Gorospe
16. Kaylyn McCoy
17. Andrew Gray
18. Rhonda Suka
19. TBD (QUEST/PMNM Partner)

Divemaster/Chamber Operator

20. TBD

Data Management

21. Michael Akridge

CTD/Night Ops

22. TBD

SST Berth

23. TBD

Section B: Project Information

5a. Project location(s):

Ocean Based

- | | | | |
|--|-------------------------------------|---|-------------------------------------|
| <input type="checkbox"/> Nihoa Island | <input type="checkbox"/> Land-based | <input type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input type="checkbox"/> Necker Island (Mokumanamana) | <input type="checkbox"/> Land-based | <input 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 type="checkbox"/> Gardner Pinnacles | <input type="checkbox"/> Land-based | <input type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input type="checkbox"/> Maro Reef | <input type="checkbox"/> Land-based | <input type="checkbox"/> Shallow water | <input type="checkbox"/> Deep water |
| <input type="checkbox"/> Laysan Island | <input type="checkbox"/> Land-based | <input 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 type="checkbox"/> Midway Atoll | <input type="checkbox"/> Land-based | <input 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 | | | |

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:

CREP's multidisciplinary monitoring teams collect data in shallow water environments from surface levels to 30 m deep. These teams plan to survey approximately 300 sites throughout the Monument in addition to the towed diver surveys to investigate the various coral reef environments in forereef, backreef and lagoon habitats. Sites will be identified prior to the cruise, and a list of positions will be submitted in the compliance form.

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 Coral Reef Conservation Act of 2000 created a national program and authorized NOAA to conduct mapping, monitoring, assessment, restoration, and scientific research that benefits the understanding, sustainable use, and long-term conservation of coral reefs and coral reef ecosystems. As part of the mandate, CREP leads coral reef ecosystem monitoring efforts in several U.S.-affiliated jurisdictions in the Pacific, including in the Monument. CREP proposes to continue its previous Pacific RAMP efforts in the Northwestern Hawaiian Islands (NWHI) by conducting coral reef ecosystem monitoring, which includes biological and oceanographic observations and benthic habitat mapping.

In order to comprehensively study the coral reefs and related waters of the Monument, CREP utilizes several disciplines to monitor the various biota and environments. The primary research areas are listed below: (1) ocean and climate change, (2) benthic communities (with emphasis on hard corals), (3) non-coral invertebrates and (4) reef-associated fish communities.

1. Ocean and Climate Change Monitoring

Long-term time series of physical oceanographic data, supplemented by discrete biological and geochemical sampling, enables characterization of the oceanographic regime within which coral reef ecosystems reside and provides important context to spatial and temporal ecological observations. An example is information about seawater carbonate chemistry (calculated from the dissolved inorganic carbon and total alkalinity concentrations in seawater) of coral reef ecosystems, which helps scientists understand the potential effects of ocean acidification and temperature. Sensors on the seafloor recording the thermal structure of the water column surrounding the reefs provide insight into thermal stress on coral reef environments and its potential role in coral bleaching events. Additional oceanographic sensors measuring waves, currents, dissolved oxygen, pH, and turbidity provide important ancillary data for understanding the oceanographic conditions that influence the coral reef ecosystems that the CREP monitors.

Objectives:

- Perform conductivity, temperature, and depth recorder (CTD) casts to gather depth profiles of temperature and salinity in shallow-water environments.
- Conduct water sampling efforts in conjunction with CTD casts at coral reef survey sites to quantify the carbonate system present at the reef ecosystems CREP visits.
- Recover and replace instrumentation to assess and monitor changes in calcification and bioerosion rates measured within the reef environment. This information will help assess the response of coral reef ecosystems to climate change and ocean acidification.
- Complete maintenance and replacement of various oceanographic instrument arrays that have been long-term scientific features at permanent survey sites.

- Collect coral cores from *Porites* spp., providing a historical record of variability of coral growth rates and skeletal density. Data collected from coral cores can be linked with carbonate chemistry information to calculate coral calcification rates and compared with historical oceanographic data to evaluate the influence of regional and basin-wide oceanic processes on coral reef ecosystems.
- Collect voucher tissue samples for genetic analysis to correlate coral and *Symbiodinium* functional genomics with ecological response to bleaching events, marking colonies for future resampling.
- Use photomosaics to collect coral community composition data at climate stations and contextualize any physical and/or biological changes recorded at the climate stations over time.
- Habitat characterization of the permanent sites.
- Obtain visual estimates of relative abundance of sea urchins at visited sites.

2. Benthic monitoring

2.1 Reef Benthos

Quantitative assessment and monitoring of coral reef benthic communities is central to CREP's programmatic mission to provide sound science to enable informed and effective implementation of ecosystem-based management and conservation. Within this context, surveys are conducted at a range of shallow (0–30 m depth), hard-bottom habitats to document community status and change over time. Largely, these activities involve two main themes: 1) coral reef benthic composition and percent benthic cover; and 2) community demographics (density, size-class distribution), health condition, and recruitment. These themes are assessed at geo-referenced, stratified random sites that are selected to provide spatial-temporal appraisals of coral reef dynamics in the region, to better understand coral reef benthic community structure and processes in the light of human and natural impacts. Continued monitoring of these parameters is pivotal to the understanding of coral reef community integrity and health status over time. More importantly, it enables resource managers to make informed decisions pertaining to the protection and preservation of coral reef habitats within their jurisdictions. Towed-diver surveys are also used to collect broad scale information about benthic habitat structure and key benthic invertebrates (e.g. Crown of thorns seastars (*Acanthaster planci*), giant clams (*Tridacna* spp.)).

Objectives:

- Continue to collect information to assess the status and trends of coral reef benthic communities, building upon quantitative studies initiated in 2002.
- Continue to assess and monitor the abundance and geographical distribution of shallow-water (< 30 m) diseases and diseased corals, building upon studies that were initiated in 2004, and methodically describe the gross morphology of disease and lesions in diseased corals.
- Provide a basis for inter and intra-archipelagic status and trend analyses.

- Provide a basis to evaluate the effects of potential local and global environmental impacts, including land-based sources of pollution, siltation and sedimentation stress, physical damage (storms, groundings), habitat degradation, climate change, and ocean acidification.

2.2. Genetic Connectivity of *Pocillopora meandrina*

Genetic connectivity and gene flow are important for maintaining healthy populations of plants and animals; populations that exchange genes with other populations maintain or increase their genetic diversity and thus decrease their risk of extirpation. It is therefore an important research goal to estimate gene flow and the environmental features that both promote and impede it, so that the effects of environmental drivers on gene flow can be estimated. Assessing the relationship between genetic connectivity and environmental covariates is a central goal in the field of population genetics.

This project seeks to understand the genetic connectivity of *Pocillopora meandrina* in the Hawaiian Archipelago. This project is led by graduate student Erika Johnson, under the direction of Dr. Robert Toonen Associate Researcher at the Hawai'i Institute of Marine Biology (HIMB).

Objectives:

- Measure genetic connectivity of *P. meandrina* across the Hawaiian Archipelago.
- Quantify the genetic diversity per location and determine if this diversity, or lack thereof, may be attributed to various environmental factors.

3. Non-coral Invertebrates

3.1. Microbial Communities

No long-term data on the dynamics of natural bacterial assemblages in reef systems (let alone other ecotypes) are currently available. Building a pan-Pacific microbial data set is an extremely important step towards greater understanding of the overall health of the reef system. The majority of reefs on the planet are affected and analyses are confounded by the inability to attribute differences in reef system dynamics to variation in resource availability caused by oceanography or human activity. The region monitored through Pacific RAMP includes reefs experiencing various combinations of human activity and resource availability. The hope is that new patterns in the microbial data sets will emerge at regional or pan-Pacific scales and that this information can be used to understand the mechanisms underlying reef system decline.

Objectives:

- Continue to assess the abundance, diversity, trophic structure of the microbial community associated with the water column in reef ecosystems, by building upon work started in 2008.

- Assess and characterize the microbial community associated with the benthos as an indicator of reef health.
- Provide the basis to assess temporal change.

3.2. Autonomous Reef Monitoring Structures (ARMS)

The need for conservation of coral reef ecosystems throughout the world requires knowledge concerning species richness within and among habitats, and an understanding of the factors that influence species survivorship. The collection of systematic information concerning which taxa are present is essential to understand the changes in coral reef communities and having these indices of biodiversity are crucial baselines for ongoing monitoring programs. Historically, coral reef biodiversity assessments and monitoring programs have focused strictly on charismatic fauna such as corals and fish even though the majority of reef biodiversity is represented by cryptic invertebrate fauna such as sponges, mollusks, echinoderms, crustaceans, annelids, bryozoans and tunicates. Proper inventory of such taxa requires two factors: physical sampling and taxonomic expertise. Thus, specimen collections are necessary for biodiversity assessments. This project will build upon previous baseline and monitoring efforts to enhance the state of knowledge of coral reef invertebrate populations in the Hawaiian Archipelago and in relationship to the other Pacific island areas.

Objectives:

- Continue coral reef cryptic biodiversity studies.
- Collect both quantitative and qualitative information for invertebrate species present at all study sites.
- Continue to recover, replace and process Autonomous Reef Monitoring Structures (ARMS).
- Site habitat characterization.
- Visual estimates of the relative abundance of sea urchins at visited sites.

3.3. Population Structure and Connectivity of Crown-of-Thorns Sea stars

The crown-of-thorns seastar (COTS, *A. planci*) is native to coral reefs in the Indo-Pacific region. On healthy coral reefs, the coral-eating starfish plays an important ecological role, as it tends to feed on the fastest growing corals such as staghorns and plate corals, allowing slower growing coral species to form colonies; this helps increase coral diversity. However, outbreaks of this corallivore can pose one of the most significant threats to the coral reefs Pacific wide, wherein the starfish consume coral tissue faster than corals can grow, and therefore a decline in live coral cover is likely to occur. Catastrophic reductions in coral cover have been reported following mass COTS outbreaks. This project builds upon previous work examining the population structure and connectivity patterns of COTS in the Hawaiian Archipelago. These collections would provide an opportunity to explore the genetic connectivity of outbreak populations along the Hawaiian Archipelago in more depth. Having a better understanding of their gene flow could

provide greater insight into their population dynamics that could aid in the management of this destructive corallivore.

Objectives:

- Continue studies on population connectivity of outbreak populations of COTS in the Hawaiian Archipelago, to dovetail with prior and ongoing work conducted Pacific wide.

3.4. Phylogeography of *Palythoa tuberculosa*

Phylogeography is the study of the spatial and temporal distribution of gene sequences in populations of a single species, or among closely related species. Phylogeography can contribute to knowledge of speciation and the assembly of community structure and identify geographic areas of high genetic diversity and/or regions where evolutionary processes may be identified and included in conservation planning on regional scales. This project is aimed at conducting a phylogeography study of the zoanthid *Palythoa tuberculosa* on a small scale (Hawaiian Archipelago) and larger context, across the species range. This project is led by graduate student Ale‘alani Dudoit, under the direction of Dr. Robert Toonen Associate Researcher at HIMB.

