NOAA DEEP-SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM THREE-YEAR FIELD RESEARCH PROGRAM SCIENCE PLAN

Pacific Islands Deep-Sea Coral and Sponge Initiative (PICSI)

February 23, 2015

SECTION 1: PROJECT SUMMARY

The EEZ of the U.S Pacific Islands encompasses more than 5.8 million km². The area stretches from the Northwestern Hawaiian Islands (NWHI) in the north, to American Samoa in the south, to the Marianas Archipelago in the west, with many isolated islands and seamounts in between. This area contains more than 70% of the nations’ shallow-water coral reefs, which support a diverse and abundant collection of abundant fishes and invertebrates, many of which are harvested by commercial fishing. The geographic and depth distributions of deep-sea coral and sponge ecosystems are largely unknown even in the densely inhabited main Hawaiian Islands, where since 1981, limited surveys and ecological work have been done in waters shallower than 2000 m, with the majority of surveys conducted between depths of 200-600 m. Most other areas in the U.S. Pacific Islands have yet to be explored in any systematic way. Limited submersible and ROV surveys have been done at Johnston Atoll (35 dives), American Samoa (11 dives), Kingman Reef (5 dives), Palmyra Atoll (4 dives), and Jarvis Island (3 dives). All but 7 of these dives were shallower than 1000 m and none were below 2000 m. To date, the deep-sea coral and sponge fauna off Wake Island, Howland Island, Baker Island and most of the Mariana Trench Marine National Monument have never been surveyed (Wagner in Parrish et al. 2014). For the most part, the diversity and abundance of deep-water coral and sponge communities in US Pacific waters are unknown, as are the environmental conditions that promote the formation and growth of these communities.

Participants of the 2014 Pacific Islands Deep-Sea Coral and Sponge Research and Management Priorities Workshop discussed this dearth of information that is available for deep-water corals and sponges in the U.S. Pacific, and identified a number of fundamental research questions that
need to be answered to provide for effective management of these invaluable yet poorly understood resources (Parrish et al. 2014). This workshop brought together over 20 researchers and resource managers in Honolulu in order to identify and prioritize information needs to increase our understanding and improve management of deep-sea coral and sponge ecosystems in the Pacific Island Region. Workshop participants discussed each information and management need, focusing on applied research activities that are logistically feasible to implement. Participants acknowledged that limited resources are available to address the expansive geographic area of the Pacific Islands Region. Consequently, a coordinated approach will be required in order to address the region’s objectives by undertaking targeted research activities in FY15-17. The workshop participants identified five priority research questions:

1) What information can be derived from existing data sets?
2) What are the biogeographic patterns at the basin-scale?
3) What are the depth distributions of corals and sponges, especially between 500 and 4000 m?
4) What are the environmental factors that affect the distributions of deep-sea corals and sponges?
5) What are the life history traits, genetic factors, and growth characteristics that determine how long it takes a deep-sea coral or sponge community to recover from disturbance?

The Pacific Islands Deep-Sea Coral and Sponge Initiative (PICSI) will map and characterize deep-sea coral and sponge ecosystems in select areas of Hawaii and the U.S. Pacific Islands through systematic field surveys that utilize bathymetry and other seascape features to prioritize survey locations. A particular focus of this effort will be to determine depth limits and distribution gradients of deep-sea coral and sponge communities, and if topographically induced acceleration of bottom currents is a major driver of community location. If the opportunity and vessel capability arises, the PICSI will also incorporate projects that examine the biology and ecology of deep-sea corals and sponges, and will set up a series of sampling stations in known locations with deep-sea corals and sponges in order to determine ages, growth rates, fecundities and reproductive rates of these organisms, as well as prevalent environmental parameters that characterize these assemblages. These projects will also include collections of specimens that
will be used to resolve questions on the taxonomy and genetic connectivity of deep-sea corals and sponges at different locations of the Pacific Islands Region. Finally, the PISCI will support efforts to determine the length of time that deep-sea coral and sponge communities need in order to recover from anthropogenic and natural disturbances. Throughout this project, we hope to (1) advance NOAA’s Deep-Sea Coral Research and Technology Program priorities, (2) develop long-term collaborative relationships between scientists from different offices, and (3) advance our knowledge of deep-sea corals and sponges in the U.S. Pacific Islands in order to improve the management of these important resources.

SECTION 2: BACKGROUND

The U.S. EEZ in the Pacific Islands encompasses more than 5.8 million km$^2$. The area stretches from the Northwestern Hawaiian Islands (NWHI) in the north, to American Samoa in the south, to the Mariana Archipelago in the west, with many isolated islands and seamounts in between. This area contains more than 70% of the nations’ shallow-water coral reefs, which support a diverse and abundant collection of fishes and invertebrates, many of which are harvested by commercial fishing. Although the prevalence and diversity of deep-sea coral and sponge ecosystems throughout the region is largely unknown, scattered observations indicate that some areas support extremely rich communities of deep-water corals and sponges. Factors influencing the abundance and diversity of these communities may include relative proximity to centers of marine biodiversity, age, type, and form of undersea volcanic seascapes, currents, aragonite saturation horizon and others. Fortunately, throughout the U.S. Pacific Islands, few extractive activities have taken place at depths > 500 m, so most of these communities remain intact. However, benthic crusts of the demersal ocean in the Pacific contain significant deposits of precious minerals that are increasing in demand and are likely to be targeted for extraction in the near future. Recent expansion of the Pacific Remote Islands Marine National Monument (PRIMNM) and the recent creation and designation of the Phoenix Islands Protected Area (PIPA) as a UNESCO World Heritage site demand correlative investments in exploration and research in order to support science-based management of these areas. Concerns over the future effects of global climate change and ocean acidification increase the need for adequate scientific research to answer questions regarding the response of marine resources to the effects of human-induced change.
The distribution of deep-sea coral and sponge ecosystems throughout the Pacific Islands is generally unknown, especially at depths greater than 200 m. In Hawaii, the NWHI, and the Line Islands, submersible and ROV dives have recorded abundant and diverse assemblages of corals and sponges down to the operational depth limits of these underwater vehicles (<2000 m). A myriad of fishes and invertebrates are known to make use of these deep-sea coral and sponge communities, and the degree to which they are relevant to shallower ecosystems is starting to be considered. An example of this is in the NWHI where tracking and diving data of Hawaiian monk seals suggests they know about and revisit patches of deep corals (Parrish et al. 2002).

One of the main challenges of managing deep-sea coral and sponge ecosystems in the Pacific Islands is that the abundance and diversity of these organisms are largely unknown. Because of the size and scope of the area under U.S. jurisdiction in the Pacific Islands, the vast majority of the area has not been surveyed for the presence of deep-sea coral and sponge communities. Since the spatial distribution of these communities is unknown in the Pacific Islands, it is difficult to predict the locations and types of human activities that may present threats to these ecosystems. It is known that many species of deep-sea corals and sponges are found at depths below 400 m, suggesting that future impacts will more likely be the result of activities other than fishing (e.g. deep-sea mining). The one extractive process that has taken place in the past has been the harvesting of a few species of deep-sea “precious” corals for use in the jewelry industry.

A workshop on deep-sea coral research and management priorities was held in Honolulu, Hawaii, in April 2014 (Parrish et al. 2014). Participants at that workshop identified a number of important research questions that need to be addressed in order to effectively manage these ecosystems throughout the U.S. Pacific Islands, as well as to address the goals of the NOAA Deep-Sea Coral Research and Technology Program. These questions and priorities are listed below.

**Question 1: What information can be derived from existing data sets?**

Reviewing past research efforts is the first step in designing any research program. We therefore intend to conduct an extensive review of existing data in order to build an inventory of species and depth ranges. The most potentially useful types of datasets include archived video from submersible and ROV dives, museum database records of specimens collected from deep water in the U.S. Pacific, multibeam sonar data from previous mapping surveys, and water quality data.
from CTD casts. Chris Kelley has completed a major portion of this work for the national deep sea coral and sponge program, and will continue to supervise the further development of this database.

**Video Data**
The central Pacific, particularly the Hawaiian Archipelago, has benefited from the presence of resident and visiting deep-water manned and unmanned vehicles. The most extensive video and still image archive is that of the Hawaii Undersea Research Laboratory (HURL), which has operated *Pisces* class submersibles and a small ROV since 1981. Furthermore, HURL is one of only two facilities of its kind committed to annotating its video archive. The HURL database created from this effort will greatly facilitate the extraction of information on what coral and sponge species are present above 2,000 m in the region, as well as their locations, depths, preferred substrates, and associated communities of fish and invertebrates. The Monterey Bay Aquarium Research Institute (MBARI) is the other facility that has created an annotation database from its ROV dive video. MBARI conducted one Central Pacific cruise in 2001 on its ship *R/V Western Flyer* to the Main Hawaiian Islands, where high-resolution video was obtained with their ROV *Ventana* down to depth of 3,000 m. Additional video archives that are not yet annotated are available from *Jason* ROV dives off the *R/V Kilo Moana*, *Shinkai 6500* submersible dives off JAMSTEC’s *R/V Yokosuko*, and *Keiko* ROV dives off JAMSTEC’s *R/V Kairei*. A copy of this archive is available at the University of Hawaii, where HURL is located.

**Museum Collections Data**
A substantial number of deep-sea coral and sponge specimens collected in the U.S. Pacific exist in various museums, such as the (1) National Museum of Natural History, Smithsonian Institution, (2) the Bernice P. Bishop Museum, and (3) the California Academy of Sciences. While many of these have not been formally described in the literature, information about them is catalogued in museum databases. Obtaining these records will help guide collection activities during PICSI field operations.
Multibeam Sonar Data

The Hawaiian Archipelago (main Hawaiian Islands and the Papahānaumokuākea Marine National Monument) along with the other monuments in the Pacific have been the focus of multibeam sonar mapping efforts. As a result, a significant data set of seafloor imagery exists for this region that can provide the basis for increasing our understanding of the relationship between substrate type/topography and deep-sea corals and sponges. As part of the PICSIs, we will collect, integrate and make available all pertinent bathymetry, backscatter, and bathymetric derivative maps and data.

Data sets are also available for non-substrate, water-column factors important to these animals, such as temperature, salinity, dissolved oxygen, alkalinity, pCO$_2$, and other factors at different levels of resolution that can be used to further our understanding. Extractions from these and other existing data sets will be an ancillary part of the coral observation extraction work, and will help guide the research by identifying important research gaps.

**Question 2: What are the biogeographic patterns at the basin-scale?**

There is a need to expand surveys to under-sampled regions in the U.S. Pacific including the NWHI, the Marianas, the Pacific Remote Islands Marine National Monument (PRIMNM), and American Samoa. To do this effectively over such a large area, sampling protocols must be developed that optimize field efforts in each region. Fortunately, the *Okeanos Explorer* will be operating in the U.S. Pacific Islands Region in 2015-2017, and has plans to conduct mapping and ROV operations within each of the major island chains of the U.S. Pacific at depths greater than 500 m. The NOAA Ship *Hi‘ialakai*, home ported in Honolulu, is expected to conduct cruises throughout the region in 2015-2017 as well. Equipped with two different multibeam echosounders, this ship will be able to conduct mapping at depths above 2,000 m, with a focus on depths shallower than 500 m where the *Okeanos Explorer* is unable to survey. One potential focus may be the rift zone areas with topographically-induced upwelling, which previous surveys have identified as areas amenable to coral and sponge presence. In the MHI and the NWHI, many of these areas have been mapped to a bathymetric resolution that would facilitate ROV and submersible surveys, and ridge features exist in close proximity that have multiple orientations and substrates. After survey areas and methods are established, consistent taxonomy of priority coral and sponge groups needs to be applied, and where possible, voucher samples will be
collected in order to provide a permanent record and help evaluate the degree to which various assemblages are connected. Existing local expertise needs to be supplemented through contributions from both taxonomists and geneticists, and the examination of existing archived data in multiple collections worldwide.

Ideally, surveys will involve mapping, visual transects, and voucher sampling components. Some precious coral assemblages in the MHI that are shallower than 2000 m have already been studied extensively, and may be representative of unique conditions that are not found elsewhere in the U.S. Pacific Islands. Conversely, these assemblages may represent the environmental conditions necessary to support such deep-water ecosystems throughout the Pacific Islands. Deeper-water video surveys, along with limited sampling, will be conducted to help establish better taxonomy, as well as to study within and between archipelagic connectivity.

**Question 3: What are the patterns of vertical distribution of deep-sea corals and sponges, particularly at depths below 2000 m?**

Most information on the distribution of deep-sea corals and sponges in the U.S. Pacific is derived from dives performed by the Hawaii Undersea Research Laboratory (HURL) since the early 1980s. The deep-sea vehicles used by HURL are restricted to depths shallower that 2000 m, and as a result, little is known about the deep-sea fauna found below this depth. A major focus of this initiative will be to characterize the vertical distribution and taxonomic identity of deep-sea corals and sponges between 500 and 4000 m. The capacity of the R/V *Okeanos Explorer*, and its ROV *Deep Discover*, to operate in depths down to 6000 m presents a great opportunity for us to survey deep regions throughout the U.S. Pacific. Other research vessels with deep-sea vehicles (*R/V Nautilus with its Hercules ROV*, *R/V Kilo Moana with its Luukai ROV*, and the *R/V Falkor* with its new ROV that is currently being built) may provide additional opportunities for collaborative work as well.

We will conduct dedicated vertical transects at depths between 500 and 4000 m in locations where the shallower fauna (< 2000 m) has been well surveyed (e.g. MHI, NWHI, Cross Seamount), and in more remote areas that have been adequately mapped but not yet surveyed (i.e., American Samoa, Marianas Archipelago, PRIMNM). To facilitate surveys and analyses,
target study sites should have steep slopes and well known fauna at depths shallower than 2000 m. We will primarily collect video data in order to study the abundance and vertical distributions of organisms, and if the platforms with sampling capability are available, we will collect specimens in order to determine their taxonomic identity and study their genetic connectivity with other deep-sea coral and sponge populations.

Additionally, we will examine the vertical distribution of deep-sea corals and sponges in relation to clear breaks in environmental variables (e.g. aragonite saturation horizon, oxygen minimum zone, thermocline), in order to gain insights into what environmental factors may be responsible for limiting their distributions with depth (see question 4 below).

**Question 4. What are the environmental factors affecting distribution of deep-sea corals and sponges?**

The environmental variables that govern where deep-sea coral and sponge communities colonize and develop into mature assemblages are poorly understood. A major component of this research effort will be to determine the oceanographic conditions and physical substrates needed to support these ecosystems. We will determine the appropriate temporal and spatial scales to measure parameters that likely influence coral presence and productivity (e.g., temperature, substrate type, slope, rugosity, current, surface productivity, sedimentation rates). Further, the science planning team will identify places that have the most complete environmental data sets that would support presence-absence modelling of deep-sea corals, and conduct *in situ* surveys in order to test and refine such models.

Ideally, we will develop a 3-year monitoring effort for at least one site in the U.S. Pacific Islands that may be continued (as resources permit) for a longer term. Such a site needs to be close enough that is logistically feasible to get there on a routine basis with the necessary equipment (e.g., Geologist Seamounts or MHI). We will link these data and models to ongoing long-term oceanographic monitoring efforts (e.g., Station Aloha). If feasible, or in lieu of a longer term monitoring effort, we will identify and survey a group of locations in the Line Islands that display a wide variability of environmental conditions that could serve as proxy for change over time.
Question 5. What are the life history traits, growth characteristics, genetic factors, and environmental conditions that determine how long it takes a deep-sea coral or sponge community to recover from disturbance?

Many deep-sea corals grow extremely slowly. Once damaged, it is unknown how long individuals and communities take to recover, if they recover at all. Deep-sea corals are vulnerable to impacts caused by a variety of activities that disturb the seafloor, including fishing gears that contact the seafloor, invasive species, military activities, exploration, minerals and energy extraction, and cable deployment. Additionally, ocean acidification may affect the ability of deep-sea coral and sponges to grow and maintain their calcium carbonate structures. Measures of environmental and population parameters (e.g. oceanographic conditions, recruitment, connectivity, growth, reproduction) will be made to determine the relationship between these variables and recovery rates.

A number of such studies have been conducted in Hawaii in the past, and some of these studies are ongoing. The PICS I intends to support these studies through both collaboration and funding. We hope to support a series of projects including ones that examine (1) colonization and succession on lava flows off the Big Island, (2) life history and genetics of black corals in the MHI, (3) growth and reproductive rates of black corals in the MHI and taxonomy of black corals in American Samoa, (4) growth and succession rates of bamboo and gold corals, and (5) recovery of deep-sea corals on a NWHI seamount where extensive bottom trawling took place decades ago.

SECTION 3: OBJECTIVES AND SCOPE

The Pacific Islands Deep-Sea Coral and Sponge Initiative (PICS I) will be carried out in FY15-17. Biogeographic exploratory work will be a major component of this initiative, because so many areas of the Pacific have not been surveyed, and we have very little information regarding the distribution and abundance of deep-sea coral and sponge communities in the Pacific Islands. Ecological field work will primarily be focused in the MHI and NWHI, where the infrastructure and technical capacity exist to support this type of field work. The objectives of the PICS I...
fieldwork plan are to address the research needs outlined above. Nine specific projects will be undertaken that will address the following objectives:

1. Compile and synthesize existing data from deep-sea coral and sponge observations in the U.S. Pacific Islands.
2. Compile and create an interpretive geological substrate map for the U.S. Pacific Islands, along with an updated bathymetry and backscatter syntheses from OE mapping data.
3. Identify and map areas of high abundance and diversity, and the vertical distribution, of deep-sea corals and sponges in the MHI, the, Papahanaumokuakea MNM, the Pacific Remote Islands MNM, the Mariana Trench MNM, American Samoa, and PIPA.
4. Examine the population ecology, growth rates, genetics and distribution of black corals in Hawaii. Set up monitoring sites to sample and study growth and post-harvest recovery rates of SCUBA-accessible black coral populations in the MHI.
5. Survey SCUBA-accessible black coral populations in American Samoa to determine taxonomy and distribution of black corals in American Samoa.
6. Estimate community recruitment rates in new habitat (e.g. lava flow).
7. Examine the benthic and oceanographic conditions that promote development of deep-sea coral and sponge ecosystems.
8. Collect data on temperature, currents, pH, etc. from deployed instruments in known precious coral beds and use analysis of collected coral precious skeletons as a record of environmental change.
9. Conduct multibeam surveys of American Samoa, the Pacific Remote Islands, the Mariana Archipelago, and the Hawaiian Archipelago in depths shallower than 500 m.

10. Compile, manage, document and format data to national program standards for submittal into national deep-sea coral and sponge database, and create geospatial database that resides in the PIFSC.

Additional projects that will be conducted if the budget allows and the necessary vessels and platforms can be contracted include:

11. Improve the taxonomy of sponges and corals through special collections of unidentified specimens.
13. Confirm the taxonomy and estimate the connectivity of populations of deep-sea corals in the U.S Pacific Islands through genetic studies.

Each of the projects corresponding to these objectives is outlined in more detail in Sections 4 and 7 below, as well as in Appendix 2.

Each of the PICSI objectives also supports one or more of the DSCRTP objectives. The PICSI objectives align with the DSCSE Strategic Plan by addressing information needs that have been identified in the implementation plan. The PICSI fieldwork will address objectives that compile and synthesize existing data (Projects 1 and 2), and specifically locate, map, and characterize deep-sea coral and sponge ecosystems in the U.S. Pacific Islands Region (Project 3). We will conduct projects that examine the ecology of deep-sea corals and the effect of human activity on deep-sea coral and sponge ecosystems (Projects 4 and 5). The PICSI will attempt to determine the physical and oceanographic conditions that contribute to the presence/absence of deep-sea corals and sponges (Projects 6, 7, and 8). We will map depths down to 500 m throughout the Pacific Islands region using multibeam instruments available on regional NOAA research vessels (Project 9). If the opportunity arises, and vessels and platforms are available, projects that improve our understanding of deep-sea coral and sponge genetics, bioactivity, and ecology will also be included (Projects 10, 11, and 12).

At the conclusion of this initiative, we will have advanced our knowledge of the ecology of deep-sea corals and sponges in the U.S. Pacific Islands, so that management of these resources can be based on a scientific understanding of how humans and biophysical conditions influence these communities. Among other products, we expect to produce high-resolution bathymetry and backscatter maps with coral and sponge species distributions, detailed taxonomic descriptions of various species, and descriptions of environmental factors that influence the formation of deep-sea coral and sponge communities.

SECTION 4: METHODS
The PICSI will incorporate 10 component projects to address the objectives outlined above. These projects will include a diverse array of methods, including mapping, monitoring, direct
observations, video surveys, and when possible, field collections and laboratory analysis. Detailed descriptions of the methods for each PICS component project can be found in Appendix 2.

The major challenges that the PICS will have to overcome to implement a successful field plan will be (1) the vastness of the Pacific Islands Region (and inherent problems with logistics and making results applicable to the entire area), (2) the diversity of research questions that need to be addressed, and (3) the limited access to specialized tools and vessels needed to conduct this work. These challenges will necessitate a focus on the MHI and NWHI (or nearby seamounts) for the vast majority of ecological and life-history work. It is not feasible to expect even short-term monitoring efforts to be conducted in the remote islands where the technological infrastructure does not exist. Even with this concentration of efforts in the MHI, it will take flexibility, coordinated planning and efficient project management to complete component projects.

Two major types of field projects will be conducted during the 3-year PICS, mapping/survey projects, and ecological/life history projects. The majority of mapping/survey work will be conducted by the Okeanos Explorer with scientific support and guidance from the PICS. This work will attempt to map and survey representative areas in each major island group that comprises the U.S. Pacific Islands Region. Most of the ecological/life history research will take place in the MHI, or in areas that are close enough to the MHI to be able to make such work feasible. This work will primarily be conducted using mixed-gas SCUBA, with supplemental work using ROVs and AUVs of opportunity. There is some chance of conducting PICS projects in conjunction with other PIFSC and NOS sanctuary/monument scheduled field research activities, but these possibilities are limited. We expect that the Hi’ialakai will be able to support limited multibeam mapping, particularly at depths above 500 m, to complement work planned for the Okeanos Explorer. We plan to conduct major field mapping and video surveys in each year of the PICS. We will also support and conduct a series of environmental and ecological sampling missions, if possible. We will support a pair of data integration products, one that will compile existing deep-sea coral and sponge observations into an easily accessible database, and the other which will create an interpretive geological substrate map for Pacific Island waters.

FY15 Coral and Sponge Observations Database and Multibeam/Geological substrate synthesis
Extract, correct, and format all deep-sea coral cnidarian and sponge records in HURL and other UH databases, and from the National Museum of Natural History (Smithsonian), the Bishop Museum, and the California Academy of Sciences. Obtain all available CTD data, specifically temperature, depth, salinity, and dissolved oxygen, and where possible, merge these data to individual coral and sponge observations.

Acquire, edit, and process multibeam data from EX cruises and from other legacy sources. Create updated, or new, bathymetry and backscatter syntheses along with interpretive geological substrate maps for the Pacific Island waters scheduled to be surveyed during this three-year program. The new multibeam datasets will be merged with pre-existing multibeam data or existing syntheses, and fused with the USGS GLORIA sidescan sonar mosaics (where available).

FY15 *Okeanos Explorer* operations

In FY15, there will be three *Okeanos Explorer* research cruises sponsored by OAR to the Papahanaumokuakea MNM in the NWHI and the Pacific Remote Islands MNM, specifically Johnston Atoll. The first cruise will be a mapping cruise to collect bathymetry and backscatter data. The second and third cruises will use the video data collected by the *Okeanos Explorer* ROV to determine the presence, abundance and diversity of deep-sea corals and sponges in both monuments. Prior to these three cruises, PIs will develop maps of potential survey areas that contain features that match the predicted locations of deep-sea corals and sponges in the NWHI. A sampling design stratified across depth zones (500 m to 4000 m), geographic orientation, predicted currents, and potential substrate types will be employed to determine if these influence coral presence, abundance, and diversity. The *Okeanos Explorer* will also conduct a 7-day cruise with ROV operations in (1) the MHI to retrieve/deploy deep-water instruments and to examine settlement rates on recent and historic lava flows, and (2) the Geologist Seamounts area to retrieve/deploy deep-water instruments and conduct multiple video surveys.

Also in FY15, ancillary projects to conduct multibeam surveying, to be completed by *Hi’ialakai’s* personnel on a not-to-interfere basis with the ship’s primary missions are being requested for her cruises to American Samoa and the Pacific Remote Islands MNM.

*FY15 Ecology and life history*
Using the *Okeanos Explorer*, the ecological and life history work will establish a few fixed stations to be re-visited each of the 3 years. Instruments will be purchased and deployed at the sites with the expectation that they will be recovered and redeployed the following year providing a total of 2 years of environmental data during the 3 year project. Variables to be recorded will include temperature, currents, particulates, dissolved oxygen and PH. If possible, clippings of a cross section of dominant corals will be collected to look for differences in reproductive state.

Research on black corals will address four components, including (1) population size structure within the Maui black coral beds and how it has changed over time, (2) species and colony densities in the depths of 60 to 80 m in the Au‘au Channel, Maui, (3) the genetic connectivity of *Antipathes griggi* across the Maui beds and other islands (Hawai‘i, O‘ahu, Kaua‘i, Northwestern Hawaiian Islands, and Johnston Atoll), and (4) the possible impacts of changes to the population through the development of a population model based on demographics and spatial distribution. Additionally, coordinated research on black corals will examine which black coral species exist at depths accessible through mixed-gas technical diving (50-90 m) in American Samoa, and characterize the growth rates and minimum size of reproductive maturity of the three commercially valuable Hawaiian black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulax*) at different depths (50-90 m) in Hawaii.