The small-scale Hawaiian Archipelago population connectivity project is aimed at addressing the following objectives:

Objectives:

- Assess whether populations of these species connected or do they form different populations
- Assess if populations are influenced by biogeographic barriers
- Assess whether there are genetic breaks among islands

3.5. Plankton Samples

Biodiversity remains greatly under described, especially with regards to the smaller invertebrate animals that reside in and on the reef. Many of these organisms have planktonic larvae that can be sampled, and thus their occurrence documented via plankton samples. While identification of larval forms is currently not practicable, identification of species via DNA sequences is possible when matching sequences for benthic identified adult samples are available. Massive parallel sequencing of plankton samples (metabarcoding) allows for the assessment of total biodiversity in the plankton sample.

Objective:

- Expand upon the documentation of the marine biota of coral reefs

4. Reef Fishes:

Quantitative assessment and monitoring of shallow reef fish assemblages is an integral part of the CREP's mission to improve our scientific understanding of these fish resources, and to contribute to the scientific basis necessary for sound management. Currently, triennial monitoring surveys are conducted at each geographic sub-region (e.g. American Samoa, Hawaiian Archipelago) to document status and trends in reef fish assemblages. Habitat types surveyed encompass a wide range of habitats within CREP's survey domain (i.e. 0–30 m hard-bottom). Survey sites are determined via a stratified-random sampling scheme; the majority of sites are located on outer reef slopes. Inventories and assessments of shallow reef fishes have been completed by CREP at 40 U.S.-affiliated Pacific islands, and monitoring is ongoing. Continued updating of data, and analysis of this growing database will enable species-specific numerical and biomass densities to be calculated, fish assemblage structure to be described at various spatial and temporal scales, and statistical correlations to be determined. Further analysis of CREP's oceanographic and biological data will aid in understanding patterns of fish distribution and abundance as well as ecosystem associations.

Objectives:

- Gather data sufficient to assess status and trends of Pacific reef fish populations.
- Provide the basis for meaningful comparison of reef fish stocks across the PNMN.
- Provide the basis needed to assess the response (or potential response) of reef fish communities to possible ecosystem impacts such as fishing, ecotourism, pollution, habitat damage, sedimentation, and hurricanes.

Intended Use of Results:

Pacific RAMP research cruises are conducted in collaboration with colleagues and partners from other NOAA offices; Federal, State, and Territorial agencies; academia, industry, and nongovernmental organizations. These partnerships are essential to the effectiveness of long-term ecosystem monitoring in the region since they bring together scientists and managers with expertise and experience with a broad range of scientific and management issues. The data collected on this cruise are pivotal to long-term biological and oceanographic monitoring of coral reef ecosystems in the U.S. Pacific and the Monument. This 2016 expedition will add to information collected during baseline, monitoring and mapping surveys conducted in the NWHI between 2002 and 2013. In particular, data on the abundance and spatial distribution of reef fishes and benthic organisms will allow scientists to evaluate potential changes in the condition and integrity of coral reef ecosystems in the region and enable managers to more effectively manage and conserve reef-associated biota.

*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/angered/>

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?

There will be little to no adverse impacts on the Monument cultural, natural and historic resources, qualities and ecological integrity from the proposed activities. All intended activities contribute significantly to an understanding of the ecosystems within the Monument. CREP conducts RAMP cruises with the intent to provide scientific data needed to support management of the Monument through cruise reports and coral reef ecosystem monitoring reports. Coral Reef Ecosystem team members conduct reef monitoring surveys with little to no adverse impacts to the natural resources of the Monument. The scientific objectives are to observe the natural habitat with minimal disturbance and to only come in contact with resources in limited occurrences to further comprehensive understanding and research in the Monument. In addition, team members attend a Hawaiian Cultural Briefing each year before entering the Monument. This education instills an awareness of the natural, cultural and historical values the Monument holds. Also, the NOAA research ship *Hi'ialakai* has informative cultural literature provided by the Office of Hawaiian Affairs and the Monument for personnel seeking further knowledge or who may not be able to attend the briefings.

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?

All management regulations pertaining to the Monument are strictly adhered to when conducting operations within the Monument (such as disease mitigation regulations) and in Special Preservation Areas. The PIFSC and CREP supply trained, knowledgeable and experienced researchers who are aware of and educated about the Monument's cultural, natural and historic resources, qualities and ecological integrity through cultural educators, partnerships with the co-trustees, and will act accordingly to enhance the management of the Monument. To the knowledge of PIFSC and CREP, there will be no indirect, secondary, or cumulative effects on the Monument's cultural, natural and historic resources, qualities and ecological integrity from the proposed activities. All activities proposed provide critical data that will greatly enhance the ability of Monument managers to characterize and understand the ecosystems within the Monument. As stated, all scientific methods that will be used on this cruise are designed to have minimal, if any, effects on the environment or cultural resources. The fundamental goals of conservation and management are of utmost importance to the intended research, and no work outside of permitted activities shall be considered.

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 the research within the Monument because monitoring data gathered from this research pertains to the area being managed and is to be utilized by the Monument.

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

There will be little to no adverse impacts on the Monument cultural, natural and historic resources, qualities and ecological integrity from the proposed activities. All intended activities contribute significantly to an understanding of the ecosystems within the Monument. CREP conducts RAMP cruises with the intent to provide scientific data needed to support management of the Monument through cruise reports and coral reef ecosystem monitoring reports.

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

The upcoming RAMP cruise will use the minimum amount of time needed within Monument waters to complete the required work. Due to the considerable size of the Monument and the transit time between locations, the planned schedule will maximize the amount of operational days available.

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

RAMP cruises have been successfully conducted on an annual basis in the NWHI since 2000 in conjunction with the co-trustees of the Monument. Team members are experienced divers and highly trained personnel who will be under the guidance of the Chief Scientist (Biography attached). Personnel from CREP have been collecting monitoring data with little to no adverse impacts to the natural resources of the islands.

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.

RAMP operations are funded by yearly grants from the NOAA CRCP to the CREP, which is a part of the PIFSC. PIFSC contributes in-kind to the foundation and activities conducted by the CREP. Collaborators and partners also supply personnel and effort through their own funding.

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.

Standardized survey procedures are employed during operations. A dive plan is being formulated and all NOAA diving procedures will be followed. For each discipline there are procedure manuals, including safety instructions, for both ship and diving operation that are followed and enforced. RAMP cruises are conducted with the intention of monitoring and assessing the coral reef ecosystem with negligible impact to Monument resources. It is important to note that the methods used have shown to have little impact on the habitat being observed through various cruises and reports.

i. Has your vessel been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?

Under a separate permit, the *Hi'ialakai* is outfitted with a mobile transceiver unit.

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

We are not aware of any other factors that would make the issuance of a permit for the activity inappropriate. CREP plans to conduct vigilant operations and exercise protocols exhibited on previous RAMP cruises unless requested by the Monument to modify.

8. Procedures/Methods:

The proposed research cruise will use the NOAA research vessel *Hi'ialakai* as a platform and be in the Monument from August 30th, 2016 to September 30th, 2016. The CREP utilizes several disciplines to comprehensively monitor various biota and environments associated with coral reefs. The primary research areas are listed below with accompanying methodological descriptions: (1) Ocean and Climate Change, (2) Benthic Communities (focused on hard coral), (3) Non-coral Invertebrates, and (4) Reef-Associated Fish Communities

1. Ocean and Climate Change Monitoring
Several activities are conducted for the monitoring of ocean and climate change. In addition, previously deployed instrumentation such as Ecological Acoustic Recorders (EARs), which monitor the sounds of marine animals and vessel traffic around the islands, will be retrieved.
- 1.1 Subsurface Temperature Recorder (STR): Deployed at select locations to obtain high-resolution temperature data
- 1.2 Wave-and-tide Recorder (WTR): Deployed at select locations to collect high-resolution wave and tide records.
- 1.3 Portable Underwater Collector (PUC): PUC units are used to automatically collect multiple water samples at depth at pre-programmed time intervals over a period of 24–48 hours. We routinely deploy 6 PUCs at a time to collect 2 liter samples every 4 hours over a 24 hour period. We plan on performing a maximum of twelve 24-hour deployments on this cruise.
- 1.4 Water Samples: These are collected throughout the cruise in conjunction with CTD casts. The volumes of seawater samples are 500mL per DIC sample and 250 mL per salinity/nutrient sample. A small amount of mercuric choride soluton (200 microliters) is used to halt biological activity in water samples. This is necessary for accurate analysis of dissolved inorganic carbon. The mercuric chloride solution is added to the water sample bottle after the sample is collected. The sample bottle is secured and brought back to port for later laboratory analysis. The mercuric chloride solution is not introduced into Monument waters. Surface water, offshore and near reef water samples are collected at selected sites and later processed for each analyte. The total number of samples is variable and dependent upon work conditions, weather and unpredictable oceanographic occurrences. We estimate that an approximate total of 400 water samples (at presently unknown locations) will be collected. The location of all samples will be submitted in the cruise completion summary and the cruise report.
- 1.5 Calcification Accretion Units (CAUs): These are instruments that allow for spatial and temporal evaluation of coral reef net calcification and productivity. These analyses are made by measuring the settlement of stony corals, crustose coralline algae and

macroalgae. Settled organisms are removed from the ocean environment when a CAU is recovered. CAUs are photographed in the laboratory for community composition analysis and are dried and weighed to determine net calcification and productivity. Only organisms that have settled on the CAU are removed. No other impacts to the surrounding environment or substrate occur during removal.

- 1.6 Bioerosion Monitoring Unit (BMU): Bioerosion rates are measured by attaching a calcium carbonate block (5 cm × 2 cm × 1 cm), known as a Bioerosion Monitoring Unit (BMU), to each installed CAU. The total number of blocks any each island will not exceed 25. These blocks act as settling substrate for bioeroding organisms. Prior to deployment, each block is scanned by microCT (to create a 3D image of each block) and autoclaved; blocks are retrieved during subsequent RAMP cruises. Retrieved blocks are re-scanned by microCT and sampled for bioeroding organisms. Pre and post scans will be used to estimate bioerosion rates of the calcium carbonate reef framework. Bioerosion community composition will be measured using the ReefChip microarray. Only organisms that have settled on the BMU are removed from the reef ecosystem. No other impacts to the surrounding environment or substrate occur during removal.
- 1.7 Coral Cores: Skeletal cores of the scleractinian, *Porites* spp., which is a relatively common species found throughout the Pacific, is the target for coral core sampling. This study is conducted in support of the CREP's long-term ocean acidification monitoring program, to establish a baseline of coral calcification, growth and skeletal density baseline across the Pacific. *Porites* was chosen as it develops typically robust colonies, can be cored successfully, recovers quickly, and is not proposed or listed under the ESA. Furthermore, coral coring is only conducted opportunistically, when time, conditions, and appropriate colonies exist.
- A 2–3 person dive team locates a suitable coral colony and uses a pneumatic drill with a masonry drill bit and powered by a SCUBA tank to extract the core. CREP scientists will make on-site determinations that coral colonies be of sufficient size and in good health prior to extracting a coral skeleton sample (2.5 cm in diameter and 5–70 cm in length). An exact fit cement plug and underwater epoxy will be used to seal the hole created by removing the core, to prevent invasion of the colony by bioeroding species and to facilitate coral tissue growth. Cement plugs provide a surface over which surrounding coral tissue can grow, and in many cases colonies show no sign of coring in the coral tissue within 6 months of extraction. It has been determined through previous efforts that such technique is not detrimental to the longevity of a coral colony. Analysis of the coral cores is then done through a nondestructive CAT scan/imaging technique.
- A minimum of 1 core and maximum of 3 cores will be collected within a close proximity (5–10 m) to each other at each sampling location. Sites may be chosen for coring at each island or reef system when the RAMP schedule allows for this opportunistic collection. It is possible that zero cores will be collected during the RAMP cruise, however, a maximum of 30 coral cores are proposed from within the Monument.