**FY15 Collaboration with other deep coral endeavors in the region**

- Studies directed at coral resilience to disturbance (Roark and Baco-Taylor NWHI seamount trawling) will be supported with tilt current meters that record the direction, flow rate and temperature. This will provide some year-round in-situ characterization of the environment at coral sites where revisits are planned and means to collect the gear is available.

- Development, deployment and recovery of landers at sites identified with coral assemblages using the range of available ships of opportunity.

- Funds will be provided to support analyses and publication of previously collected deep coral data.
The Center will look at putting the SeaBed AUV on the *Okeanos Explorer* as a secondary survey tool, and as a backup should the primary ROV have to go off line.

**FY16 Coral and Sponge Observations Database and Multibeam/Geological substrate synthesis**

Extract, correct, and format new records since 2015 of all deep-sea coral cnidarian and sponge records in UH databases, and from the National Museum of Natural History (Smithsonian), the Bishop Museum, and the California Academy of Sciences. Obtain all available CTD data, specifically temperature, depth, salinity, and dissolved oxygen, and where possible, merge these data to individual coral and sponge observations.

Acquire, edit, and process multibeam data from EX cruises and from other legacy sources. Create updated, or new, bathymetry and backscatter syntheses along with interpretive geological substrate maps for the Pacific Island waters scheduled to be surveyed during this three-year program. The new multibeam datasets will be merged with pre-existing multibeam data or existing syntheses, and fused with the USGS GLORIA sidescan sonar mosaics (where available).

**FY16 Okeanos Explorer operations**

In FY16, *Okeanos Explorer* research cruises sponsored by OAR will be conducted in the Marianas Archipelago and at Wake Island, in the PRIMNM. These cruises will have a mapping component to collect bathymetry and backscatter data for regions that have been incompletely mapped in the past, and also an ROV video component to determine the abundance and diversity of deep-sea corals and sponges (Project 3). Prior to these three cruises, PIs will develop maps of potential survey areas that contain features that match the predicted locations of deep-sea corals and sponges in the region. A sampling design stratified across depth zones (500 m to 4000m), geographic orientation, predicted currents, and potential substrate types will be employed to determine if these influence coral presence, abundance, and diversity. OE will also conduct a 7-day cruise with ROV operations in the MHI to retrieve/deploy deep water instruments and to examine settlement rates on recent and historic lava flows, and in the Geologist Seamounts area to retrieve/deploy deep water instruments, and conduct multiple video surveys.
In addition to the *Okeanos Explorer* work described above, ancillary projects for *Hi‘ialakai* personnel to conduct multibeam surveying by on a not-to-interfere basis with the ship’s primary missions, will be requested for her cruises in the Hawaiian Archipelago in FY16.

**FY16 Ecology and life history**

Using the *Okeanos Explorer*, the ecological and life history work will establish a few fixed stations to be re-visited each of the 3 years. Instruments will be purchased and deployed at the sites with the expectation that they will be recovered and redeployed the following year, providing a total of 2 years of environmental data during the 3 year project. Variables to be recorded will include temperature, currents, particulates, dissolved oxygen and PH. If possible, clippings of a cross section of dominant corals will be collected to look for differences in reproductive state.

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Research on black corals will address four components, including population size structure within the Maui black coral beds and how has it changed over time, species and colony densities in the depths of 60 to 80 m in the Au'au Channel, Maui, the genetic connectivity of *Antipathes griggi* across the Maui beds and other islands (Hawai‘i, O‘ahu, Kaua‘i, Northwestern Hawaiian Islands, and Johnston Atoll), and the possible impacts of changes to the population through the development of a population model based on demographics and spatial distribution.

Coordinated research on black corals will examine which black coral species exist at depths accessible through mixed-gas technical diving (50-90 m) in American Samoa. Growth rates and minimum size of reproductive maturity of the three commercially valuable Hawaiian black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulex*) in Hawaii will be characterized.
Finally, growth rates and minimum size of reproduction will be analyzed to see if they vary in colonies found at different depths (50-90 m).

**Collaboration with other deep coral endeavors in the region**

- Studies directed at coral resilience to disturbance (Roark and Baco-Taylor NWHI seamount trawling) will be supported with tilt current meters that record the direction, flow rate and temperature. This will provide some year-round in-situ characterization of the environment at coral sites where revisits are planned and means to collect the gear is available.

- Development, deployment and recovery of landers at sites identified with coral assemblages using the range of available ships of opportunity.

- Funds will be provided to support analyses and publication of preciously collected deep coral data.

The Center will look at putting the SeaBed AUV on the *Okeanos Explorer* as a secondary survey tool, and as a backup should the primary ROV have to go off line.

**FY17 Coral and Sponge Observations Database and Multibeam/Geological substrate synthesis**

Extract, correct, and format new records from 2016 of all deep sea coral cnidarian and sponge in UH databases, and from the National Museum of Natural History (Smithsonian), the Bishop Museum, and the California Academy of Sciences. Obtain all available CTD data, specifically temperature, depth, salinity, and dissolved oxygen, and where possible, merge these data to individual coral and sponge observations.

Acquire, edit, and process multibeam data from *Okeanos Explorer* cruises and from other legacy sources. Create an updated, or new, bathymetry and backscatter syntheses along with interpretive geological substrate maps for the Pacific Island waters scheduled to be surveyed during this three-year program. The new multibeam datasets will be merged with pre-existing multibeam data or existing syntheses, and fused with the USGS GLORIA sidescan sonar mosaics (where available).
FY17 Okeanos Explorer operations

In FY17, Okeanos Explorer research cruises sponsored by OAR will be conducted in American Samoa, the Pacific Remote Islands MNM, and the Phoenix Islands Protected Area (PIPA) in the central Pacific. These cruises will have a mapping component to collect bathymetry and backscatter data for regions that have been inadequately mapped, and also an ROV video component to determine the presence, absence, abundance and diversity of deep corals and sponges (Project 3). Prior to the field season, PIs will develop maps of potential survey areas that contain features that match the predicted locations of deep-sea corals and sponges in American Samoa and the monument. A sampling design stratified across depth zones, geographic orientation, predicted currents, and potential substrate types will be employed to determine if these influence coral presence, abundance, and diversity. OE will also conduct a 7-day cruise with ROV operations in the MHI to retrieve/deploy deep water instruments and to examine settlement rates on recent and historic lava flows, and in the Geologist Seamounts area to retrieve/deploy deep water instruments, and conduct multiple video surveys.

Also in FY17, ancillary projects for Hi‘ialakai personnel to conduct multibeam surveying by on a not-to-interfere basis with the ship’s primary missions, will be requested for her cruises is the Marianas and the NWHI in FY17.

FY17 Ecology and life history

Using the Okeanos Explorer, the ecological and life history work will establish a few fixed stations to be re-visited each of the 3 years. Instruments will be purchased and deployed at the sites with the expectation that they will be recovered and redeployed the following year providing a total of 2 years of environmental data during the 3 year project. Variables to be recorded will include temperature, currents, particulates, dissolved oxygen and PH. If possible, clippings of a cross section of dominant corals will be collected to look for differences in reproductive state.

Using the Okeanos Explorer, the ecological and life history work will establish a few fixed stations to be re-visited each of the 3 years. Instruments will be purchased and deployed at the sites with the expectation that they will be pulled and redeployed the following year providing a total of 2 years of environmental data during the 3 year project. Variables to be recorded will
include temperature, currents, particulates, dissolved oxygen and PH. If possible, clippings of a cross section of dominant corals will be collected to look for differences in reproductive state.

Research on black corals will address four components, including population size structure within the Maui black coral beds and how has it changed over time, species and colony densities in the depths of 60 to 80 m in the Au‘au Channel, Maui, the genetic connectivity of *Antipathes griggi* across the Maui beds and other islands (Hawai‘i, O‘ahu, Kaua‘i, Northwestern Hawaiian Islands, and Johnston Atoll), and the possible impacts of changes to the population through the development of a population model based on demographics and spatial distribution.

Coordinated research on black corals will examine which black coral species exist at depths accessible through mixed-gas technical diving (50-90 m) in American Samoa. Growth rates and minimum size of reproductive maturity of the three commercially valuable Hawaiian black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes* cf. *ulex*) in Hawaii will be characterized. Finally, growth rates and minimum size of reproduction will be analyzed to see if they vary in colonies found at different depths (50-90 m).

**Collaboration with other deep coral endeavors in the region**

- Studies directed at coral resilience to disturbance (Roark and Baco-Taylor NWHI seamount trawling) will be supported with tilt current meters that record the direction, flow rate and temperature. This will provide some year-round in-situ characterization of the environment at coral sites where revisits are planned and means to collect the gear is available.

- Development, deployment and recovery of landers at sites identified with coral assemblages using the range of available ships of opportunity.

- Funds will be provided to support analyses and publication of previously collected deep coral data.

The Center will look at putting the SeaBed AUV on the *Okeanos Explorer* as a secondary survey tool, and as a backup should the primary ROV have to go off line.
SECTION 5: RISK MANAGEMENT PLAN

We anticipate three types of challenges to successful completion of this three year project; logistical challenges, technical challenges, and budgetary challenges.

The PICSI will face the same logistic challenges that all Pacific-wide endeavors face; i.e. how to most efficiently manage technological and personnel assets to cover an area that is both vast and diverse, and that often lacks the infrastructure or technological capacity to provide much support to remote field efforts. The primary logistical challenge will be access to and use of the Okeanos Explorer ROV. If this ship and its ROV are not available, we will have to make major changes to our research plans and develop new survey and sampling methods. The second logistical challenge is the amount of time needed to sail to many of the remote research locations that have been identified as priority sites.

The PICSI will be relying heavily on a partnership with OAR and the Okeanos Explorer for the majority of our biogeographical mapping and survey work, but a major limitation we may face is the inability of this ship to collect any physical specimens. The Okeanos Explorer will conduct its first ever collecting trials on the 7 day cruise in the MHI and if successful then its anticipated that collecting will take place during subsequent cruises. However, if the trials are unsuccessful and if for any reason this ship is unable to operate as planned, our entire research plan will have to be redeveloped using different and less capable vessels. The ability to respond to equipment failures when working in remote locations is essential to successful completion of the project objectives. Availability of backup systems is constrained by space and personnel limitations on the Okeanos Explorer, but given the remote nature of most of this work, we will continue to work with OER to plan for back-up instrumentation in the event that the ROV becomes inoperable. For other ROV and AUV work, appropriate vessels need to be identified that have the support capacity. Different operating capabilities of these instruments will demand alternative survey plans.

Careful planning and communication among the investigators will help to minimize logistical challenges. Coordination with other PIFSC and NOS Sanctuary activities such as the Coral Reef Ecosystem Division surveys and monument explorations are ongoing, and we will need to maintain communications between the coral and sponge project and the scientists tasked with other research in the U.S. Pacific Islands. The key personnel involved in this project are all very
aware of the logistical challenges of working in remote locations in the Pacific Islands, and all have experience working across line offices and under budgetary and technical constraints.

The final series of challenges are budgetary. Federal budget delays will no doubt cause scheduling and contracting problems. We will work with the DSCRTP to minimize any effects and will also work within the PIFSC and PIR to maximize our budgetary flexibility. We are working to establish a new project within the Joint Institute of Marine and Atmospheric Research to enable us to pay labor contracts for University of Hawaii collaborators, and to facilitate the use of funds beyond the NOAA fiscal year deadline.

**SECTION 6: PROJECT TEAM**

**Pacific Islands Deep Sea Coral and Sponge Research Program Science Planning Team**

Michael Parke (PIFSC), Frank Parrish (PIFSC), Eric Breuer (PIFSC), Margot Bohan (OER), Daniel Wagner (NOS-Papahanaumokuakea MNM), Christopher Kelley (University of Hawaii), John Rooney (JIMAR), Danielle Jaywardene (PIRO)

**NOAA - Pacific Islands Fisheries Science Center (NOAA-PIFSC)**

1) Michael Parke: Team Lead responsible for the overall coordination of the three-year field effort including related analyses. Oversees the planning and execution of the three-year fieldwork effort, including coordinating ship requests and field activities. Ensures fieldwork data, metadata and deliverables are accessible and appropriately archived within NOAA. Maintains communication channels with headquarters, team members, science center, region leadership, OAR, and the Western Pacific Regional Fishery Management Council. Scientific co-lead on projects 1, 3, and 10.

2) Frank Parrish: As chief scientist, ensures the research methods and results are scientifically sound. Identifies NMFS deep-sea coral information needs and NMFS science assets. Presents interim and final results in reports, publications and presentations as needed. Scientific lead for project 8 and collaborator on 3, 4, 5, and 8.

3) John Rooney: Scientific lead on project 9.

4) Frances Lichowski: Scientific co-lead on project 9.
5) Bryan Dieter: Data management. Collaborator on project 10.
6) Eric Breuer: Collaborator on projects 2 and 3.

**NOAA - Pacific Islands Regional Office (NOAA-PIRO)**

1) Danielle Jaywardene: Responsible for ensuring coordination with the Western Pacific Regional Fishery Management Council, and NMFS regional management responsibilities (e.g., Essential Fish Habitat information needs).
2) Samantha Brooke: Responsible for coordination between CAPSTONE and PIRO.

**NOAA- OAR - Office of Ocean Exploration and Research (OER)**

1) Kelley Elliot and Jeremy Potter: Serve as OER liaisons to the PICS1 Team. Build synergy between the program-funded fieldwork and OAR’s exploration activities.

**NOAA-NOS - Papahānaumokuākea Marine National Monument**

2) Randall Kosaki: Builds linkage with NOS science assets and expertise. Contributes to media and public outreach activities. Collaborator on projects 3, 4, and 5.
3) Jason Leonard: Collaborator on project 5.
4) Brian Hauk: Collaborator on project 5.

**Western Pacific Region Fisheries Management Council**

1) Josh DeMello – WPRFMC deep coral management specialist

**University of Hawaii**

1) Christopher Kelley: Scientific lead on projects 3 and 7. Co-lead on project 1.
2) John Smith: Scientific lead on project 2.
3) Les Watling: Scientific co-lead on project 7. Collaborator on project 3, 4, and 5.
4) Rob Toonen: Scientific co-lead on project 4.
5) Anthony Montgomery: Scientific co-lead on project 4.
6) Virginia Moriwake: Collaborator on project 1.
Hawaii Pacific University

1) Sam Kahng: Scientific lead on project 6.

Bernice P. Bishop Museum

1) Sonia Rowley: Collaborator on project 1, 3 and 7.

University of Louisiana at Lafayette

1) Scott France: Collaborator on project 3 and 7.

University of Texas A&M

1) Brendan Roark, Collaborator on project 7 and 8.

University of Victoria

2) Henry Reiswig: Collaborator on project 3 and 7.

National Museum of Natural History-Smithsonian

1) Steven Cairns: Collaborator on project 1, 3, and 7.
## SECTION 7: THREE-YEAR WORKPLAN

The major activities planned for the PICSI implementation are listed in the table below (with cost estimates and target dates for milestones). The map below shows where each activity will occur in the Pacific Islands.

<table>
<thead>
<tr>
<th>Target Date</th>
<th>Major Activity</th>
<th>Milestones</th>
<th>Activity Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4 2015</td>
<td><em>Compilation and synthesis of existing deep coral and sponge data</em></td>
<td>1) Creation of annotated database containing observations of deep sea coral and sponges in the U.S. Pacific Islands</td>
<td>$30,000</td>
</tr>
</tbody>
</table>
| Q3 2015     | *Multibeam mapping surveys in PMNM and Johnston (Capstone cruise 1 Okeanos Explorer FY15)* | 1) Multibeam mapping, data editing and processing of the Papahanaumokuakea MNM and Johnston seafloor in 500 to 4000 m depths.  
2) Creation of updated bathymetry and backscatter syntheses and interpretive geological substrate maps for PMNM and Johnston. | $18,500 $18,500 |
| Q3-Q4 2015  | *ROV surveys in PMNM and Johnston (Capstone cruises 2 and 3, Okeanos Explorer FY15)* | 1) ROV transects for deep sea corals and sponges conducted at multiple study sites with targeted starting and ending depths of 4000 m and 500 m, respectively.  
2) *Okeanos Explorer* operations and video data files copied and delivered to PIFSC and DSCP.  
3) ROV video annotated for abundance and diversity of deep sea corals and sponges for inclusion into the DSCP database.  
4) Creation of an updated GIS of deep sea coral and sponge locations in the Hawaiian Archipelago and analysis of geographic and depth distribution patterns for individual species. | $40,000 $0 $86,000 $24,000 |
| Q3-Q4 2015  | *Life history characteristics of Hawaiian black corals and Population ecology, genetics, and modelling of Antipathes griggi in Hawaii* | 1) Examine the current population size structure within the Maui black coral beds and how has it changed over time  
2) Determine the species and colony densities in the depths of 200 to 260 feet in the Au’au Channel, Maui | $50,000        |
### Q4 2015

**Life history of commercially valuable black corals in Hawaii and taxonomy of black corals in American Samoa**

| 1) | Colonies of the three commercially Hawaiian valuable black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulex*) tagged, measured and sampled using mixed-gas technical diving at depths ranging between 50-90m off Oahu. |
| 2) | Samples and measurements of Hawaiian black corals analyzed to determine growth rates and minimum size of reproductive maturity. |
| 3) | Sites at depths between 50-90 m surveyed off American Samoa using mixed-gas technical diving to determine distribution and taxonomic affinities. |

**$50,000**

### Q3-Q4 2015

**Community succession in deep sea corals**

| 1) | Conduct ROV dive to compare coral communities on disturbed substrate (a lava flow of known age) and surrounding undisturbed substrate. |
| 2) | Analyze video for abundance and diversity of deep-sea corals and sponges. |

**$30,000**

### Q3-Q4 2015

**ROV surveys on the Geologist Seamounts**

| 1) | Conduct ROV dives to identify high density deep sea coral and sponge habitats on the Geologist seamounts and collect specimens for taxonomic identification. |
| 2) | Video data files copied and delivered to PIFSC and DSCP. |
| 3) | ROV video annotation for abundance and diversity of deep sea corals and sponges for inclusion into the DSCP database. |

**$140,000**
<table>
<thead>
<tr>
<th>Quarter</th>
<th>Activity</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3-Q4 2015</td>
<td><strong>ROV dives to collect long-term data sets of temperature, current direction and flow rate, particle load, and pH on deep sea coral habitat</strong></td>
<td>4) Creation of an updated GIS of deep sea coral and sponge locations in the Geologist seamounts and analysis of geographic and depth distribution patterns for individual species. 1) Conduct submersible or ROV dives to retrieve existing data loggers and deploy new data loggers on monitoring stations located in precious coral beds off Oahu, the Big Island, and Cross Seamount. Collect specimens of unidentified corals and sponges found in the beds. 2) Process and analyze data for PIFSC and DSCP</td>
<td>$17,000</td>
</tr>
</tbody>
</table>
| Q3 2015  | **Bathymetric mapping in American Samoa and the PRIMNM (Hi’ialakai cruises, FY15)** | Preparation, synthesis and delivery of existing bathymetry data to Hi’ialakai to guide new data collection  
Processing of new multibeam data, incorporation into existing data sets, delivery of metadata to NGDC and posting online for viewing and download | $86,000 |
| Q4 2015  | **Creation and maintenance of database and metadata that meets Deep-Sea Coral and Sponge Research Program guidelines** | 1) Create database, compile and document all data collected during research activities. Format data to meet program requirements. Create and populate PIFSC deep-coral geodatabase. | $40,000 |
| Q4 2016  | **Compilation and synthesis of existing deep coral and sponge data** | 1) Creation of annotated database containing observations of deep sea coral and sponges in the U.S. Pacific Islands | $32,000 |
| Q3 2016  | **Multibeam mapping surveys in the PRIMNM, the Marianas, and the MTMNM (Capstone cruise 4 Okeanos Explorer (FY16)** | 1) Multibeam mapping, data editing and processing of the MTMNM seafloor in 500 to 4000 m depths.  
2) Creation of updated bathymetry and backscatter syntheses and interpretive geological substrate maps for Marianas and MTMNM. | $18,500 |
| Q3-Q4 2016 | **ROV surveys in in the PRIMNM, the Marianas, and the MTMNM (Capstone cruises 5 and 6 Okeanos Explorer (FY16)** | 1) ROV transects for deep sea corals and sponges conducted at 4 study sites with targeted starting and ending depths of 4000 m and 1,000 m, respectively. | $40,000 |
| Q1-Q4 2016 | **Population ecology, genetics, and modelling of Antipathes griggi in Hawaii** | 1) Examine the current population size structure within the Maui black coral beds and how has it changed over time  
2) Determine the species and colony densities in the depths of 200 to 260 feet in the Au‘au Channel, Maui  
3) Determine connectivity of Antipathes griggi across the Maui beds and other islands (Hawai‘i, O‘ahu, Kaua‘i, Northwestern Hawaiian Islands, and Johnston Atoll)  
4) Predict the impacts of changes to the population through the development of a population model based on demographics and spatial distributions | $51,000 |
| Q4 2016 | **Life history of commercially valuable black corals in Hawaii and taxonomy of black corals in American Samoa** | 1) Colonies of the three commercially Hawaiian valuable black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulex*) tagged, measured and sampled using mixed-gas technical diving at depths ranging between 50-90m off Oahu.  
2) Samples and measurements of Hawaiian black corals analyzed to determine growth rates and minimum size of reproductive maturity. | $50,000 |
3) Sites at depths between 50-90 m surveyed off American Samoa using mixed-gas technical diving to determine distribution and taxonomic affinities.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Activity Description</th>
<th>Objective</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3-Q4 2016</td>
<td><strong>ROV surveys on the Geologist Seamounts</strong></td>
<td>1) Conduct submersible or ROV dives to identify high density deep sea coral and sponge habitats on the Geologist seamounts and collect specimens for taxonomic identification</td>
<td>$140,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Video data files copied and delivered to PIFSC and DSCP.</td>
<td>$0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) ROV video annotation for abundance and diversity of deep sea corals and sponges for inclusion into the DSCP database.</td>
<td>$10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4) Creation of an updated GIS of deep sea coral and sponge locations in the Geologist seamounts and analysis of geographic and depth distribution patterns for individual species.</td>
<td>$10,000</td>
</tr>
<tr>
<td>Q3-Q4 2016</td>
<td><strong>ROV dives to collect long-term data sets of temperature, current direction and flow rate, particle load, and pH on deep sea coral habitat</strong></td>
<td>1) Conduct submersible or ROV dives to retrieve existing data loggers and deploy new data loggers on monitoring stations located in precious coral beds off Oahu, the Big Island, and Cross Seamount. Collect specimens of unidentified corals and sponges found in the beds.</td>
<td>$105,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Process and analyze data for PIFSC and DSCP</td>
<td>$0</td>
</tr>
<tr>
<td>Q1-Q3 2016</td>
<td><strong>PIFSC multibeam surveys in the Hawaiian Archipelago (Hi'ialakai cruises, FY16)</strong></td>
<td>1) Preparation, synthesis and delivery of existing bathymetry data to Hi'ialakai to guide new data collection and processing of new multibeam data, incorporation into existing data sets, delivery of metadata to NGDC and posting online for viewing and download.</td>
<td>$88,000</td>
</tr>
<tr>
<td>Q4 2016</td>
<td><strong>Creation and maintenance of database and metadata that meets Deep-Sea Coral and Sponge Research Program guidelines</strong></td>
<td>1) Create database, compile and document all data collected during research activities. Format data to meet program requirements. Populate PIFSC deep-coral geodatabase.</td>
<td>$42,000</td>
</tr>
<tr>
<td>Q4 2017</td>
<td><strong>Compilation and synthesis of existing deep coral and sponge data</strong></td>
<td>1) Creation of annotated database containing observations of deep sea coral and sponges in the U.S. Pacific Islands</td>
<td>$34,000</td>
</tr>
<tr>
<td>Quarter</td>
<td>Project Description</td>
<td>Activities</td>
<td>Cost</td>
</tr>
<tr>
<td>---------</td>
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</tr>
</tbody>
</table>
| Q3 2017 | Multibeam mapping surveys in the PRIMNM and American Samoa (Capstone cruise 7 Okeanos Explorer (FY17)) | 1) Multibeam mapping, data editing and processing of the PRIMNM and American Samoa seafloor in 500 to 4000 m depths.  
2) Creation of updated bathymetry and backscatter syntheses and interpretive substrate maps for PRIMNM and Am Samoa. | $18,500 |
| Q3-Q4 2017 | ROV surveys in the PRIMNM and American Samoa (Capstone cruise 8 and 9 Okeanos Explorer (FY17)) | 1) ROV transects for deep sea corals and sponges conducted at 4 study sites with targeted starting and ending depths of 4000 m and 500 m, respectively.  
2) Okeanos Explorer operations and video data files copied and delivered to PIFSC and DSCP.  
3) ROV video annotation for abundance and diversity of deep sea corals and sponges for inclusion into the DSCP database.  
4) Creation of an updated GIS of deep sea coral and sponge locations in the PRIMNM and American Samoa and analysis of geographic and depth distribution patterns for individual species. | $40,000 |
| Q1-Q4 2017 | Population ecology, genetics, and modelling of Antipathes griggi in Hawaii | 1) Examine the current population size structure within the Maui black coral beds and how has it changed over time  
2) Determine the species and colony densities in the depths of 200 to 260 feet in the Au’au Channel, Maui  
3) Determine connectivity of Antipathes griggi across the Maui beds and other islands (Hawai‘i, O‘ahu, Ka‘u‘ai, Northwestern Hawaiian Islands, and Johnston Atoll)  
4) Predict the impacts of changes to the population through the development of a population model based on demographics and spatial distributions | $30,000 |
<table>
<thead>
<tr>
<th>Quarter</th>
<th>Project Title</th>
<th>Description</th>
<th>Budget</th>
</tr>
</thead>
</table>
| Q4 2017 | Life history of commercially valuable black corals in Hawaii and taxonomy of black corals in American Samoa | 1) Colonies of the three commercially Hawaiian valuable black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulex*) tagged, measured and sampled using mixed-gas technical diving at depths ranging between 50-90m off Oahu.  
2) Samples and measurements of Hawaiian black corals analyzed to determine growth rates and minimum size of reproductive maturity.  
3) Sites at depths between 50-90 m surveyed off American Samoa using mixed-gas technical diving to determine distribution and taxonomic affinities. | $50,000 |
| Q3-Q4 2017 | Community succession in deep sea corals | 1) Conduct ROV dive to compare coral communities on disturbed substrate (a lava flow of known age) and surrounding undisturbed substrate  
2) Analyze video for abundance and diversity | $45,000 |
| Q3-Q4 2017 | ROV surveys on the Geologist Seamounts | 1) Conduct submersible or ROV dives to identify high density deep sea coral and sponge habitats on the Geologist seamounts and collect specimens for taxonomic identification  
2) Video data files copied and delivered to PIFSC and DSCP.  
3) ROV video annotation for abundance and diversity of deep sea corals and sponges for inclusion into the DSCP database.  
4) Creation of an updated GIS of deep sea coral and sponge locations in the Geologist seamounts and analysis of geographic and depth distribution patterns for individual species. | $140,000 |
<p>| Q3-Q4 2017 | ROV dives to collect long-term data sets of temperature, current direction and flow rate, particle load, and pH on deep sea coral habitat | 1) Conduct submersible or ROV dives to retrieve existing data loggers and deploy new data loggers on monitoring stations located in precious coral beds off Oahu, the Big | $125,000 |</p>
<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Project Description</th>
<th>Activities</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1-Q3 2017</td>
<td>PIFSC multibeam surveys in the Hawaiian and Mariana Archipelagos (Hi’ialakai cruises, FY17)</td>
<td>1) Preparation, synthesis and delivery of existing bathymetry data to Hi’ialakai to guide new data collection and processing of new multibeam data, incorporation into existing data sets, delivery of metadata to NGDC and posting online for viewing and download.</td>
<td>$90,000</td>
</tr>
<tr>
<td>Q4 2017</td>
<td>Creation and maintenance of database and metadata that meets Deep-Sea Coral and Sponge Research Program guidelines</td>
<td>1) Create database, compile and document all data collected during research activities. Format data to meet program requirements. Populate PIFSC deep-coral geodatabase.</td>
<td>$44,000</td>
</tr>
</tbody>
</table>
APPENDIX 1: FY15 IMPLEMENTATION PLAN AND BUDGET