- 1.8 Coral and *Symbiodinium* functional genomics: In the last two years, Hawai‘i went through the worst coral bleaching event in recorded history, with high levels of bleaching throughout the islands. However, sites were variable in their response to bleaching. We plan to collect small tissue biopsies of *Monipora capitata* and *Porites lobata* to enable analysis into any genetic correlates of ecosystem level response (coral mortality) to the bleaching events. We are requesting permission to collect a maximum of 12 biopsies to represent each of the 2 different coral taxa at 16 different Climate sites in the PMNM, as follows: French Frigate Shoals, 4 stations; Lisianski, 4 stations; Pearl and Hermes, 4; and Kure, 4 sites. This equates to 192 samples of each species. In the field, after gathering the appropriate specimen sample metadata a 2 × 2 cm diameter biopsy sample will be collected using sterile sampling gear and stored in a cool, dark container for transport to the ship. As following response to future environmental conditions is critical to this research, each colony sampled will be marked with a plastic tag for future resampling.
 - 1.9 Photomosaics: The collection of photomosaics is straightforward and requires little special equipment or dive operations. The mosaic camera system consists of two SLR Nikon D7000 cameras and a single GoPro video camera mounted to a custom frame. The camera used to generate processed photomosaics uses a wide-angle lens (18 mm) to ensure high overlap among adjacent images. The other camera uses a longer focal length lens (55 mm) to capture images with sub-cm spatial resolution. Image frames from the extreme wide angle GoPro video camera can be used for photomosaic processing in the rare event of missing imagery for a given portion of the reef. To obtain continuous coverage of the reef floor within a plot, the diver operating the camera system swims a gridded pattern approximately 1.5 m above the average depth of the plot at speeds sufficient to maintain maximum overlap between adjacent images. Images are simultaneously captured every second from both DSLR cameras, while the GoPro continuously captures 30fps HD video. Lasers are mounted above the longer focal length camera to provide approximate scale in the high resolution imagery. Depending on local conditions a single mosaic will take 45–60 minutes to collect and consists of approximately 2500 individual images per camera. To calibrate mosaic images, a second diver collects a series of detailed measurements between a number of temporary and/or permanent reference markers deployed during surveys.
2. Benthic monitoring
 - 2.1 Reef Benthos: Two complementary, underwater surveys are used to enumerate and describe the diverse components of shallow-water reef benthic assemblages. Towed-diver surveys are designed to provide broad-scale assessments of benthic community structure and target invertebrate density and relative abundance. Site-based, fine-scale demographic surveys provide an assessment of coral density, size class distribution, condition/disease, and recruitment.

- 2.1.1 Towed-Diver Surveys: Shallow water habitats around each island, bank, or reef are surveyed using pairs of divers towed 60 m behind a 19' SAFE Boat survey launch. In each towed-diver buddy team, one diver is tasked with quantifying the benthos while the other quantifies fish populations. Each towed-diver survey lasts 50 minutes, is broken into 10 five-minute segments, and covers approximately 2 km. A GPS track of the survey launch track is recorded at five-second intervals using a Garmin GPS76Map GPS unit. A custom algorithm is used to calculate the track of the divers based on the track, speed, and course of the boat and depth of the diver. Each tow board is equipped with a precision temperature and depth recorder (Seabird SBE39) which takes measurements at five-second intervals. At the end of each day, data are downloaded, processed and presented in ArcGIS and can be displayed in conjunction with IKONOS satellite imagery, NOAA chart data and/or other spatial data layers. The benthic tow board is equipped with a downward-oriented, high-resolution digital still camera with dual strobes. The downward-oriented camera is maintained 1–2 m off the bottom and is programmed to photograph the benthic substrate every 15 seconds. The diver on the benthic tow board observes and records habitat composition (hard coral, stressed hard, soft coral, macroalgae, coralline algae, and sand) and tallies conspicuous macro invertebrates (e.g. COTS, urchins) along a 10-m swath.
- 2.1.2 Coral Demographics Surveys: A stratified random sampling design is employed to REA survey sites. Depth categories of shallow (0–6 m), mid (6–18m) and deep (18–30 m) are incorporated into the stratification scheme. Allocation of sampling effort is proportional to strata area and survey sites are randomly selected within each stratum. The focal point of the surveys at each site are two, 18-m belt transects. Adult coral colonies (≥ 5 cm) are surveyed within four 2.5 m² segments (1.0 × 2.5 m) which begin at 0, 5, 10, and 15 m of the transect. In each segment, all adult coral colonies whose center falls within 0.5 m of either side of the transect line are identified to lowest taxonomic level (species if possible, otherwise genus). In addition, the following estimates and empirical measurements are made for each coral colony: morphology noted, size (maximum diameter to nearest cm), partial mortality estimated as percent of colony (both 'recent' and 'old' dead), the cause of recent mortality identified if possible (e.g. predation by COTS or gastropods), condition (including disease, bleaching, skeletal growth anomaly, pigmentation response, etc.) with the extent and level of severity noted. Juvenile coral colonies (< 5 cm) are surveyed within three (1.0 × 1.0 m) segments that are embedded within three of the segments where adult coral colonies were surveyed on each transect. Still photographs of the benthos are collected every 1 m from the 1 m mark to the 15 m mark yielding 30 photographs per site, which are the basis for deriving estimates of benthic cover and composition using image analysis software. Coral disease biopsies are collected as needed, catalogued, and fixed in appropriate solutions for further histopathological and/or molecular analyses (see below).

2.1.3 Coral Health and Disease Studies: Because a particular type of gross lesion can present multiple microscopic manifestations, coral disease assessments and studies may require biopsies or samples for histological (microscopic) evaluation and verification. Hence, we are requesting that the permit cover the collection of a maximum of 10 samples representing each species/taxon and 7 general disease gross morphologies including: tissue loss, skeletal growth anomalies, tissue necrosis, band diseases, pigmentation response, other discolorations, and fungal infections.

In the field, after gathering the appropriate specimen sample metadata (colony size, type of affliction, area affected, percent live/dead, severity of the affliction, and photographic records), a 5–7 cm diameter biopsy sample will be collected using sterile sampling gear and stored in a cool, dark container for transport to the ship. Additionally, opportunistic sampling of any potential new diseases/lesions observed at the sites will occur.

Coral biopsies (maximum diameter ≤ 7 cm) are carefully collected using bone cutters or hammer and chisel (as necessary). Biopsies from healthy and diseased portions of the same colony will be collected using separate sets of sterile tools. In addition, collection tools will be sterilized in 3% bleach solution between collection sites/dives, and decontaminated overnight in 3% bleach solution between islands. Aboard the ship, coral tissue samples will be fixed in zinc-formalin (Z-fix® Anatech Ltd) for 18–24 hours and subsequently transferred to 70% ethanol. Samples will be stored in capped containers and transported to Honolulu. Waste product (i.e., formaldehyde fixing solution) will be stored for appropriate chemical disposal in Honolulu. In collaboration with scientists at Nova Southeastern University, Dania Beach Florida, histopathological sample processing will be conducted. This process involves embedding tissues in paraffin to allow for sectioning with a microtome and producing histological slides. Tissue samples and paraffin blocks will be accessioned at in an appropriate institution (e.g., NOAA IRC; Bishop Museum, Honolulu).

No more than 2 type samples (healthy and diseased) will be collected for each suspected new disease state. In no case will specimens be collected if it is judged that doing so might inhibit the capacity of the taxon to replenish itself.

2.1.4 Coral Taxonomic Verification: We are also requesting that the permit cover the collection of coral skeletal and tissue samples for taxonomic verification. Collections will be based upon provisional identification of the candidate species in the field. Samples required for taxonomic verification need only be large enough to examine the skeletal architecture (e.g., polyp structure and coenosteum patterning) with a dissecting microscope; hence samples will be no more than 7 cm maximum diameter (or length for branching species). In the field, samples taxonomic verification will be procured following the same approach and protocols as the samples for disease studies. In no case will specimens be collected if it is judged that doing so might inhibit the capacity of the taxon to replenish itself. No more than 2 type specimens will be collected for each suspected new coral species or new record. Voucher samples for taxonomic verification will be bleached to

remove tissue, and stored dry until an appropriate expert is identified and agrees to examine the specimen.

- 2.2 Genetic Connectivity of *Pocillopora meandrina*: Skeletal samples of *Pocillopora meandrina* will be collected opportunistically as time and weather conditions permit. Collections will be conducted using bone cutters, by clipping off the apical 2–3 cm portion of branches. We request permit to collect a maximum of 10 clippings per site at a maximum of 8 sites (80 samples total). Because this is a study for genetic connectivity each clipping will be collected from a different colony. All samples will have live tissue only; there should be no dead coral as part of the collection. Collections are not the emphasis on this cruise and will therefore be occurring opportunistically by divers during their surveys.
- Specimens will be carefully collected with bone cutters and placed in separate labeled bags with site and depth location. Aboard the ship, samples will be fixed and preserved in DMSO and stored in capped containers and transported to Honolulu. In the lab samples will be processed first by crushing the tissue and skeleton. These samples will then be processed using commercially available DNA extraction kits. We will use a reduced genomic sequencing approach to generate our data. We expect that gene flow will be restricted between islands and may even be restricted between locations surrounding islands. This study will inform us about the scale at which populations are connected and, following disturbances, the rate at which populations may be expected to rebound.

3. Non-coral Invertebrates

- 3.1 Microbial Community Surveys: Diver-deployable Niskin bottles will be used to collect up to 24 L of seawater at each REA site. All samples will be collected 0.5–1.0 meters above the reef surface at a depth of 10–15 meters and transported back to the ship. Collected seawater samples are subdivided into the following categories:

3.1.1 Water samples

- 3.1.1.1 Microscopy/Microbial Counts: Microscopy/Microbial Counts: Water from each sample will be fixed with paraformaldehyde and glutaraldehyde to be filtered onto nucleopore filters (0.02 μm and 0.2 μm). 0.02 μm filters will be stained with SYBR-Gold (for enumeration of microbes and viruses) and 0.2 μm filters will be stained with DAPI (cell size measurements). Slides will be stored in a slide box at $-20\text{ }^{\circ}\text{C}$ until they can be transported to San Diego State University (SDSU) for processing. Syringes will be used to draw 60 ml of water from the benthos. This water will be added to RNA-Later to derive metatranscriptomes of the reef microbes in each site. The viral-inducing antibiotic Mitomycin C will be added to viral samples (derived from our preexisting sampling procedures), incubated and the viral particles recovered. The Mitomycin C will be degraded in at least 1:32 commercial bleach or as needed before being disposed of to ensure no negative environmental or mechanical consequences of its use. Seawater will be cultured on Thiosulfate-citrate-bile salts-sucrose (TCBS) agar plates to quantify the

abundance of *Vibrio* species, an opportunistic microbial consortium associated with human disturbance.

- 3.1.1.2 Water Chemistry: Water samples will be pushed through precombusted GF/F glass filters and the filtrate will be collected in plastic bottles washed with 5% hydrochloric acid. The bottles will be stored at -20°C and will be analyzed for dissolved organic carbon at SDSU. The GF/F filters will be stored at -20°C and analyzed for particulate organic carbon (concentration and stable isotopes of C & N) at SDSU. Water will also be filtered through a 0.2µm filter for nutrient samples that will be analyzed at SDSU
- 3.1.1.3 Flow Cytometry: Water from each site will also be pushed through a 8 µm filter. The filtrate will be dispensed into 3 × 5 ml cryovials, and glutaraldehyde added to each [final = 0.125%]. Vials will be inverted to mix, and incubated in the dark for 15 min. The glutaraldehyde preserved samples will be flash frozen in liquid nitrogen (contained in a dry shipper) until they can be transported to SDSU for flow cytometry analysis.
- 3.1.1.4 Microbial DNA Analysis: The rest of the water in each Niskin bottle will be pushed through a 20 µm prefilter (to remove large eukaryotes) followed by a 0.22 micron Sterivex filter. The filter will be stored at -20 degrees C until the microbial DNA is isolated for 16S analysis at SDSU.
- 3.1.1.5 Microbial and Viral Metagenomes: Diver deployable collapsible carboys will be filled by manually suctioning reef water from the benthos using a hand pump. The carboys will be transported back to the ship where the water will be pre-filtered through a 100 µM cloth filter. A tangential flow filter (100kD) cleaned with sodium hydroxide will then be used to concentrate the bacteria and viruses to ~50 ml water volume. The bacterial fraction will be collected by filtering the 50 ml concentrate through a 0.45 µm Sterivex filter. These filters will be stored frozen at -20 °C until they can be processed for metagenomic analysis at SDSU. To the 0.45 µm filtered water (viral fraction), 250 µl of chloroform will be added. This sample will be stored in a 50ml conical at 4 °C until transport to SDSU for 454 sequencing analysis. Water from sites in the PRIA and American Samoa will be stored and added to water of different provenance to assess the effects of exposure to varied DOC sources and viral communities. No water will be discharged into the environment at any time during this cross and treated water will be stored in varying levels of containment aboard the ship
- 3.1.2 Benthic Grabs: As time permits and at select sites small coral rubble or sediment samples are collected in Ziploc bags. The bacterial 16s rRNA genes associated with these samples will be sequenced to characterize the microbial communities associated with the benthos.
- 3.1.3 Macroalgal Samples: As time permits and at select sites small pieces of the most dominant alga will be collected in Ziploc bags. The bacterial 16s rRNA genes associated with these samples will be sequenced to characterize the microbial communities associated with the benthos.

- 3.1.4 Coral-associated Viral and Microbial Community Samples: Three large *Porites* colonies interacting with turf algae and three large colonies interacting with coralline crustose algae (CCA) will be sampled at each island (24 colonies total in the Monument). An underwater drill with diamond-tip drill bits will be used to minimize damage when extracting six coral biopsies (1 cm in diameter), three interaction biopsies, and six turf/CCA biopsies per colony. Areas drilled will be filled with epoxy according to methods described in 1.7 in order to prevent invasion of the colony by bioeroding species and facilitate coral tissue growth. These methods are congruent with sampling techniques in Caribbean and Line Islands (da Silva et al. 2015). One set of samples from each coral will be preserved in RNA later for metatranscriptomic analysis, another set will be preserved in methanol for metabolomic analysis, and the last set will be flash frozen in liquid nitrogen for metagenomic analysis.
- 3.1.5 Coral Geometry: One coral colony per day will be imaged using an underwater camera system. Full colony images will be collected by imaging from multiple perspectives at a fixed focal length and 90% overlap between imaged sections. Macro coral perimeter images will also be taken at a fixed focal length with 90% overlap between imaged sections.
- 3.2 Autonomous Reef Monitoring Structures (ARMS): ARMS are small, long-term settlement devices that are used to assess the cryptic taxonomic diversity of coral reef associated species. These devices are typically installed at climate and ocean change monitoring sites in sets of three. ARMS deployed in 2013 will be recovered and redeployed at established climate stations. The number and type of organisms collected off the ARMS units is dependent upon random recruitment and colonization. Therefore, it is not possible to know or predict this information with a high degree of confidence. Upon retrieval, ARMS are encapsulated within a mesh-lined crate, brought to the surface support vessel, and transferred to the *Hi'ialakai* for processing. Onboard, the ARMS are disassembled, the plates are photographed, and the associated seawater is sieved for motile organisms. Motile organisms >2 mm are sorted, identified and preserved. Sediment and motile organisms <2 mm are immediately bulk preserved for future metabarcoding next-generation sequencing (NGS). The plates are scraped clean and the resulting sessile organisms are homogenized and preserved for NGS. Back on land, the contents of the ARMS may be sent to our partners at the Smithsonian, Florida Museum of Natural History L.A. County Museum, University of Hawai'i at Hilo, San Diego State, Moss Landing Marine Laboratories, Scripps Oceanographic Institute, and HIMB for molecular processing and taxonomic archiving. The number and types of specimens sent to each of these institutions will vary depending on what has recruited to the ARMS platforms and the expertise of the institution. Remaining contents will be archived and stored within the NOAA facility in Honolulu until genetic processing occurs.
- 3.3 Population Structure and Connectivity of Crown-of-Thorns Sea stars: Opportunistic collections of COTS tissues will occur for population connectivity studies. Understanding

population size and migration (dispersal and recruitment) of this corallivore will aid in the management of these pristine reefs. Arms from COTS will be removed underwater during the dive using a knife or shears and placed within a mesh bag or whirlpak. We are requesting permit to collect up to 50 COTS arms per outbreak event, with an estimated maximum of approximately 200 arms in total. Back on board the ship, tube feet tissue will be removed using tweezers and placed into 95% ethanol for future molecular processing. Collections are not the emphasis on this cruise and will therefore be occurring opportunistically by divers during their surveys

- 3.4 Phylogeography of *Palythoa tuberculosa*: Opportunistic collection of *P. tuberculosa* will also occur as time and weather conditions permit. *P. tuberculosa* are common benthic reef inhabitants in the main and Northwestern Hawaiian Islands. Using a knife, divers will remove a dime size piece of tissue from each collected colony of *P. tuberculosa* with the tissue place in individual whirl paks. Location and depth metadata will be recorded. Back on board the ship, samples will be placed in DMSO (dimethyl sulfoxide) or 95% ethanol to fix and preserve the sample. Collections are not the emphasis on this cruise and will therefore be occurring opportunistically by divers during their surveys. We are requesting to collect a maximum of 10 samples per site at a maximum of 20 sites.
- 3.5 Plankton Samples: A plankton net 50 cm diameter with a 80 µm mesh size having a 1L cod end jar attached to net with flow meter will be trailing a few yards behind the stern of a small boat. Each tow will be assigned a unique station number with corresponding GPS coordinates, date & time recorded for start and finish of each tow. The tows will be just below the surface, for 5 minutes and the small boat will be going just fast enough for net to be tight and flow meter to run (1–2 knots). The net will be brought back onto the small boat and processed in the field. The outside of the plankton net will be washed down with seawater applied to outside collecting flora and fauna in the cod end. Depending on the number of days spent at each island, we expect to conduct 5–20 plankton tows per island, with a maximum of 50 plankton tow samples in the Monument. After using a hand net to separate taxa, all samples will be put into 50 mL Falcon tube(s) using 95% ethanol in squirt bottles to be fixed. All nets will be rinsed with freshwater between collections and the sample tubes/ethanol will be stored in protected containers reducing exposure the environment. Samples will then be stored aboard the *Hi'ialakai* scientific freezer until returning to Honolulu, HI. Sample analyses will occur in partnership with the Florida Museum of Natural History. Preserved samples will reside at the Florida Museum of Natural History.
4. Reef Fish Monitoring: Two complementary, noninvasive underwater-surveys are used to enumerate the diverse components of diurnally active shallow-water reef fish assemblages. Each method is replicated at randomly generated sites within and/or among the various habitat types present around each island or bank. Fish length-class is estimated for all quantified fish to provide an estimate of numerical size structure and

biomass densities by taxa. No permanent markers, e.g. transect pins are used for either of the fish survey methods.

4.1 Stationary Point Counts (SPC): Stationary point counts are the main method used by CRED to survey reef fish assemblages. At each site replicate SPC surveys are conducted by a pair of divers, surveying adjacent visually estimated cylinders of 7.5 m radius, centered on the divers. Each SPC diver records the number, size (TL, to nearest cm), and species of all fishes present or passing through the cylinder in the course of the survey. SPC surveys consists of 2 components: (i) a 5 minute species listing component –the aim of which is to build a list of species present or passing through the cylinder; and (ii) an enumeration component, in which each diver records the number and sizes of fishes of those listed species in a series of instantaneous visual sweeps of their cylinder. SPC Survey sites are randomly located with specified habitat strata encompassing all 0-30m hard-bottom areas at each surveyed reef-with specific positions generated prior to each cruise using a randomization tool and CREP’s GIS habitat and bathymetric layers. As described above, no permanent site markers are needed because survey locations are re-randomized each time.

4.2 Towed-diver Survey: Shallow water habitats around each island, bank, or reef are surveyed using pairs of divers towed 60 meters behind a 19’ SAFE Boat survey launch. In each towed-diver buddy team, one diver is tasked with quantifying the benthos while the other quantifies fish populations. Each towed-diver survey lasts 50 minutes, broken into 10 five-minute segments, and covers approximately 2 km. A GPS track of the survey launch track is recorded at five-second intervals using a Garmin GPS76Map GPS unit. A custom algorithm is used to calculate the track of the divers based on the track, speed, and course of the boat and depth of the diver. Each tow board is equipped with a precision temperature and depth recorder (Seabird SBE39) that takes recordings at five-second intervals.

At the end of each day, data are downloaded, processed and presented in ArcGIS and can be displayed in conjunction with IKONOS satellite imagery, NOAA chart data and/or other spatial data layers. The fish tow board is equipped with a forward-looking digital video camera, which creates a visual archive of the survey track and can be used to evaluate stochastic changes in the reef environment, particularly following episodic events such as coral bleaching and vessel grounding. The diver on the fish tow board records (to the lowest possible taxon) all fish greater than 50 cm total length (TL) along a 10-m swath in each time segment. Fish are recorded in terms of species and length in centimeters. Species of particular concern observed outside the survey swath are classified as presence/absence data and are recorded separately from the quantitative swath data.