Introduction

The U.S. EEZ in the Pacific Islands encompasses more than 5.8 million km². The area stretches from the Northwestern Hawaiian Islands in the north, to American Samoa in the south, to the Mariana Archipelago in the west, with many isolated islands in between. Prevalence and diversity of deep-sea coral and sponge ecosystems throughout the region is largely unknown, but scattered observations indicate that some areas support extremely rich communities of deep-water corals and sponges. Factors influencing the abundance and diversity of these communities may include relative proximity to the centers of marine biodiversity, age, type, form of the undersea volcanic seascapes, currents, aragonite saturation horizon, and other factors. Fortunately, throughout the U.S. Pacific Islands, few extractive activities have taken place at depths > 500 m, so most of these communities remain intact. However, benthic crusts of the demersal ocean in the Pacific contain significant deposits of precious minerals that are increasing in demand and will soon be the object of extraction. Recent expansions of the Pacific Remote Islands Marine National Monuments demand correlative investments in exploration and research to support science-based management of these areas. Concerns over the future effects of global climate change and ocean acidification increase the need for adequate scientific research to answer questions regarding the response of marine resources to the effects of human-induced change.

The challenges facing management of deep-sea coral and sponge ecosystems in the Pacific Islands begin with the lack of knowledge of where these organisms occur in high abundance and diversity. Because of the size and scope of the area under U.S. jurisdiction in the Pacific Islands, the vast majority of the area has not been surveyed for the presence of coral and sponge communities. Since the spatial distribution of these communities is not known, it is difficult to predict the locations and types of human activities that may be threats to the deep-sea coral and sponge ecosystems. Given the depths at which these communities occur, it is more likely that future extractive endeavors would focus on precious minerals rather than fishes. The one extractive process that has taken place in the past has been the harvesting of precious corals themselves.
A workshop on deep-sea coral research and management priorities was held in Honolulu, Hawaii, in April 2014 (Parrish et al. 2014). Participants in that workshop identified a number of important research questions that need to be addressed for effective management of these ecosystems throughout the U.S. Pacific Islands, and to address the goals of the NOAA Deep-Sea Coral and Sponge Research and Technology Program. Research to answer these questions and priorities will be conducted by the Pacific Islands Deep Sea Coral and Sponge Initiative (PICSI) during FY15-17 through eight research projects. The PICSI fieldwork will locate and characterize deep-sea coral and sponge ecosystems in the U.S. Pacific Islands though a series of systematic field surveys. The PICSI will research the oceanographic and geophysical factors that influence the biogeography of these corals and sponges. The biology and ecology of black and other precious corals will be examined through studies on coral succession, recovery, growth, and reproduction rates. Knowledge of coral and sponge biodiversity and ecology will also be enhanced through collection of specimens to resolve taxonomic issues and genetic connectivity between and among Pacific Island populations. Finally, the potential effects of geologic substrate on deep-water coral and sponge communities will be addressed by a project that provides a synthesis of the surficial geology of the U.S. Pacific Islands. At the conclusion of this project, we hope to have advanced our knowledge of deep-sea sponge and coral ecology in the Pacific Islands, so that management of these resources can be based on the best scientific knowledge available.

**Project Strategy**

The PICSI will follow a similar strategy all three years. We will take advantage of the presence of the OAR research vessel *Okeanos Explorer* in all three years to conduct exploratory surveys of deep-water coral and sponges throughout the Pacific Islands. Year one will focus on the Hawaiian Archipelago. Year two will focus on the Marianas Archipelago and Wake Island in the PRIMNM. Year 3 will look at the islands in American Samoa and some of the islands in the PRIMNM. With the exception of studies that can piggyback onto other research cruises, ecological and monitoring research will take place almost exclusively in the main Hawaiian Islands due to logistic limitations. Any studies that depend on deployment of instrumentation for monitoring purposes will be prioritized in the first year.
In FY15, proposed field projects involving the Okeanos Explorer will be in the Northwestern Hawaiian Islands and around Johnston Atoll, with other field components in the main Hawaiian Islands. Major ROV surveys will be completed in the Papahanaumokuakea MNM, Johnston Atoll in the Pacific Remote Islands MNM, and at the Geologist Seamounts south of Oahu. The video data from these surveys will be used to help determine abundance and distribution of deep-sea corals and sponges in these areas of the Pacific, and help to confirm or discredit the hypotheses regarding the physiographic conditions and geographic orientation that are favored by these organisms. Multibeam mapping work will be conducted on the periphery of the Monument and at Johnston atoll. This work will fill a major gap in bathymetry data for the newly expanded Pacific Remote Islands MNM. Other multibeam mapping work in American Samoa will take place using the Hiialakai. This work will fill in bathymetry data gaps in depths shallower than 500 m.

For some projects, FY15 will serve as the first of 3-years of field observations using human divers, ROVs, or deployed instruments. These include the black coral studies, as well as the instrumentation and environmental monitoring studies. The black coral and instrumentation studies are longer-term monitoring projects that will have both field components and analytical components each of the three years. The instrumentation study will collect instruments that have been in the field for multiple years, and deploy new instruments to measure currents and temperature over time.

The anticipated data products from FY15 will include

- Multibeam maps generated from mapping activities on the periphery of Papahanaumokuakea MNM and from Johnston Atoll
- Distribution and abundance of deep-sea corals and sponges from select locations in the Papahanaumokuakea MNM and Johnston Atoll
- Temperature and water current data from the main Hawaiian Islands and the Geologists seamounts, and possibly the Northwestern Hawaiian Islands (collected in partnership with Brendan Roark/ Amy Baco survey)
• A time series of environmental, genetic, and life history data for black corals in the main Hawaiian Islands, as well as taxonomic and distribution data for black corals in American Samoa

Data Management
At the end of each cruise, we expect there will be substantial post-processing of the data to final products (i.e. examining video to estimate taxonomies, abundance, and diversity. When this is completed, we will enter the data into the PIFSC geodatabase, document the data with appropriate metadata, and transfer the data to the DSCRTP in the formats that have been specified by the national program. We will also make the data available to be analyzed by other interested researchers through an ArcGIS Server. The budget for a part-time data manager will be $40,000 in FY2015, $42,000 in FY 2016, and $44,000 in FY 2017. The management plan for data products generated from the PICSI will ensure timely delivery of data and metadata from individual projects to the project team, followed by dissemination to the DSCRTP. Although some data products resulting from the PICSI will not be available on an annual basis (for example some of the field and laboratory studies may not produce results until the end of year 3), most data products can be generated within the same year as the field component in which they originated. By requiring individual projects to generate metadata and data for the project team as they become available, we will make sure these products are made available to the DSCRTP for archiving and incorporating into existing databases. Most data generated through this program will also be housed in spatial databases that either exist or will be created at the PIFSC.
APPENDIX 2: Individual Project Descriptions

Attached are short descriptions for each of the 8 projects expected to be funded fully or in part by the Pacific Islands Deep-Sea Coral and Sponge field initiative in FY15-FY17. An overall budget table combining the individual budgets is included. In addition, travel for each of the team members to a 2-day meeting in each year of the project is also included as a line item.

**Full Budget Table (FY15-17)**

<table>
<thead>
<tr>
<th>Project #</th>
<th>Project title</th>
<th>Lead Investigator(s)</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
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<tbody>
<tr>
<td>1</td>
<td>Synthesis of existing deep coral and sponge observations in U.S. Pacific Islands</td>
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<td>$37,000</td>
<td>$37,000</td>
<td>$37,000</td>
<td>$111,000</td>
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<td>$150,000</td>
<td>$150,000</td>
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<td>Community succession in deep sea corals</td>
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Title: Project 1. Creation of an Existing Deep-Sea Coral Records Database focused on Hawaii and the US Pacific Islands for Project Planning and Subsequent Incorporation into the Deep Sea Coral Program’s National Database

Lead Investigator: Christopher Kelley – University of Hawaii (ckelley@hawaii.edu), Les Watling - University of Hawaii (watling@hawaii.edu), Michael Parke - NOAA PIFSC (michael.parke@noaa.gov),

Collaborators: Virginia Moriwake – University of Hawaii, Sonia Rowley – Bishop Museum

Project Duration: 3 years: 2015-2017

Funds Requested: $30,000 for each year for a total of $90,000 over 3 years to cover the estimated costs of 3 months of support to compile a video/database.

Background and Justification:
As mentioned earlier in this proposal, reviewing past research efforts is crucial for designing any research program. We therefore propose to conduct an extensive review of existing deep-sea coral and sponge data obtained from Hawaii and the US Pacific Islands in order to build a working database of known species and depth ranges. In addition to being a planning tool for the overall project, the ultimate destination of the records will be the DSCP National Database to supplement material that has already been incorporated and to provide as complete a dataset as possible for the US Pacific. The most potentially useful types of existing data include archived video records from submersible and ROV dives, museum database records of specimens collected from deep water in the U.S. Pacific, and water quality data from CTD casts.

The Central Pacific, particularly the Hawaiian Archipelago, has benefited from the presence of HURL, its two Pisces class submersibles and a small ROV since 1981. HURL is one of only two facilities of its kind committed to annotating its video archive. The HURL database created from this effort will greatly facilitate the extraction of information on what coral and sponge species are present above 2,000 m in the region, as well as their locations, depths, preferred substrates, and associated communities of fish and invertebrates. In 2014, 40,000 coral records from the HURL database were extracted, formatted, and submitted to DSCP for inclusion into its national database. It’s estimated that at least that many more coral records as well as over 40,000 sponge records still exist at HURL that were not ready to submit at that time. Completing the extraction and compilation of the HURL coral and sponge records in entirety would be of considerable benefit for this project.

The Monterey Bay Aquarium Research Institute (MBARI) is the other facility that has created an annotation database from its ROV dive video. MBARI conducted one Central Pacific cruise in 2001 on its ship R/V Western Flyer to the Main Hawaiian Islands, where
high-resolution video was obtained with their ROV Ventana down to depth of 3,000 m. Though limited in number the compilation of these records that extend below the 2000 m HURL operating depth would benefit the planning and execution of the project as well. Additional video archives that are not yet annotated are available from Jason ROV dives off the R/V Kilo Moana, Shinkai 6500 submersible dives off JAMSTEC’s R/V Yokosuko, and Keiko ROV dives off JAMSTEC’s R/V Kairei. Time constraints will not allow for the annotation of all of these videos however, they can possibly be scanned to at least determine a maximum depth limit for DSCP operations during the next 3 years.

A substantial number of deep sea coral and sponge specimens collected in the U.S. Pacific exist in various museums, such as the (1) National Museum of Natural History, Smithsonian Institution, (2) the Bernice P. Bishop Museum, and (3) the California Academy of Sciences. While many of these have not been formally described in the literature, information about them is catalogued in museum databases.

Data sets are also available for non-substrate, water-column factors important to these animals, such as temperature, salinity, dissolved oxygen, alkalinity, pCO2, and other factors at different levels of resolution that can be used to further our understanding. Extractions from these and other existing data sets will also help guide the research by identifying important research gaps.

**Statement of Work:**
This is a deskwork rather than fieldwork task that will not require the purchase of any equipment or supplies. The DSCP support will be used exclusively for salary, benefits, and overhead costs of a video and database specialist, overseen by the PI of this particular task, and who is trained in the identification of Pacific deep sea corals and sponges. The work will be carried out in the Marine Sciences Building of the University of Hawaii where the HURL video archive, database, and offices are located.

1) Correcting and formatting to the DSCP database fields all remaining cnidarian records, focusing first on gorgonians, antipatharians, and scleractinians, before proceeding to the other groups.
2) Correcting and formatting to the DSCP database fields existing sponge records, focusing first on glass sponges (hexactinellids) before proceeding to the other two groups.
3) Combining these data together with data already provided to DSCP.
4) Combining and formatting database records of corals and sponges from the National Museum of Natural History (Smithsonian), the Bishop Museum, and the California Academy of Sciences.
5) Obtaining all available CTD data, specifically temperature, depth, salinity, and dissolved oxygen, merging these data to those above if and where possible.
**Budget Narrative:**
The $90,000 for this task will pay for approximately 3 months of salary, benefits, and JIMAR overhead (36.7%) for the specialist to accomplish this task in 2015 - 2017. No salary support for either the PI or for a potential volunteer to assist with this project is necessary. The volunteer is a recently retired HURL video specialist who also has considerable experience with Pacific corals and sponges and will be asked to assist with additional annotations as well as extractions from HURL’s VARS database.

**Contingencies**
The only potential problem that could arise is the availability of the specialist to perform this task when needed. In that case, as much of the work as possible will be carried out directly by the PIs and volunteer. If the specialist becomes entirely unavailable, then the PIs will make an effort to identify a graduate student capable and interested in completing this task.

**Title: Project 2. Okeanos Explorer Multibeam Sonar Surveys of PMNM, MTMNM, PRIMNM, and Am. Samoa**

**Lead Investigator:** John Smith – University of Hawaii (jrsmith@hawaii.edu)

**Collaborators:** Daniel Wagner – NOS- Papahānaumokuākea Marine National Monument (daniel.wagner @noaa.gov), Eric Breuer- NOAA-PIFSC

**Project Duration:** 3 years: 2015-2017

**Funds Requested:** $37,000 per year for a total of $111,000 to cover 2 months of salary, benefits, and overhead for Smith

**Background and Justification:**
Beyond its basic operational need for use in manned submersible, ROV, and technical wet dive site planning, the acquisition of high-resolution seafloor mapping data is an essential precursor to making significant biological, geological, and oceanographic discoveries. However, these data can be both expensive and difficult to acquire in areas as remote as the Marine National Monuments of the Pacific. The lack of such data has clearly restricted the pace of discoveries in the proposed regions of study.

Biologically speaking, our ongoing hypotheses across numerous projects have been that 1) high density coral and sponge beds are more common on ridges oriented with accelerated current flow than on ridges with parallel orientation to it; and 2) high density coral and sponges are more common on seamounts with ridge-like shapes and summits oriented perpendicular to the accelerated flow than cone-shaped seamounts. Identifying more of these ridges and seamounts of different shapes is important to testing these
hypotheses. The goal here is to use the mapping data to determine the best sites to place diving assets to investigate the deep-sea biological communities. The contiguous high-resolution multibeam bathymetry can also allow ecological modelers to project species distributions across unsampled locations. Thus, the mapping data are invaluable for identifying the spatial extent of important benthic habitats, potential biological hotspots and vulnerable species locations/distributions.

In a geological sense, quality multibeam data is a key element for delineating and interpreting the morpho-structural origins of the deeper portions of seamounts and similar constructs including the base of the platforms and location of volcanic centers, rift zone ridges, and landslide features. Furthermore, these data allow scientists to model and understand the processes of mass wasting and sediment transport down canyons and debris chutes. More complete mapping at shallower depths permits better correlation of the drowned reef terraces surrounding many of the edifices, and leads to a better understanding of their overall evolution. Fossil reefs host a record of sea-level variability and climate change and, along with analyses of recovered samples, provides a powerful tool for building a detailed paleoceanographic history with implications for the future.

These edifices, which are typically composed of volcanic material capped by carbonates (if they were once shallow enough), have yet another unique geologic feature: polymetallic crusts found at 800-2,500 m depths on their exposed rocky slopes that have precipitated from the overlying water at an average rate of 2.5 mm/Myr. The crusts found in the Central Pacific have the richest content of cobalt (Co) and other commercially valuable minerals in the world. A number of countries are now actively engaged in developing the technology to mine this resource, a process that will be extremely destructive to their associated biological communities. The total area of crust habitat inside the monuments is unknown, and is believed to be substantial, a fact that will likely increase in importance as deep sea mining progresses. Furthermore, it is as yet unclear if there is a significant preference for or against, or consequences of, sessile organisms attaching to these polymetallic crusts.

Finally, additional mapping of these regions will simply lead to a more complete, modern day mosaic of the monuments’ seafloor that will serve as a necessary basemap on which to overlay results from the following studies proposed here. Moreover, the mapping results will act as a roadmap, or catalyst, for further studies of the seamounts, ridges, banks, atolls, and island flanks in these protected areas yet to be proposed. This project will provide a significant contribution toward understanding the ecosystem habitat and marine geology of the Pacific Monuments.

**Statement of Work:**
The first of 3 *Okeanos Explorer* cruises each year will be dedicated to multibeam mapping. The primary mapping system on this ship, an EM 302 multibeam sonar) will
be used to map depths between 500 and 4,000 m. Survey planning will be carried out using Hypack navigation software. Data acquisition, editing, and processing will be carried out using SIS, MB Systems, CARIS, and possibly SABER. The secondary objective will be the creation of updated, or new, bathymetry and backscatter syntheses along with interpretive geological substrate maps for the Pacific Island waters surveyed during this three-year program. The multibeam datasets acquired here, merged with pre-existing multibeam data or existing syntheses, and fused with the USGS GLORIA sidescan sonar mosaics (where available) will provide a full and robust quiver to work with toward this goal. It will permit us to carry out comparisons with similar features and processes in the well-studied main Hawaiian Islands and elsewhere. Though of varying resolutions, navigational consistency, and extent of coverage, a major advantage of working with the different datasets is that they provide a crosscheck to each other. We anticipate there will be enough overlap to maintain assurance that the data and resulting interpretations are accurate and seamless throughout the transitions.

**Budget Narrative:**
Budget calculations were based on 2014 monthly salary, benefits, and overhead rates for John Smith which total $18,500 respectively. Smith will be chief scientist on these cruises and will be responsible for planning and execution of the project work plan, and creating the data products that include updated bathymetry and backscatter syntheses and simplified geologic maps of the various monuments. Shiptime, shipboard technicians, use of the EM302 multibeam sonar, XBTs, and other supplies are expected to be covered by OER. Other participants on these cruises (collaborators, employees or students from PIFSC, UH, or other institutions will be expected to cover their own costs.

**Contingencies:**
In the event that Smith is not available to carry out this project for any of the 3 years, then an alternate PI will be appointed for this project who has experience with the EM302 multibeam system and the software required for planning, execution, and post cruise data processing.

**Title:** Project 3. *Okeanos Explorer* ROV Surveys of PMNM, MTMNM, PRIMNM, and Am. Samoa

**Lead Investigators:** Christopher Kelley – University of Hawaii (ckelley@hawaii.edu), Daniel Wagner – NOS- Papahānaumokuākea Marine National Monument (daniel.wagner@noaa.gov), Michael Parke- PIFSC, (michael.parke@noaa.gov), Les Watling- University of Hawaii (watling@hawaii.edu)

**Collaborators:** Frank Parrish- NOAA-PIFSC and Eric Breuer- NOAA-PIFSC

**Project Duration:** 3 years: 2015-2017
Funds Requested: $150,000 in 2015, 2016 and 2017 to cover 6 months of salary, benefits, and overhead ($120,000) for Kelley in each FY, and to provide OER with $30,000 for operational costs and the development of an improved sampling capability.

Background and Justification:
The Papahānaumokuākea Marine National Monument (PMNM) surrounding the Northwestern Hawaiian Islands (NWHI) represents one of the largest marine protected areas in the world, encompassing over 362,000 km² and spanning close to 2,000 km from the edge of Middle Bank past Kure Atoll. Due to their geographic isolation, the coral reefs of PMNM are among the healthiest and most extensive in the world. Approximately 25% of the Monument’s known marine species are unique to the Hawaiian Archipelago, representing one of the highest rates of marine endemism in the world (Friedlander et al. 2007). At the northernmost atolls (Kure, Midway, and Pearl and Hermes) endemic species make up over 50% of reef fish populations (DeMartini & Friedlander 2004) and 37-53% of the relative abundance of stony corals on each reef (Maragos et al. 2004).

Ninety-eight percent of PMNM's seafloor is found below 100 m. where its resources and potentially unique fauna are far less known. From what little work has been done at these depths, it appears that many of its biological and geological secrets have yet to be discovered. One of PMNM surprises recently unveiled is the presence of high density deep sea coral and sponge beds that appear to be associated with seamounts and rift zone ridges at depths below 1,000 m (Kelley, unpub data). Four of these beds have been located and surveyed by submersible. Additional ridges recently revealed by multi beam mapping suggest that many more of these beds are waiting to be discovered. Furthermore, new types of organisms have been documented on nearly every expedition, indicating that the Monument still contains a very large number of undiscovered species. Limited collections supported on deep-sea beds in PMNM in 2003 recorded eight new species of bamboo corals in six new genera, three new species of stylasterids, one new species of zoanthid, four new species of antipatharians, six new species of sponges and one new sponge genus (Baco 2007; Parrish & Baco 2007; Kelley, unpubl. data). This extraordinarily high rate of new discoveries indicates that PMNM’s deep-sea fauna still contains a large number of undiscovered species and represents an enormous opportunity for future scientific studies.

In 2014, 72 days of multibeam mapping on the R/V Falkor in PMNM’s northern half revealed a complex area of seamounts from intersecting chains that differ in age by at least 50 million years (Kelley et al., in press). Some of these seamounts were never near the surface and have retained their original peaked volcanic summits. Others did reach the surface in the distant past as revealed by their flattened summits, but have since sunk down to depths anywhere between 70 m to below 1,500 m. Some have rift zone ridges
while others do not. How have these differences in topography, depth, age, and ridges affected their deep-sea coral and sponge communities? This area with its different habitat morphologies in close proximity to each other provides an ideal study site for revealing significant new understanding of deep-sea coral and sponge ecology.

This is where this project will begin in 2015, then will move to Johnston Atoll in the PRIMNM, and then west to more monument sites in the Marianas (MTMNM), Wake Island in the PRIMNM, American Samoa, and the Line Islands (PRIMNM), in an effort to continue the effort to improve our understanding of deep-sea coral and sponge ecology across the Pacific, while at the same time, informing management agencies of their resources that have never before been surveyed.

**Statement of Work:** The second and third of 3 Okeanos Explorer cruises each year will be dedicated to conducting deep-sea ROV surveys. Site selection and transect plans will be created in ArcGIS. At the preparation of this report, survey targets include rift zone and drowned reef terrace ridges, seamounts, and submerged craters in the various monuments where deep-sea corals and sponges are expected to be found in abundance. Based on planning information provided by OER, each Deep Explorer ROV dive will have a duration of approximately 8 hrs and cover a minimum distance of 1 km. Exact site selection and survey lines will be created once OER has finalized its plan. Following the cruises, ROV video will be annotated to create deep-sea coral and sponge records for inclusion into the DSCP national database. A GIS project that provides location, species, and abundance data will be updated with the new records.

**Budget Narrative:**
Budget calculations were based on 2014 monthly salary, benefits, and overhead rates for Christopher Kelley, which total $120,000. The six month estimate is based on 1-2 cruises, each of approximately 1 month duration, and 4-5 months for post cruise video annotation and data extraction. Kelley will be chief scientist on these cruises and will be primarily responsible for planning and execution of the project work plan, post cruise video annotation using VARS, and creating the data products that will include coral and sponge records from the video in DSCP national database format, video still images, tracking data, and CTD data. Shiptime, shipboard technicians, use of the Deep Explorer ROV, external hard drives, and other supplies are expected to be covered by OER. Other participants on these cruises (co-PIs, collaborators, and employees or students from PIFSC, UH, or other institutions) will be expected to cover their own costs.