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:

1. Ocean and Climate Change Monitoring
 - 1.1 Subsurface Temperature Recorder (STR) - NA
 - 1.2 Wave and Tide Recorder (WTR) - NA
 - 1.3 Portable Underwater Collector (PUC)
Water samples are not done to collect biota, but may incidentally collect various microscopic phyto- and zooplankton.
 - 1.4 Water Samples:
Water samples are not done to collect biota, but may incidentally collect various microscopic phyto- and zooplankton.
 - 1.5 Calcification Accretion Units (CAUs):
These plates act as settling substrate for various fouling organisms, including stony corals, crustose coralline algae and macroalgae, other misc. sessile benthic organisms.
 - 1.6 Bioerosion Monitoring Unit (BMU):
These blocks act as settling substrate for various bioeroding organisms, including crustaceans, mollusks, and marine worms.
 - 1.7 Coral Cores:
Mound & Lobe coral
 - 1.8 Coral and *Symbiodinium* functional genomics:
Rice coral, lobe coral
 - 1.9 Photomosaics - NA
2. Benthic monitoring
 - 2.1 Reef Benthos
 - 2.1.1 Towed-Diver Surveys - NA
 - 2.1.2 Coral Demographics Surveys - NA
 - 2.1.3 Coral Health and Disease Studies:

Gross Morphology	Common Name
Tissue loss	Lobe coral
	Mound coral
	Antler coral
	Rice coral
	Cauliflower coral
	Finger coral

- | | |
|---------------------------|-------------|
| Tissue necrosis | Lobe coral |
| | Mound coral |
| | Rice coral |
| Pigmentation response | Lobe coral |
| Skeletal growth anomalies | Lobe coral |
| | Mound coral |
| | Rice coral |
- 2.1.4 Coral Taxonomic Verification:
 - Various stony corals
 - 2.2 Genetic Connectivity of *Pocillopora meandrina*:
 - Cauliflower coral
 - 3. Non-coral Invertebrates
 - 3.1 Microbial Communities
 - 3.1.1 Water Samples:
 - Microplankton, bacteria and viruses
 - 3.1.2 Benthic Grabs:
 - Microplankton, bacteria and viruses
 - 3.1.3 Macroalgal Samples:
 - Algae/Limu
 - 3.1.4 Coral-associated Microbial Samples
 - Mound/lobe coral
 - 3.1.5 Coral geometry - NA
 - 3.2 Autonomous Reef Monitoring Structures (ARMS):
 - Sponges, anemones and hydroids, marine worms, snails, sea slugs, mussels and clams, octopi, barnacles, crustaceans, bryozoans, starfish, sea cucumbers, brittle stars, feather stars, sea squirts
 - 3.3 Population Structure and Connectivity of Crown-of-Thorns Sea stars:
 - Crown-of-thorns seastars
 - 3.4 Phylogeography of *Palythoa tuberculosa*:
 - Blue-grey zoanthid
 - 3.5 Plankton Samples:
 - Identification of larval forms is currently not practicable, but samples will likely include a diverse range of plankton and larval reef organisms
 - 4. Reef Fish Monitoring
 - 4.1 Stationary Point Counts (SPC) - NA
 - 4.2 Towed-diver Survey - NA

Scientific name:

- 1. Ocean and Climate Change Monitoring
 - 1.1 Subsurface Temperature Recorder (STR) - NA

- 1.2 Wave-and-tide Recorder (WTR) - NA
- 1.3 Portable Underwater Collector (PUC):
 Water samples are not done to collect biota, but incidentally collect various microscopic phyto- and zooplankton. Identification of these organisms is not practicable, but may include microscopic organisms from groups such as Bacteria, Crustacea, Mollusca, Protista and Dinoflagellata.
- 1.4 Water Samples:
 Water samples are not done to collect biota, but incidentally collect various microscopic phyto- and zooplankton. Identification of these organisms is not practicable, but may include microscopic organisms from groups such as Bacteria, Crustacea, Mollusca, Protista and Dinoflagellata.
- 1.5 Calcification Accretion Units (CAUs):
 These plates act as settling substrate for various fouling organisms, including miscellaneous Scleractinia, Rhodophyta, Chlorophyta, Crustacea, Mollusca, Phaeophyceae.
- 1.6 Bioerosion Monitoring Unit (BMU):
 These blocks act as settling substrate for various microscopic bioeroding organisms including Crustacea, Mollusca, Polychaeta.
- 1.7 Coral Cores:
Porites lobata, *P. lutea*
- 1.8 Coral and *Symbiodinium* functional genomics:
Monipora capitata, *Porites lobata*
- 1.9 Photomosaics - NA
- 2. Benthic monitoring
 - 2.1 Reef Benthos
 - 2.1.1 Towed-Diver Surveys - NA
 - 2.1.2 Coral Demographics Surveys - NA
 - 2.1.3 Coral Health and Disease Studies

Gross Morphology	Common Name	Taxon
Tissue loss	Lobe coral	<i>Porites lobata</i>
	Mound coral	<i>Porites lutea</i>
	Antler coral	<i>Pocillopora eydouxi</i>
	Rice coral	<i>Monipora</i> spp.
	Cauliflower coral	<i>Pocillopora meandrina</i>
	Finger coral	<i>Porites compressa</i>
Tissue necrosis	Lobe coral	<i>Porites lobata</i>
	Mound coral	<i>Porites lutea</i>
	Rice coral	<i>Monipora</i> spp.
Pigmentation response	Lobe coral	<i>Porites lobata</i>

Skeletal growth anomalies	Lobe coral	<i>Porites lobata</i>
	Mound coral	<i>Porites lutea</i>
	Rice coral	<i>Monipora</i> spp.

- 2.1.4 Coral Taxonomic Verification:
 - Various Scleractinia
- 2.2 Genetic Connectivity of *Pocillopora meandrina*:
 - Pocillopora meandrina*
- 3. Non-coral Invertebrates
 - 3.1 Microbial Communities
 - 3.1.1 Water Samples:
 - Identification of these organisms is not practicable, but may include microscopic organisms from groups such as Bacteria, Crustacea, Mollusca, Protista and Dinoflagellata, viruses
 - 3.1.2 Benthic Grabs:
 - Identification of these organisms is not practicable, but may include microscopic organisms from groups such as Bacteria, Crustacea, Mollusca, Protista and Dinoflagellata, viruses
 - 3.1.3 Macroalgal Samples
 - Rhodophyta, Chlorophyta, Phaeophyceae
 - 3.1.4 Coral-associated Microbial Samples
 - Porites lutea/Porites lobata*
 - 3.1.5 Coral geometry - NA
 - 3.2 Autonomous Reef Monitoring Structures (ARMS):
 - Specimens from the following Phyla have been found on ARMS units:
 - Phylum Porifera (Sponges)
 - Phylum Cnidaria (Anemones, hydroids)
 - Phylum Annelida (Marine worms)
 - Phylum Mollusca (Snails, sea slugs, mussels, clams, octopi)
 - Phylum Arthropoda (Barnacles, other crustaceans)
 - Phylum Echinodermata (Starfish, sea cucumbers, brittle stars, feather stars)
 - Phylum Bryozoa (Bryozoans)
 - Phylum Chordata (Sea squirts)
 - 3.3 Population Structure and Connectivity of Crown-of-Thorns Sea stars:
 - Acanthaster planci*
 - 3.4 Phylogeography of *Palythoa tuberculosa*:
 - Palythoa tuberculosa*
 - 3.5 Plankton Samples:
 - Identification of larval forms is currently not practicable, but may include microscopic organisms from groups such as Bacteria, Crustacea, Mollusca, Protista, Teleostei, Cnidaria and Dinoflagellata.

- 4. Reef Fish Monitoring – No collections
- 4.1 Stationary Point Counts (SPC) - NA
- 4.2 Towed-diver Survey - NA

& size of specimens:

- 1. Ocean and Climate Change Monitoring
 - 1.1 Subsurface Temperature Recorder (STR) - NA
 - 1.2 Wave-and-tide Recorder (WTR) - NA
 - 1.3 Portable Underwater Collector (PUC):
Water samples are not done to collect biota, but incidentally collect various microscopic phyto- and zooplankton. Organisms would be micro- and nanoscopic, so it is not possible to estimate numbers.
 - 1.4 Water Samples:
Water samples are not done to collect biota, but incidentally collect various microscopic phyto- and zooplankton. Organisms would be micro- and nanoscopic, so it is not possible to estimate numbers.
 - 1.5 Calcification Accretion Units (CAUs):
Organisms settle haphazardly, so it is not possible to predict numbers accurately. Sessile organisms are generally five centimeters across or less.
 - 1.6 Bioerosion Monitoring Unit (BMU):
Organisms settle haphazardly, so it is not possible to predict numbers accurately. Sessile organisms are generally five centimeters across or less.
 - 1.7 Coral Cores:
Sampling will be opportunistic, and will only occur if time permits. A maximum of 30 samples, 1 cm in diameter and 5–70 cm in length, are requested. One REA site will be chosen for coring at each island or reef system when the RAMP schedule allows for this opportunistic collection. A minimum of 1 core and maximum of 3 cores will be collected within a close proximity (5–10 m) to each other at each sampling location.
 - 1.8 Coral and *Symbiodinium* functional genomics:
We are requesting permit to collect a maximum of 12 biopsies representing each of 2 different coral taxa (*Monipora capitata* and *Porites lobata*) at 16 different Climate sites in the PMNM, as follows: French Frigate Shoals, 4 stations; Lisianski, 4 stations; Pearl and Hermes, 4; and Kure, 4 sites. In the field, after gathering the appropriate specimen sample metadata a 2 × 2 cm diameter biopsy sample will be collected using sterile sampling gear and stored in a cool, dark container for transport to the ship. This equates to 192 samples for each species.
 - 1.9 Photomosaics - NA
- 2. Benthic monitoring
 - 2.1 Reef Benthos
 - 2.1.1 Towed-Diver Surveys - NA

2.1.2 Coral Demographics Surveys - NA

2.1.3 Coral Health and Disease Studies:

Gross Morphology	Taxon	Quantity	Size
Tissue loss	<i>Porites lobata</i>	20	7 cm
	<i>Porites lutea</i>	20	7 cm
	<i>Pocillopora eydouxi</i>	10	7 cm
	<i>Monipora</i> spp.	20	7 cm
	<i>Pocillopora meandrina</i>	10	7 cm
	<i>Porites compressa</i>	10	7 cm
Tissue necrosis	<i>Porites lobata</i>	20	7 cm
	<i>Porites lutea</i>	20	7 cm
	<i>Monipora</i> spp.	10	7 cm
Pigmentation response	<i>Porites lobata</i>	10	7 cm
Skeletal growth anomalies	<i>Porites lobata</i>	20	7 cm
	<i>Porites lutea</i>	20	7 cm
	<i>Monipora</i> spp.	10	7 cm
Total		140	7 cm

2.1.4 Coral Taxonomic Verification:

Samples will be no more than 7 cm maximum diameter (or length for branching species). No more than 2 type specimens will be collected for each suspected new coral species or new record.

2.2 Genetic Connectivity of *Pocillopora meandrina*:

We request permit to collect a maximum of 10 clippings per site at a maximum of 8 sites. Because this is a study for genetic connectivity, each clipping will be collected from a different colony.

3. Non-coral Invertebrates

3.1 Microbial Communities

3.1.1 Water Samples:

Organisms are distributed haphazardly, so it is not possible to predict numbers accurately. Organisms are generally millimeters to less than a micrometer in size.