**Contingencies:**
If the weather is too rough at the target dive sites to deploy the vehicle, alternate sites, mostly likely in the lee of atolls/islands will be selected where topographic features that are at least somewhat similar to the target sites can be found. In the event that Kelley is not available to carry out this project for any of the 3 years, then an alternate biologist
experienced with deep-sea coral and sponge identification (and ideally experienced with the VARS video annotation software) will be appointed for this project.

**Title: Project 4. Population ecology, genetics, and modelling of *Antipathes griggi* in Hawaii**

**Lead Investigators:** Daniel Wagner – NOS – Papahānaumokuākea Marine National Monument (daniel.wagner@noaa.gov); Anthony Montgomery – Hawai‘i Institute of Marine Biology – University of Hawai‘i at Mānoa (amont@hawaii.edu); Robert Toonen – Hawai‘i Institute of Marine Biology – University of Hawai‘i at Mānoa (toonen@hawaii.edu)

**Collaborators:** Zac Forsman – Hawai‘i Institute of Marine Biology – University of Hawai‘i at Mānoa (zac@hawaii.edu)

**Project Duration:** 3 years: 2015-2017

**Funds Requested:** $150,000 over three years ($50,000/year)

**Background and Justification:** The Hawaiian black coral fishery has been studied extensively since the 1970s. Despite this previous work, many aspects of the ecology remain poorly understood, and limit effective management of the fishery. Previously published and unpublished data has shown the population of *Antipathes griggi* to be in decline both in terms of the reduction of larger individuals through fishing as well as a decline in recruitment into the population (Grigg, 2004; Montgomery, 2006). Unpublished data from 2009 (A. Montgomery) indicated both a recent decline in recruitment and a decrease in larger individuals within the size structure of the population. Extensive research shows the disproportionate reproductive value of the largest size classes in marine organisms. If the recruitment decline continues and larger individuals are not allowed to remain in the population, this fishery could face rapid and significant declines in the coming years. However, divers on Maui (T. Winn, pers. comm.) report an anecdotal recruitment pulse of black coral around Molokini Crater. Insofar as such reports are reliable, they indicate the population is still changing and needs closer monitoring. The factors causing these changes and their implications for future changes to the population remain poorly understood. Previous research has included multiple assessments of population size structure, basic growth rates, basic reproductive biology, species assemblages across depths, and taxonomic refinement for the various species (Grigg 1965; Grigg, 1976; Grigg, 2001; Grigg, 2004, Montgomery et al., 2006; Wagner et al., 2010, 2011a, 2011b, 2012, 2013, in press; Montgomery, unpub.). However, the population variables of recruitment, growth, mortality, fecundity, colony density, colony distribution, and
population source and sinks have yet to be analyzed together to create a complete picture of the population dynamics as previous research projects have focused on smaller scale research questions.

Here, we propose to fill some of these gaps and collaborate with a corresponding proposal (Wagner – Life history of commercially valuable black corals in Hawaii and taxonomy of black corals in American Samoa). We propose continued monitoring of the population size structure in the Au‘au Channel, Maui, conducting transects at depths that have not been surveyed off Maui (60-80 m), determining the population connectivity of *Antipathes griggi* across small and large scales, and utilizing historical and new data to model the population demographics and distribution. This work would be synergistic with the work proposed by Wagner, and his results would be valuable to input into the population model.

**Statement of Work:**
This work will address four research components including: 1) what is the current population size structure within the Maui black coral beds and how has it changed over time, 2) what are the species and colony densities in the depths of 60-80 m in the Au‘au Channel, Maui, 3) what is the connectivity of *Antipathes griggi* across the Maui beds and other islands (Hawai‘i, O‘ahu, Kaua‘i, Northwestern Hawaiian Islands, and Johnston Atoll), and 4) can we predict the impacts of changes to the population through the development of a population model based on demographics and spatial distributions?

Question one can be addressed by conducting closed-circuit mixed gas dives in the Au‘au Channel that repeat sites previously monitored. Divers will measure colony heights and species at various depths per site. Comparisons of colony size structure can be made across different depths, sites, or habitats. Question two can be addressed by conducting transects to count the number of individuals within broad size categories for each species observed at depths of 60-80 m. This is an important depth zone that remains unexplored because previous surveys have occurred only above 60 m or below 80 m. The amount of potential black coral habitat within this zone is less than above or below, but it also serves a potential transition between varying species assemblages. Previous work has shown that *Antipathes griggi* is dominant above 60 m and *Antipathes grandis* is dominant below 80 m (A. Montgomery, unpub.). No quantitative surveys have been conducted in this transition zone (60-80 m) to date. Questions one and two can be answered in the first year.

Question three can be addressed by using Restriction Digest Associated DNA Sequencing (RAD-seq) to allow comparisons of candidate genes distributed throughout the genome of *Antipathes griggi*. Previous attempts of using mitochondrial and nuclear DNA (cytochrome oxidase subunit I [cox1], large subunit ribosomal RNA gene [rnl, 523
bp], and five intergenic spacers [trnW-nad2, 448 bp; nad5-nad1, 407 bp; rns-cytB, 900 bp with 122 bp non-coding; cytB-rnl, ≈210 bp – two short (≈80 bp) non-coding regions flanking tRNA Met], ITS1, ITS2, beta-actin, beta-tubulin, and calmodulin) have not been able to show sufficient variation between sites of large scale (across the Main Hawaiian Islands). This lack of resolution in the genetic markers is believed to reflect the low variation within mitochondrial DNA and is not useful for population level variation within black corals. With the advancing field of genomic science and the advanced RAD-seq capability of our lab, using a population genomic approach is the best way to determine population connectivity across A. griggi’s distribution within the Hawaiian Archipelago and Johnston Atoll. Previously collected samples are available for this work. We propose to use 30 samples each for four geographic to determine the level of connectivity to outside the Au'au Channel, Maui and three areas within the Au'au Channel to determine population boundaries. This question can be addressed in years two and three.

Question four can be addressed by assembling all new and historical data and building a model that can predict the effects of changing variables on the population demographics, standing biomass, reproductive potential, and other life history characteristics. We propose to combine a species distribution model with a population model to test the interactions of changing demographics and connectivity with disparate colony distributions both within and outside the Au'au Channel. This question can be address in year 3 although this can partially be worked on prior to year three.

**Budget Narrative:**
The proposed budget for this project is $129,000 ($50,000 in 2015 and 2016, $50,000 in 2017). Year one includes salary costs for support from the University of Hawai‘i Scientific Diver Program, supplies for field work (oxygen, helium, CO₂ absorbent, batteries, equipment repair and maintenance parts, and diving related items), travel costs from O‘ahu to Maui for three people (two mixed gas divers and one safety support diver) for 19 days (15 dive days), and vessel rental for 15 days. Year two covers the cost of RAD-seq which currently runs $300 per sample. A proper sample design requires 30 samples per site, so with four sites evaluated, a total 120 samples at $300 is $36,000. Year three includes costs for additional fine scale population connectivity by running samples within a closer proximity (20 additional samples per site for three areas of Au‘au Channel [note that 10 samples from three separate sites within the Au'au Channel will be analyzed in year two, thereby only requiring 20 additional samples per site to have a robust sample design of 30 samples]) if year two shows some population differentiation. Supplies are needed to develop and run the computer model. All costs are subject to the University’s overhead rate of 41.5%.
Title: Project 5. Life history of commercially valuable black corals in Hawaii and taxonomy of black corals in American Samoa

Lead Investigator: Daniel Wagner – NOS – Papahānaumokuākea Marine National Monument (daniel.wagner @noaa.gov)


Project Duration: 3 years: 2015-2017

Funds Requested: $150,000 over three years ($50,000/year)

Background and Justification:
Hawaii is one of only few places, where black coral is harvested for the precious coral jewelry industry, a multi-million dollar business that employs over 650 people statewide. The fishery started in 1958 and has been heralded as a rare example of sustainable fishery management. However, recent surveys indicate substantial declines in black coral populations, and raise questions about whether fishery regulations need to be redefined in order to regain a sustainable harvest. Unfortunately, very little is known about the basic life history of black coral, which complicates effective management of the fishery. The objective of this project is to characterize the growth rates and minimum size of reproductive maturity of the three commercially valuable Hawaiian black coral species (Antipathes griggi, A. grandis and Myriopathes cf. ulex), and determine whether these parameters vary by depth. Field surveys will be performed using mixed-gas technical diving at depths between 50-90 m off Oahu. Black coral colonies will be tagged and measured, and re-measured over a three year period to determine their growth rate. Additionally, colonies will be sampled to determine their reproductive maturity using standard histological techniques (Wagner et al. 2011a, 2012). This research will provide key parameters which are essential to update models that have been used to manage the Hawaiian black coral fishery. The project will therefore provide tools that are urgently needed to improve the management of the fishery. Effective management has important implications, both economic and ecological. Ensuring a sustainable fishery supports a continued $30 million commercial industry. Protection of these important foundational species also has broader ecological implications, because black corals provide critical habitat for a myriad of associated species, including feeding grounds for the endangered Hawaiian monk seal and many other species.
Additionally, the lead investigator and collaborators of this study will be in American Samoa in February 2015 to conduct crown of thorns eradication efforts. Given the rare occasion of having a mixed-gas technical diving team in American Samoa, we are requesting a limited amount of funds to conduct taxonomic surveys of deep-water (50-100 m) black corals there. With the exception of very limited surveys using towed camera systems (Bare et al. 2010), this depth range has never been surveyed in American Samoa.

**Statement of Work:**
The objective of this project is twofold: (1) to characterize the growth rates and minimum size of reproductive maturity of the three commercially valuable Hawaiian black coral species (*Antipathes griggi*, *A. grandis* and *Myriopathes cf. ulex*) in Hawaii, and (2) to conduct a taxonomic survey of black coral populations accessible through mixed-gas technical diving off American Samoa. In terms of the first objective, the proposed research project seeks to answer the following questions which are essential to the management of the Hawaiian black coral fishery: (1) What is the growth rate and does it change as colonies get larger? (2) What is the minimum size of sexual reproduction? (3) Do growth rates and minimum size of reproduction vary in colonies found at different depths (50-90 m)? Field surveys and specimen collections will be performed using trimix technical diving using closed-circuit rebreathers at depths ranging between 50-90 m off the south shore of Oahu. Black coral populations off south Oahu have already been surveyed previously as part of a related project, and include dense aggregations (1 colony/m²) of all three commercially valuable species. At these sites, black coral colonies covering a wide range of colony sizes will be tagged with a label attached to the base, and their height and width will be measured by using a tape measure underwater. Tagged colonies will be visited again within 36 months, and re-measured to determine their growth rate. Additionally, all tagged colonies will be sampled to determine their reproductive maturity. For this purpose, samples consisting of 3 cm branchlets will be clipped from the mid-section of each colony, preserved in 10% buffered formalin, and transferred to 70% ethanol after 3-5 days. Histological sections of preserved specimens will be prepared using standard histological techniques at the Histological and Imaging Core Facility located at the John A. Burns School of Medicine (JABSOM) of the University of Hawaii. Sections will be viewed under light microscopy to determine whether specimens are reproductively mature.

In terms of the second objective, the proposed research seeks to understand what black coral species exist at depths accessible through mixed-gas technical diving (50-90 m) off American Samoa. Field surveys and specimen collections will be performed using trimix technical diving with the aid of closed-circuit rebreathers at depths ranging between 50-90 m. Black coral colonies will be photographed *in situ* and 3 cm samples collected and
preserved in 10% buffered formalin. Samples will be prepared for scanning electron microscopy (SEM) (Wagner et al. 2010, 2011b) and viewed at the Biological Electron Microscope Facility (BEMF) at the University of Hawaii.

**Budget Narrative:**
The proposed budget for this project is $150,000 ($50,000/year over three years) and includes (1) boat charters to conduct dive operations off the south shore of Oahu and off American Samoa, (2) supplies for diving and specimen collections, (3) contractual costs to the Histological Core Facility at JABSOM to conduct histological analyses of collected specimens, (4) contractual costs to the BEMF to conduct electron microscope analyses of collected specimens, and (5) per-diem costs for one week of field work in American Samoa.

**Title:** Project 6. Community succession in deep sea corals

**Lead Investigator:** Samuel Kahng – Hawaii Pacific University (skahng@hpu.edu)

**Collaborators:** Meagan Putts – Hawaii Pacific University

**Project Duration:** 3 years: 2015-2017

**Funds Requested:** $30,000 in 2015, $35,000 in 2016 and $35,000 in 2017 for a total of $105,000 over 3 years to cover the estimated costs of 1 ROV dive in 2015 and 1 ROV dive in 2017

**Background and Justification:**
Given the heightened awareness of potential anthropogenic impacts (e.g., trawl fishing, precious coral harvesting, eutrophication/sedimentation, climate change, etc.) on deep-water coral communities (e.g., Koslow and Gowlett-Holmes 1998; Roberts 2002; Kleypas et al. 2006; Waller et al. 2007, the need to understand recovery processes and community succession are of increasing importance and relevance for resource managers (Ross and Nizinski 2007). Unfortunately, many deep-water corals and sponges are long-lived, making longitudinal studies difficult or unfeasible (Grigg 1976). In Hawaii, the lava flows on the Big Island provide a unique opportunity to examine ecological processes across time. Large lava flows entering the sea have been accurately recorded for over 200 years (Holcomb 1987; Lockwood and Lipman 1987; Moore et al. 1987). Radiocarbon dating of charcoal from beneath lava flows of Mauna Loa, Kilauea, and Hualalai have provided a detailed prehistoric eruptive history for about one third of the lava flows throughout the Holocene (Moore et al. 1987; Rubin et al. 1987). Each lava flow represents a severe but localized disturbance event that created fresh substrata and restarted the ecological clock on community succession of the deep-water coral communities. By comparing communities on successively older lava flows to each other
and to “undisturbed” control communities adjacent to each flow (usually of much older age), patterns and timelines of community succession can be reconstructed (Grigg and Maragos 1974). This is the objective of this project.

**Statement of Work:**
Given DSCP budget constraints, this project is only aiming to conduct a single dive per year from 2015 to 2017. Each dive will focus on a single lava flow of known age. Three lava flows have already been surveyed in a previous study on 400 m depth Corallium communities by the Pisces submersible (Kahng & Putts, unpub data). There are two options for this new DSCP effort: 1) to continue the study of disturbance and recovery of 400 m Corallium communities but on different lava flows of different ages, or 2) survey at deeper depths (i.e., 1000 m on the three flows already surveyed at 400 m, thereby expanding the previous study to the deeper isidid/chrysogorgiid communities.

**Budget Narrative:**
The *Okeanos Explorer* ROV dive rate is $30,000 per day for 2015. The University of Hawaii Luukai ROV dive rate for 2014 including ship costs is $58,000. Since 2016-2017 day rates are unknown and it is not clear at this time which type of vehicle will be available for this project, the budget estimate for this project was based on an expected rate of $35,000 per dive day using the EX. Kahng will be chief scientist on these dives that will be piggybacked onto the annual cruise conducted for project 3. Kahng will be primarily responsible for planning and execution of the project work plan, post cruise video annotation, data extraction and analysis, and creating the data products that will include coral and sponge records from the video in DSCP national database format, video still images, tracking data, and CTD data. Kahng has agreed to provide his time for this project without compensation. External hard drives, and other supplies are expected to be covered under the day rate for the ROV. Other participants on these cruises (collaborators, and employees or students from HPU or other institutions) will be expected to cover their own costs.

**Contingencies:** In the event that Kahng is not available to carry out this project for any of the 3 years, then his collaborator, Meagan Putts, will be appointed as substitute PI.

**Title:** Project 7. Submersible/ROV surveys on the Geologist Seamounts to identify ecosystem conditions for deep sea corals and sponges

**Lead Investigators:** Christopher Kelley – University of Hawaii (ckelley@hawaii.edu) and Les Watling – University of Hawaii (watling@hawaii.edu)

**Collaborators:** Scott France, Henry Reiswig, Steven Cairns, Brendan Roark

**Project Duration:** 3 years: 2015-2017
Funds Requested: $150,000 in 2015, 2016, and 2017 for a total of $450,000 over 3 years to cover the estimated costs of 4 ROV dives per year and one month of post cruise video annotations per year.

Background and Justification:
The Pacific Ocean has by far the largest number of seamounts of any ocean on the planet. Many of these are volcanoes, formed episodically since the mid-Cretaceous period along the eastern boundary of the Pacific plate and subsequently rafted to different locations across the basin due to the northwesterly movement of the plate. A strange ring of these ancient volcanoes, estimated to be approximately 80 million years old, wound up within 100 miles southwest of the Big Island of Hawaii (Fig. 1). This ring, referred to as the Geologist Seamounts, is virtually unexplored even though it is located only one transit day from Honolulu. Only three of the 12 major seamounts comprising this ring have ever been visited, two of which by only single, relatively short submersible dives back in 1996. Though brief, these dives did confirm the presence of thick Mn-crust deposits suggestive of very old origins and geologic histories quite different than that of the nearby Hawaiian Islands.

Eleven of the 12 seamounts have never been close to the surface and have therefore retained their original volcanic peaks and ridges, each having its own unique shape and size. This topographic variety in close proximity offers an unprecedented means to examine how landscape influences deep sea community structure. We predict that dense communities of corals and sponges will be found on some of these seamounts, but not on others, and the reason is due to differences in their shapes and orientations relative to the direction of the M2 tide. Of particular interest are the ridge-type seamounts that include Swordfish, Ellis, and McCall, since ridges in the PMNM have been found to be sites of the most dense coral and sponge communities found so far in the central Pacific. We hope to find similar communities in the Geologist Seamounts as well as new species and known species not previously documented in this area of the Pacific.

Statement of Work:
We propose to explore for the first time ever three of the ridge type seamounts, Swordfish, Ellis, and McCall, during 3 separate cruises in years 2015-2017. Each cruise will be 4 days long and will involve the deployment of the ROV from the NOAA ship Okeanos Explorer in 2015. For 2016 and 2017, we will use the OE (if available), or some other combination of vessels and ROVs from the University of Hawaii or the PIFSC. The ROV will be used to conduct transects along the summit ridge and flanks of each seamount. During the surveys, one of the vehicles cameras will be pointed downward in order to document deep water coral and sponge orientations. We will also try to fit a small downward facing ADCP to simultaneously record current velocity and direction along the bottom for correlation to the video data. Corals and sponges will be collected
for taxonomic, genetic, and reproductive studies. Rocks will be collected for determination of age, origin, and thickness of Mn-crusts.

Analysis of the video data obtained on this will potentially yield insights on the relationship between topography, current velocity and direction, and deep water coral and sponge communities. Analysis of rock samples should lead to a better understanding of the origin and age of these seamounts, which at the moment are presumed to be similar for all 12 of the seamounts in this ring, although those assumptions have never been proven. Biological collections will almost certainly result in new species and new records for the mid-Pacific. These along with observational data from the video should provide greater insight on the connectivity of these seamounts to the Hawaiian Archipelago and other locations in the Pacific.

**Budget Narrative:**

*Okeanos Explorer* ROV dive rate is $30,000 per day for 2015. The University of Hawaii Luukai ROV dive rate for 2014 including ship costs is $58,000. Since 2016-2017 day rates are unknown and it is not clear at this time which type of vehicle will be available for this project, the budget estimate for this project was based on an expected rate of $35,000 per dive day using the *EX*. The 4 dive days per year include the transit to and from Honolulu Harbor. The remainder of the budget request for this project is for personnel costs for post cruise video annotation and data extraction, and is based on expectations of a minimum of 40 hrs of video per year and a required annotation time estimate of 4X video length or 160 hrs. Kelley will be chief scientist on these cruises and will be primarily responsible for planning and execution of the project work plan, post cruise video annotation using VARS, and creating the data products that will include coral and sponge records from the video in DSCP national database format, video still images, tracking data, and CTD data. External hard drives, and other supplies are expected to be covered under the day rate for the submersible or ROV. Other
participants on these cruises (co-PIs, collaborators, and employees or students from PIFSC, UH, or other institutions) will be expected to cover their own costs.

**Contingencies:**
If the weather is too rough at the target dive sites to deploy the vehicle, an alternate site, mostly likely in the lee of the Big Island will be selected where topographic features that are at least somewhat similar to the target sites can be found. In the event that Kelley is not available to carry out this project for any of the 3 years, then an alternate biologist experienced with deep sea coral and sponge identification (and ideally experienced with the VARS video annotation software) will be appointed as the substitute PI for this project.

**Title:** Project 8. Instrumentation and environmental monitoring.
**Lead investigator:** Frank Parrish – NMFS- Pacific Islands Fisheries Science Center

**Collaborators:** Brenda Roark and others to be named

**Project Duration:** 3 years: 2015-2017

**Funds Requested:** $335,000 over 3 years

**Background and Justification:**
Two decades of surveys in the Main Hawaiian Islands has provided a good sense of where different patches of deep corals occur and have prompted questions about why some corals occur in some areas and not others. Environmental data loggers have been opportunistically deployed and collected on Pisces submersible dives over the last few years such that an acoustic current meter and 9 flow meters with thermographs, which are all still on the bottom waiting for recovery. We need to recover these instruments and their data to create a coordinated approach to documented environmental differences at known sites.

**Statement of work:**
In 2015 we will seek boat time and ROV capability to recover this equipment. Also in 2015 we will develop landers with an improved suite of sensors to deploy at known sites in a comparative approach that characterizes the year round environment of deep coral assemblages. The landers will be recovered in 2016, and new ones will be deployed. These landers will be recovered in 2017 and the data analyzed by a post-doc with the appropriate data analysis experience to move the findings directly to publication.

**Budget Narrative:**
The Okeanos Explorer ROV dive rate is $30,000 per day for 2015. The University of Hawaii Luukai ROV dive rate for 2014 including ship costs is $58,000. Since 2016-2017
Day rates are unknown and it is not clear at this time which type of vehicle will be available for this project, the budget estimate for this project was based on an expected rate of $35,000 per dive day using the EX. The proposed budget for this project is $340,000, $110,000 which includes 2 ROV dive days and equipment and contract labor for development of landers in 2015, and 2 ROV dive days in 2016, and 2 ROV dive days in 2017, and hiring of a part-time post-doc to help process, document, and analyze instrument data.

**Title: Project 9: PIFSC multibeam surveys of Am. Samoa, PRIA, HI and Marianas (focused on <500 m)**

**Lead Investigators:** John Rooney (john.rooney@noaa.gov) & Frances Lichowski (frances.lichowski@noaa.gov) - Joint Institute of Marine and Atmospheric Research, University of Hawaii and PIFSC

**Collaborators:**

**Project Duration:** 3 years 2015-2017

**Funds Requested:** $86,000 in 2015, $88,000 in 2016, and $90,000 in 2017 for a total of $264,000 for 3 years

**Background and Justification:**
The NOAA Ship Hi’ialakai had her multibeam systems refurbished and upgraded during a dry dock period in FY14 and shipboard personnel received training in data acquisition using the Kongsberg multibeam echosounders and ISS2000 software installed onboard. This proposal seeks to take advantage of the ship’s multibeam capabilities while this TAGOS class vessel is still in operational status. We propose to fill gaps in coverage of deep sea coral habitats with ancillary missions using ship’s personnel to collect data on a not interfere basis with the ship’s primary missions. Surveying can be accomplished at night or during other periods when the ship’s capabilities are under-utilized. Recognizing the need for additional multibeam data collection in the region, the NOAA Office of Marine and Aviation Operations supported the Hi’ialakai multibeam refurbishment and the Marine Operations Center – Pacific Islands has endorsed the approach outlined here for cost effective data collection and better utilization of the ship’s capabilities. Support of the Hi’ialakai, as well as agencies and chief scientists with cruises onboard the Hi’ialakai, will be requested over the next 3 years to support this effort.

Funds are requested to support updates of existing multibeam syntheses with data collected recently, both by PIFSC and other agencies, and for preparation and delivery of those data to the Hi’ialakai to enable surveying to fill gaps in coverage. Additional funding is requested to then process collected data, update existing multibeam
bathymetry and backscatter syntheses and maps, and provide the data and associated metadata to the National Geophysical Data Center. Updated grids and maps showing the bathymetry and backscatter imagery around each island, along with associated metadata will also be made available for viewing and download on the Pacific Islands Benthic Habitat Mapping Center website (http://www.soest.hawaii.edu/pibhmc).

In the event that there are cruises in which ships’ personnel are unable to collect multibeam data, but a science berth and time at night or other times are available, a trained scientist could go aboard to run the multibeam acquisition. In the event that a scientist is required to conduct multibeam survey operations, and alternative funding scenario is requested, to cover an estimated 50 scientist sea days per year, along with required travel funds (r/t Honolulu-Guam, FY17).

The Hiialakai is scheduled to conduct cruises in American Samoa, the Pacific Remote Islands Area (PRIA) and Northwestern Hawaiian Islands (NWHI) in FY15. It is expected that she will also have cruises to the MHI and NWHI in FY16 and to the Mariana Archipelago and NWHI in FY17. Considerable surveying within deep sea coral depths remains to be completed in each of these locations.

Statement of Work:
FY 2015: Multibeam data synthesis and preparation (3.0 mo.), processing of newly collected data, delivery of data and metadata to NGDC (3.0 mo.), production of updated maps of bathymetry and backscatter (1.0 mo.), webpage development (0.5 mo.), project management (0.5 mo.).

FY 2016: Multibeam data synthesis and preparation (3 mo.), processing of newly collected data, delivery of data and metadata to NGDC (3 mo.), production of updated maps of bathymetry and backscatter (1 mo.), webpage development (0.5 mo.), project management (0.5 mo.).

FY 2017: Multibeam data synthesis and preparation (3 mo.), processing of newly collected data, delivery of data and metadata to NGDC (3 mo.), production of updated maps of bathymetry and backscatter (1 mo.), webpage development (0.5 mo.), project management (0.5 mo.).

Budget Narrative:
FY 2015: Contract Labor $86,000
FY 2016: Contract Labor $88,000
FY 2017: Contract Labor $90,000
 References