3.1.2 Benthic Grabs:

Organisms are distributed haphazardly, so it is not possible to predict number of organisms accurately. Organisms are generally millimeters to less than a micrometer in size.

3.1.3 Macroalgal Samples:

We expect to collect a maximum of 40 macroalgal samples. Collections are not the emphasis on this cruise and will therefore be occurring opportunistically by divers during their surveys. Samples will generally be a few centimeters of algae, along with associated microorganisms.

3.1.4 Coral-associated Microbial Samples

Twenty four colonies total will be sampled in the Monument: At each island three large *Porites* colonies interacting with turf algae and three large colonies interacting with coralline crustose algae (CCA) will be sampled. An underwater drill with diamond-tip drill bits will be used to minimize damage when extracting six coral biopsies (1 cm in diameter), three interaction biopsies, and six turf/CCA biopsies per colony.

3.1.5 Coral geometry – NA

3.2 Autonomous Reef Monitoring Structures (ARMS):

The number and size of organisms collected off the ARMS units is dependent upon random recruitment and colonization. Therefore, it is not possible to know or predict this information reliably. Due to the geometry of the ARMS, however, even the largest organisms associated with them are small, on the order of centimeters or less.

3.3 Population Structure and Connectivity of Crown-of-Thorns Sea stars:

Only encountered COTS outbreak populations will be sampled for population connectivity work. We are requesting permit to collect up to 50 COTS arms per outbreak event, with an estimated maximum of approximately 200 arms in total. The portion of the arm collected is generally between 5-10 cm in length.

3.4 Phylogeography of *Palythoa tuberculosa*:

Using a knife, divers will remove a dime size piece of tissue from each collected colony of *P. tuberculosa* with the tissue place in individual whirl paks. Collections are not the emphasis on this cruise and will therefore be occurring opportunistically by divers during their surveys. We are requesting permit to collect a maximum of 10 samples per site at a maximum of 20 sites (for a maximum of 200 samples).

3.5 Plankton Samples:

Planktonic organisms are distributed haphazardly, so it is not possible to reliably predict the number and size that will be collected. However, the size of organisms is constrained by the collecting apparatus, which is 50 cm diameter with an 80 µm mesh size having a 1L cod end jar. Most organisms will be small planktonic forms that cannot evade the net, on the order of several centimeters or less.

4. Reef Fish Monitoring – No collections

4.1 Stationary Point Counts (SPC) - NA

4.2 Towed-diver Survey - NA

Collection location:

Generally speaking, all RAMP activities will be conducted between 0-30m depth around French Frigate Shoals, Kure Atoll, Lisianski Island and Pearl and Hermes Atoll. Collections conducted as part of Ocean and Climate Change Monitoring will occur at locations indicated below. Other collections will occur at REA site locations. The locations of REA surveys have not yet been determined, so exact positions will be provided in our compliance letter. If an opportunistic

collection were to occur outside of these areas, the position will be noted and submitted within cruise reporting.

Island	Latitude (N)	Longitude (W)
French Frigate Shoals	23.63498	166.18559
French Frigate Shoals	23.63686	166.18500
French Frigate Shoals	23.76887	166.26197
French Frigate Shoals	23.79247	166.25400
French Frigate Shoals	23.83515	166.11700
French Frigate Shoals	23.85626	166.27519
French Frigate Shoals	23.87806	166.29100
French Frigate Shoals	23.88021	166.27700
Kure Atoll	28.37653	178.37700
Kure Atoll	28.38172	178.32572
Kure Atoll	28.38506	178.34100
Kure Atoll	28.39067	178.28269
Kure Atoll	28.40908	178.37800
Kure Atoll	28.41822	178.34322
Kure Atoll	28.43037	178.28500
Kure Atoll	28.45152	178.35621
Kure Atoll	28.45290	178.34700
Lisianski Island	25.93497	173.89100
Lisianski Island	25.93831	173.95400
Lisianski Island	25.96762	173.91587
Lisianski Island	25.98702	173.99400
Lisianski Island	26.03741	173.87900
Lisianski Island	26.07842	173.99700
Lisianski Island	26.10010	173.99799
Lisianski Island	26.10017	173.99797
Pearl and Hermes Atoll	27.78168	175.88088
Pearl and Hermes Atoll	27.78212	175.88143
Pearl and Hermes Atoll	27.78237	175.88200
Pearl and Hermes Atoll	27.79097	175.86299
Pearl and Hermes Atoll	27.79316	175.99700
Pearl and Hermes Atoll	27.85393	175.81588
Pearl and Hermes Atoll	27.86679	175.73400
Pearl and Hermes Atoll	27.94055	175.86200
Pearl and Hermes Atoll	27.94057	175.86171
Pearl and Hermes Atoll	27.95493	175.83600

Whole Organism Partial Organism

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

1. Ocean and Climate Change Monitoring
 - 1.1 Subsurface Temperature Recorder (STR) - NA
 - 1.2 Wave-and-tide Recorder (WTR) - NA
 - 1.3 Portable Underwater Collector (PUC) - NA
 - 1.4 Water Samples:

Water samples are brought back aboard the ship for initial processing and stored for transport. Upon arrival to Honolulu all samples are sent to analytical facilities for further analysis. CAUs and BMUs are brought back aboard the ship, individually stored in plastic bags, and frozen. Upon arrival to Honolulu all samples are sent to analytical facilities for further analysis.
 - 1.5 Calcification Accretion Units (CAUs):

CAUs are photographed in the laboratory in Honolulu for community composition analysis and are dried and weighed to determine net calcification and productivity. Only organisms that have settled on the CAU are removed. No other impacts to the surrounding environment or substrate occur during removal.
 - 1.6 Bioerosion Monitoring Unit (BMU):

Upon arrival to Honolulu all samples are sent to analytical facilities for further analysis. Retrieved blocks will be re-scanned by microCT and sampled for bioeroding organisms. Pre and post scans will be used to estimate bioerosion rates of the calcium carbonate reef framework. Bioerosion community composition will be measured using the ReefChip microarray.
 - 1.7 Coral Cores:

Coral cores will be processed, scanned, and stored at Anne Cohen's Laboratory at Woods Hole Oceanographic Institute.
 - 1.8 Coral and *Symbiodinium* functional genomics:

Samples will be preserved in 95% ethanol or DMSO and stored at the Coral Reef Ecosystem Programs laboratory at IRC, or at Rob Toonen's laboratory in the HIMB.
 - 1.9 Photomosaics - NA
2. Benthic monitoring
 - 2.1 Reef Benthos
 - 2.1.1 Towed-Diver Surveys - NA
 - 2.1.2 Coral Demographics Surveys - NA
 - 2.1.3 Coral Health and Disease Studies:

Subsequent preparation of coral tissue samples will take place in Honolulu for histological processing post cruise. In collaboration with scientists at Nova Southeastern University, histopathological sample processing will be conducted. This process involves embedding tissues in paraffin to allow for sectioning with a microtome and producing

histological slides. Tissue samples and paraffin blocks will be accessioned at in an appropriate institution (e.g., NOAA IRC; Bishop Museum, Honolulu).

2.1.4 Coral Taxonomic Verification:

After microscopic analyses, specimens will be stored at the NOAA IRC facility if space is available. Alternatively, samples will be stored at another appropriate institution (e.g., Bishop Museum, Honolulu).

2.2 Genetic Connectivity of *Pocillopora meandrina*:

All laboratory processing and analyses will take place at the HIMB. Part of the samples will be destroyed when processed. The part that is not destroyed will be stored in the Rob Toonen laboratory at the HIMB in our sample collection room. The persons who will serve as the responsible point of contact are, Erika Johnston (336) 7073717, and Rob Toonen (808) 2823820.

3. Non-coral Invertebrates

3.1 Microbial Communities:

Water samples will be filtered and processed aboard the ship. Much of the microbial samples will be used up during the molecular analyses. Benthic grabs and macroalgal samples will be frozen and transported back to Forest Rohwer's laboratory at San Diego State University for processing and analysis. For coral sampling, methods are congruent with sampling techniques in Caribbean and Line Islands (da Silva et al. 2015). One set of samples from each coral will be preserved in RNA later for metatranscriptomic analysis, another set will be preserved in methanol for metabolomic analysis, and the last set will be flash frozen in liquid nitrogen for metagenomic analysis. Any remaining samples will be stored at the Forest Rohwer laboratory at San Diego State University (619-594-1336).

3.2 Autonomous Reef Monitoring Structures (ARMS):

Collections for biodiversity assessments from the ARMS may be sent to the Smithsonian, Florida Museum of Natural History L.A. County Museum, University of Hawaii at Hilo, San Diego State, Moss Landing Marine Laboratories, Scripps Oceanographic Institute, and/or HIMB for analysis. The number and types of specimens sent to each of these institutions will vary pending on what recruits to the ARMS platforms. Identification of these specimens will involve the use of molecular and taxonomic practices. All specimens will be either frozen or preserved in ethanol.

3.3 Population Structure and Connectivity of Crown-of-Thorns Sea stars:

Pending funding, DNA from collected tube feet will be extracted, amplified, and sequenced at HIMB. Unused tube feet will either be destroyed or stored within a preservative depending on available long-term storage space. If space is available to store the samples, they will be held within the NOAA IRC building and available upon request for future investigations into the genetic composition on these corallivorous sea stars.

3.4 Phylogeography of *Palythoa tuberculosa*:

All laboratory processing and analyses will take place at the HIMB. Part of the samples will be destroyed when processed. The part that is not destroyed will be stored in the Rob

Toonen laboratory at the HIMB in our sample collection room. The persons who will serve as the responsible point of contact are: Ale'alani Dudoit (al.dudoit@hawaii.edu) or Robert Toonen (rjtoonen@gmail.com) for access to samples. Samples will be stored at HIMB ToBo lab collection facility. Samples need to contain tissue, which will be preserved. Samples will need to be preserved in DMSO, dimethyl sulfoxide, which is a non-toxic, non-flammable preservative.

3.5 Plankton Samples:

Preserved samples will be accessioned and stored at the Florida Museum of Natural History.

4. Reef Fish Monitoring – No collections

4.1 Stationary Point Counts (SPC) - NA

4.2 Towed-diver Survey - NA

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

• General site/location for collections:

Generally speaking, all RAMP activities will be conducted between 0-30m depth around French Frigate Shoals, Kure Atoll, Lisianski Island and Pearl and Hermes Atoll. Collections conducted as part of Ocean and Climate Change Monitoring will occur at locations indicated previously (see section 9b, Collection locations). Other collections will occur at REA site locations. The locations of REA surveys have not yet been determined, so exact positions will be provided in our compliance letter. If an opportunistic collection were to occur outside of these areas, the position will be noted and submitted within cruise reporting.

• Is it an open or closed system? Open Closed

Collected ARMS units will be placed in a closed system on the ship for same day processing. If scientists are unable to process all the units in the same day, the encapsulated unit will be placed in a small make-shift magnum bin. This bin accepts seawater from the shipboard system and releases seawater off the stern. Only seawater is released from the magnum bin because all the ARMS units are encapsulated within a crate, lined with a 100 µm mesh layer. The water circulation is needed to ensure that the organisms trapped within the ARMS unit are alive until processed. All organisms within the unit are preserved in either 95% ethanol or DMSO when processed.

• Is there an outfall? Yes No

Collected ARMS units will be placed in a closed system on the ship for same day processing. If scientists are unable to process all the units in the same day, the encapsulated unit will be placed in a small make-shift magnum bin. This bin accepts seawater from the shipboard system and releases seawater off the stern. Only seawater is released from the magnum bin because all the ARMS units are encapsulated within a crate, lined with a 100 µm mesh layer. Having this

circulation will ensure that the organisms trapped within the ARMS unit are alive until the ARMS are processed which will occur in a closed system the following day.

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

No

- Will organisms be released?

No

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

1. Ocean and Climate Change Monitoring

Oceanographic Water Samples: All samples are either frozen or made stable using a fixing agent upon returning to the ship, stored in dedicated containers, and offloaded upon arrival to Honolulu.

2. Benthic Monitoring

Corals and Coral Disease: In the ship's wet lab, coral tissue samples for histological studies will be fixed in zinc-formalin (Z-fix® Anatech Ltd) for 18–24 hours in plastic capped containers, and subsequently transferred to 70% ethanol. Samples will be stored in 70% ethanol in capped containers and transported to Honolulu. Waste product (i.e., formaldehyde fixing solution) will be stored for appropriate chemical disposal in Honolulu.

3. Non-coral invertebrates

Samples will be preserved in 95% ethanol, salt saturated dimethyl sulfide (DMSO) or 'RNA-later' while on-board the ship, and subsequently transported back to Honolulu.

4. Reef Fish Monitoring – NA

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

CREP collaborates with multiple agencies to minimize duplication and provides data to researchers and institutions interested in mutually beneficial collaboration. All attempts are made to incorporate these agencies and institutions in the research cruises and analysis of data.

1. Ocean and Climate Change Monitoring

The shallow water EARs (<30m) being removed by CREP are part of a partnership with Whitlow Au who also has deployed deep water EARs (>30m). The EAR lead at PIFSC, Pollyanna Fisher-Poole, also works with Whitlow Au. The list of personnel diving to remove the

EARs will be submitted with our Compliance Form. Servicing of EARs takes place in Honolulu. Coral samples for connectivity, phylogeography, and functional genomics will be processed in collaboration with Rob Toonen at HIMB.

2. Benthic Monitoring

Data will be available in the cruise report which will be finished in a timely fashion after the conclusion of the cruise. Coral tissue samples will be sent out for histological processing, which will be conducted in collaboration with scientist Allison Moulding at Nova Southeastern University. Histological slides will be read and evaluated here in Honolulu, and later deposited in an appropriate institution. Coral samples for connectivity, phylogeography, and functional genomics will be processed in collaboration with Rob Toonen at HIMB. Selected results from previous coral surveys conducted through CREP in the Hawaiian archipelago have been presented as conference posters, oral presentations, national-level reports, and publications in refereed journals. It is similarly anticipated that important results stemming from research conducted under the requested permit will be professionally disseminated within the national and international scientific community.

3. Non-coral invertebrates

Non-coral invertebrate samples from the ARMS units will be deposited at Bishop Museum, Smithsonian, Florida Natural History Museum, CREP, L.A. County Museum, University of Hawai'i at Hilo, San Diego State, Moss Landing Marine Laboratories, Scripps Oceanographic Institute, and/or HIMB for molecular processing and/or taxonomic identification. Benthic and algal grabs for microbial analysis will be processed in collaboration with Forest Rohwer at San Diego State University. Plankton samples will be processed in collaboration with Florida Museum of Natural History. *P. tuberculosis* and *A. planci* samples will be processed in collaboration with HIMB.

4. Reef Fish Monitoring - NA

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

1. Ocean and Climate Change Monitoring:

Lift bags, air tanks with nozzles, lines and clips, zip ties, cameras with underwater housings, wrenches, screw drivers, pneumatic drill, SCUBA tank, the various oceanographic arrays, CTD units and water sampling gear such as Niskin bottles mentioned in the Methods section. Transect lines, underwater clipboard, underwater paper, pencils, PVC photoquadrat, Ziploc bags, cooler.

Photomosaics: two SLR Nikon D7000 cameras, a single GoPro video camera mounted to a custom frame, lasers to provide approximate scale in the high resolution imagery.

2. Benthic Monitoring:

Transect lines, underwater clipboards, underwater paper, pencils, shears, sledgehammer and chisel, zipties, cooler, 2.5 gal buckets, dive bag, 50 ml test tubes, whirlpaks and cameras with underwater housings, towboard.

3. Non-coral Invertebrates:

Transect lines, underwater clipboard, underwater paper, pencils, shears, ARMS units, ARMS recovery crates, sledgehammer, zip ties, eye bolts, underwater epoxy, 5 gal buckets, buoy lines, lift bags, dive bag, knives, 50 ml test tubes, whirlpaks and cameras with underwater housings.

4. Reef Fish Monitoring:

Transect lines, underwater clipboard, underwater paper, pencils and cameras with underwater housings, tow-board.

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

The CREP uses very limited chemicals in the field while in the Monument. The majority of chemicals listed remain in the designated Hazmat lockers aboard the support vessel. The CREP Hazmat list contains all compounds from minor solutions like vinegar to the more caustic ones listed below. MSDS pdf will be included in a zipped file when the permit is submitted

- 10,000X SYBR Gold nucleic acid gel stain (Used by the microbiologist to stain water sampling filters to allow counting of microbes and viruses.)
- Chloroform (Used by the microbiologist to purify genetic samples.)
- Clorox Bleach (Used for the cleaning of gear and instruments.)
- DAPI (4',6-diamidino-2-phenylindole) (Used by the microbiologist to for staining of filters, facilitating cell size measurement.)
- DMSO (Dimethyl sulfoxide, a non-toxic, non-flammable preservative for samples)
- Dynamic Descaler (clean ARMS plates)
- Ethanol (Used for the preservation of various samples.)
- Methanol (Used to preserve metabolomic samples)
- Formalin (10%) (Used for the preservation of various samples.)
- Gasoline (fuel for CREP small boats)
- Glutaraldehyde (Used by the microbiologist to halt biological activity in water samples as part of the flow cytometry process.)
- Hydrochloric acid (HCl) (33-40%) (Used by the microbiologist to remove dissolved inorganic carbon from water samples.)
- Liquid Nitrogen (Used by the microbiologist to freeze flow cytometry samples.)
- Mercuric Chloride Solution (A small amount, typically micro liters per sample, is used to halt biological activity in water samples. This is necessary for accurate analysis of

dissolved inorganic carbon. The mercuric chloride solution is added to the water sample bottle after the sample is collected. The sample bottle is secured and brought back to port for later laboratory analysis. The mercuric chloride solution is not introduced into Monument waters.)

- Mictomycin (Added to viral samples)
- Paraformaldehyde (32%) (Used by the microbiologist to halt biological activity in water samples)
- PoolLife XtraBlue Shock (to sanitize dive gear and survey equipment)
- RNA-later (For sample preservation)
- Scotchcast (Flame retardant)
- Sodium Hydroxide (used by microbiologist to clean filters)
- Aquamend underwater epoxy - used for coral cores/biopsies, refurbishing ARM/CAU sites
- TCBS agar plate (a type of selective agar culture plate that is used in microbiology laboratories to isolate *Vibrio* spp.)
- Weld-on PVC glue (equipment repair)
- Z-Fix Concentrate (Used for the fixation of various coral samples.)

All MSDS can be provided if needed in hard copy form, but will be included when the permit application is submitted electronically to save paper and trees.

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

1. Ocean and Climate Change:

Long-term datasets from in situ oceanographic instruments inform our understanding how the physical environment affects the dynamics of biological components of coral reef ecosystems.

Maintenance and Longevity:

In situ instrument deployments are maintained or swapped every three years to build long time-series of data at deployment sites.

Techniques:

- SST Removal: After the instrument is recovered, the anchor to which the instrument was moored will be removed by divers utilizing lift bags.
- EAR retrieval: The EAR retrievals will involve lowering a new anchor with the instrumentation in place and recovering the old anchor and instrument. A lift bag will be used to slowly lower and raise the system and the new anchor will be set in the same spot as the old. Alternatively, if the existing anchor is in good shape, the existing anchor will be left in place and only the instrument will be changed-out.
- CAU/BMU Replacement: Up to 5 sites at each island/atoll visited will be selected for CAU installation. Each CAU site will consist of 5 deployed CAU units. One BMU will

be attached to each CAU stake, when BMUs are deployed. BMUs will only be deployed on a subset of CAU sites, up to a maximum of 50 BMUs in the Monument.

- STR Replacement: STRs are replaced by divers carrying a new instrument and anchor(4 lbs) to the existing STR site where the old STR, anchor and mooring ties are recovered. The new STR is then installed with mooring ties.

2. Benthic communities (focused on hard coral)

N/A.

3. Non-coral Invertebrates:

During the 2013 RAMP excursion, permanent climate stations were established for long-term monitoring of the biological, physical and chemical processes expected to respond to ocean acidification in coral reef ecosystems. ARMS from these permanent sites will be recovered and redeployed. No new sites will be established unless wave energy or another unforeseen environmental impact has naturally removed a station.

4. Reef Associated Fish Communities

NA

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

A Hawaiian Archipelago cruise report containing data collected in the field will be completed and submitted to the Monument within 6 months from the completion of the cruise. The Monument cruise completion report will also be completed and submitted according to Monument guidelines and requirements.

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

1. Ocean and Climate Change

Brainard, R.E., et al. 2007. Coral Reef Ecosystem Monitoring Report for American Samoa: 2002-2006. NOAA-PIFSC, Honolulu.

Vargas-Angel, B, CL Richards, PS Vroom, NN Price, T Schils, CW Young, M Johnson, RE Brainard (in review, *PLoS One*). Baseline assessment of net calcium carbonate deposition rates for U.S. Pacific reefs.

Busch, DS, R Griffis, J Link, K Abrams, J Baker, R Brainard, M Ford, J Hare, A Himes-Cornell, A Hallowed, K Osgood, N Mantua, S McClatchie, M McClure, M Nelson, M Rust, V Saba, M

Sigler, S Sykora-Bodie, C Toole, E Thunberg, R Waples (In review, *Marine Policy*). Climate science strategy for the US National Marine Fisheries Service.

Alin, S, R Brainard, N Price, J Newton, A Cohen, J Hare, WT Peterson, EH DeCarlo, E Shadwick, S Noakes (in press, *Oceanography*). Characterizing the natural system: toward sustained, integrated coastal ocean health observing systems to facilitate resource management and decision support.

Heenan, A., R Pomeroy, J Bell, P Munday, W Cheung, C Logan, R Brainard, AY Amri, P Alino, N Armada, L David, R Guieb, S Green, J Jompa, T Leonardo, S Mamauag, B Parker, J Shackeroff, Z Yasin (in press, *Ocean and Coastal Management*). A climate-informed, ecosystem-based approach to fisheries management.

DeCarlo TM, Cohen AL, Barkley HC, Cobban Q, Young C, Shamberger KE, Brainard RE, Golbuu Y (2015) Coral macrobioerosion is accelerated by ocean acidification and nutrients. *Geology* 43 (1): 7-10, doi: 10.1130/G36147.1

Manzello DP, Enochs IC, Bruckner A, Renaud P, Kolodziej G, Budd D, Carlton R, Glynn PW (2014) Galápagos Coral Reef Persistence after ENSO Warming Across an Acidification Gradient. *Geophysical Research Letters* 41 (24): 9001-9008, doi: 10.1002/2014GL062501

Birkeland C, MW Miller, GA Piniak, CM Eakin, M Weijerman, P McElhany, M Dunlap, RE Brainard (2013). Safety in numbers? Abundance may not safeguard corals from increasing carbon dioxide. *BioScience*, Vol. 63, No. 11.

2. Benthic communities (focused on hard coral)

Aeby, G. S. 2006. Baseline levels of coral disease in the Northwestern Hawaiian Islands. *Atoll Res. Bull.* 534: 471–488.

Ben-Haim, Y., F.L. Thompson, C.C. Thompson, M.C. Cnockaert, B. Hoste, J. Swings, and E. Rosenberg. 2003. *Vibrio coralliilyticus* sp. nov., a temperature dependent pathogen of the coral *Pocillopora damicornis*. *Int. J of Syst. & Evol. Microbio* 53: 309–315.

Bythell J, O. Pantos, L. Richardson. 2004. White plague, white band, and other “white diseases”. Pages 351–365 In: Rosenberg E, Loya Y (eds) *Coral Health and Disease*, Springer-Verlag, Berlin, 488 p.

Golbuu, Y., A. Barman, J. Kuartei, and S. Victor. 2005. The state of the coral reef ecosystems of Palau. Pages 488–507 in J. Waddell, ed. *The state of the coral reef ecosystems of the United States and Pacific Freely Associated States: 2005*. NOAA Technical Memorandum NOS

NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MS, 552pp.

Harvell, C. D., R. Aronson, N. Baron, J. Connell, A. Dobson, S. Ellner, L. Gerber, K. Kim, A. Kuris, H. McCallum, K. Lafferty, B. McKay, J. Porter, M. Pascual, G. Smith, K. Sutherland, and J. Ward. 2004. The rising tide of ocean diseases: unsolved problems and research priorities. *Front. Ecol. Environ.* 2:375–382.

Kaczmarzky, L. T. 2006. Coral disease dynamics in the central Philippines. *Dis. Aquat. Org.* 69:9–21.

Leray, M & Knowlton, N. (2015) DNA barcoding and metabarcoding of standardized samples reveal patterns of marine benthic diversity. *Proceedings of the National Academy of Sciences*, 112(7), 2076-2081.

Loya, Y. 2004. The coral reefs of Eilat– past, present and future: three decades of coral community structure studies. Pages 1–34 in E. Rosenberg and Y. Loya, eds. *Coral Health and Disease*, Springer-Verlag, Berlin, 488 pp.

Porter, J., P. Dustan, W. Jaap, K. Patterson, V. Kosmynin, O. Meier, M. Patterson, and M. Parsons. 2001. Patterns of spread of coral disease in the Florida Keys. *Hydrobiology* 159: 1-24.

Sutherland, K. P., J. Porter, and C. Torres. 2004. Disease and immunity in the Caribbean and Indo-Pacific zooxanthellate corals. *Marine Ecol. Prog. Ser.* 266:273–302.

Vargas-Ángel, B., E. C. Peters, E. Kramarsky-Winter, D. Gilliam, and D.E. Dodge. 2007. Cellular reactions to sedimentation and temperature stress in the Caribbean coral *Montastraea cavernosa*. *J. Invertebr. Pathol.* 95:140–145.

Vargas-Angel, B., J.C. Kenyon, J. Maragos, and R.E. Brainard. In prep. Ecological assessment of coral diseases in the US Pacific Remote Island Areas.

Weil, E., G. Smith, and D. L. Gil-Agudelo. 2006. Status and progress in coral disease research. *Dis. Aquat. Org* 69: 1–7.

Willis, B. L., C. Page, and E. Dinsdale. 2004. Coral Diseases on the Great Barrier Reef. Pages 69–104 in E. Rosenberg and Y. Loya, eds. *Coral Health and Disease*, Springer-Verlag, Berlin, 488pp.

3. Non-coral Invertebrates:

Asakura, A. and L.S. Godwin. 2005. A new species of hermit crab (Crustacea, Decapoda, Anomura, Diogenidae) of the genus *Dardanus* from the U.S Equatorial Islands. *Zootaxa*. (In prep).

Asakura, A. and L.S. Godwin. 2005. *Diogenes maclaughlinae*, a new species of hermit crab (Crustacea, Decapoda, Anomura, Diogenidae) from American Samoa. *Invertebrate Taxonomy* (In prep).

Brainard, R.E., et al. 2007. Coral Reef Ecosystem Monitoring Report for American Samoa: 2002-2006. NOAA-PIFSC, Honolulu.

Castro, P. and L.S. Godwin. 2005. The first records in the Hawaiian Archipelago for two genus of crab from the family Trapeziidae. *Bishop Museum Occasional Papers* (In press).

DeFelice, R., D. Minton and L.S. Godwin. 2002. Records of the shallow-water marine invertebrates from French Frigate Shoals, Northwestern Hawaiian Islands, with a note on non-indigenous species.

Fisher R, N Knowlton, RE Brainard, MJ Caley (2011) Differences among Major Taxa in the Extent of Ecological Knowledge across Four Major Ecosystems. *PloS ONE* 6(11): e26556-8. doi:10.1371/journal.pone.0026556

Godwin, L.S. 2003. Coral Reef Ecosystem Division Cruise OES-03-06, Northwestern Hawaiian Islands, Marine Invertebrates, Cruise report to NOAA, NMFS, Coral Reef Ecosystem Division.

Godwin, L.S. 2002. Coral Reef Ecosystem Investigation Cruise TC-02-07, Northwestern Hawaiian Islands, Marine Invertebrates, Cruise report to NOAA, NMFS, Coral Reef Ecosystem Investigation.

Godwin, L.S. 2002. Rapid ecological assessment of the marine invertebrate fauna of American Samoa and the U.S. Phoenix and Line Islands. Preliminary report Submitted to the NOAA National Marine Fisheries Service, Honolulu Laboratory, Coral Reef Ecosystem Investigation.

Plaisance L, MJ Caley, RE Brainard, and N Knowlton (2011) The Diversity of Coral Reefs: What are we missing?. *PLoS One* 6(10): e25026. doi:10.1371/journal.pone.0025026

Plaisance L, R Brainard, MJ Caley, N Knowlton. (2011). Using DNA Barcoding and Standardized Sampling to Compare Geographic and Habitat Differentiation of Crustaceans: A Hawaiian Islands Example. *Diversity* 3, no. 4: 581-591.

Timmers MA et al. (2011) Widespread dispersal of the crown-of-thorns sea star, *Acanthaster planci*, across the Hawaiian Archipelago and Johnston Atoll. *Journal of Marine Biology*. Article ID 934269, 10 pages, 2011. doi:10.1155/2011/934269

Timmers MA, Bird CE, Skillings DJ, Smouse PE, Toonen RJ (2012) There's No Place Like Home: Crown-of-Thorns Outbreaks in the Central Pacific Are Regionally Derived and Independent Events. *PLoS ONE* 7(2): e31159. doi:10.1371/journal.pone.0031159

Zimmerman T.L., and J. W. Martin. 2004. Artificial reef matrix structures (ARMS): an inexpensive and effective method for collecting coral reef-associated invertebrates. *Gulf and Caribbean Research* 16:59-64.

4. Reef Associated Fish Communities

Nadon MO, Ault JS, Williams ID, Smith SG, DiNardo GT, 2015, Assessment of Hawaiian coral reef fish populations using a length-based methodology applied to diver survey and fishery data, *PLoS ONE* 10(8):e0133960. doi:10.1371/journal.pone.0133960.

MacNeil MA, Graham NAJ, Cinner JE, Wilson SK, Williams ID, Maina J, Newman S, Friedlander AM, Jupiter S, Polunin NVC, McClanahan TR, 2015, Recovery potential of the world's coral reef fishes, *Nature*. 520:341-344. DOI: 10.1038/nature14358

Williams ID, Baum JK, Heenan A, Hanson KM, Nadon MO, Brainard RE, 2015, Human, Oceanographic and Habitat Drivers of Central and Western Pacific Coral Reef Fish Assemblages. *PLoS ONE* 10(4): e0120516. doi:10.1371/journal.pone.012051

Jouffray J-B, Nyström M, Norström, A, Williams, ID, Wedding L, Kittinger J, Williams G. 2015, Identifying multiple coral reef regimes and their drivers across the Hawaiian Archipelago. *Philosophical Transactions B*, Manuscript ID: RSTB-2013-0268.R1

Edwards CB, Friedlander AM, Green AG, Hardt MJ, Sala E, Sweatman HP, Williams ID, Zgliczynski B, Sandin SA, Smith JE, 2014 Global assessment of the status of coral reef herbivorous fishes: evidence for fishing effects. *Proc. Royal Society B* 281: 20131835.

Heenan A, Williams ID, 2013, Monitoring Herbivorous Fishes as Indicators of Coral Reef Resilience in American Samoa. *PLoS ONE* 8(11): e79604. doi:10.1371/journal.pone.0079604
Zgliczynski BJ, Williams ID, Schroeder RE, Nadon MO, Richards BL, Sandin SA, 2013, The IUCN Red List of Threatened Species: an assessment of coral reef fishes in the US Pacific Islands. *Coral Reefs* 32(3). DOI:10.1007/s00338-013-1018-0.

Richards BL, Williams ID, Vetter OJ, Williams GJ, 2012, "Environmental Factors Affecting Large-Bodied Coral Reef Fish Assemblages in the Mariana Archipelago", PLoS ONE: 10.1371/journal.pone.0031374

Nadon MO, Baum JK, Williams ID, McPherson JM, Brainard RE, 2012, Re-Creating Missing Population Baselines for Pacific Reef Sharks. Conservation Biology. DOI: 10.1111/j.1523-1739.2012.01835.x

Williams ID, Richards BL, Sandin SA, Baum JK, Schroeder RE, Nadon MO, Zgliczynski B, Craig P, McIlwain, JL, Brainard RE, 2011, Differences in reef fish assemblages between populated and unpopulated reefs spanning multiple archipelagos across the central and western Pacific, Journal of Marine Biology, DOI:10.1155/2011/826234.

Mora C, Aburto-Oropeza O, Ayala Bocos A, Ayotte PM, Banks S, .. Williams ID .., et al., 2011, Global Human Footprint on the Linkage between Biodiversity and Ecosystem Functioning in Reef Fishes, PLOS Biology 9(4): e1000606. doi:10.1371/journal.pbio.1000606.

Richards BL, Williams ID, Nadon MO, Zgliczynski BJ, 2010, A towed-diver survey method for mesoscale fishery-independent assessment of large-bodied reef fishes. Bulletin of Marine Science 87(1):55-74. DOI:10.5343/bms.2010.1019.

Schroeder, R.E., A. Green, E.E. DeMartini, J. Kenyon. (2008) Long-term effects of a ship-grounding on coral reef fish assemblages at Rose Atoll, American Samoa.

