PACIFIC ISLANDS FISHERIES SCIENCE CENTER

NOAA Deep-sea Coral and Sponge Research
and Management Priorities Workshop
for the Pacific Islands Region
Honolulu, Hawaii
April 22–23, 2014

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August 2014

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NOAA Deep-sea Coral and Sponge Research and Management Priorities Workshop for the Pacific Islands Region
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BACKGROUND

NOAA's Deep Sea Coral Research and Technology Program (DSCRTP) was established under Section 408 of the Magnuson-Stevens Act. In 2009, NOAA received funding to begin implementing field research efforts as part of the program. Initial efforts focused on a single region (South Atlantic), with the intent that funding would be for 3 years and rotate to other regions (e.g. West Coast in 2010 and Alaska in 2012, and Northeast in 2013) as funding levels allowed. To maximize the opportunity to meet the requirements of the DSCRTP, NOAA is conducting workshops to determine and evaluate regional exploration and research priorities. These will be used to form investment strategies for the regional 3-year field research efforts.

On April 22–23, 2014, scientists and resource managers met in Honolulu to identify critical information needs for deep-sea coral and sponge ecosystems in the Pacific Islands Region. The goal of the workshop was to develop a 3-year exploration and research priorities plan. Workshop participants represented a broad range of stakeholders, including representatives from the Federal Government, the Western Pacific Fishery Management Council (WPFMC), and academia (see Appendix A for a list of participants).

ACCOMPLISHMENTS

Workshop accomplishments included: (1) identifying a core list of critical information needs related to locating, surveying and modeling deep-sea corals; (2) understanding current knowledge on deep-sea coral biology and ecology; and where possible, using that knowledge to manage human impacts on deep-sea coral ecosystems; (3) identifying data sets that exist for analysis to help refine subsequent field operations; and (4) identifying initial research activities and geographical targets for meeting the Pacific Islands scientific and management needs. The information from the workshop will be used as a guiding framework to improve our knowledge, conservation, and management of deep-sea coral and sponge ecosystems in the U.S. Pacific.

Workshop recommendations for future work in the U.S. Pacific included: (1) identifying the environmental factors that affect distribution of deep-sea corals and sponges; (2) characterizing the biogeographic patterns at the basin scale; (3) documenting the resilience of deep coral assemblages after disturbance; (4) determining what new insights can be derived from existing data sets; and (5) determining the vertical distribution of coral and sponge assemblages on the steep pinnacle features of the Pacific plate.

**THE NOAA STRATEGIC PLAN FOR DEEP-SEA CORAL
AND SPONGE ECOSYSTEMS**

The NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems identifies national-level goals, objectives, and approaches to guide NOAA's research, management, and international cooperative activities on deep-sea coral and sponge ecosystems for 2010 through 2019. The Strategic Plan provides the national context for the fieldwork and research that this workshop was designed to inform. The primary goal of the Strategic Plan is to improve the understanding, conservation, and management of deep-sea coral and sponge ecosystems. The Strategic Plan covers deep-sea coral and sponge ecosystems under the jurisdiction of the United States and international cooperation activities conducted by the United States.

The Strategic Plan is divided into three sections: (I) exploration and research, (II) conservation and management, and (III) international cooperation.

Section I identifies the role of research in management, including NOAA's priorities and objectives for research and exploration of deep-sea coral ecosystems and anticipated products for each objective. The goal of NOAA's exploration and research on deep-sea coral and sponge ecosystems is to provide sound scientific information that will enable effective ecosystem- based management decisions.

Section II lays out objectives and approaches that NOAA will undertake to enhance protection of deep-sea coral and sponge ecosystems in collaboration with the Regional Fishery Management Councils, National Marine Sanctuaries (NMS), and other Federal agencies and partners. NOAA's strategy for managing deep-sea coral and sponge ecosystems is centered on the authority provided to NOAA through the Magnuson-Stevens Fishery Conservation and Management Act and the National Marine Sanctuaries Act.

Section III describes NOAA's objectives to enhance international conservation of deep-sea coral and sponge ecosystems. Those objectives are to 1) promote international partnerships to conserve deep-sea coral and sponge ecosystems through the management of deep-sea fisheries activities impacting those resources; 2) ensure that international trade of deep-sea coral and sponge species, and their parts and products, is sustainable; and 3) increase international exploration and research of deep-sea coral and sponge ecosystems.

The Strategic Plan provides guidance for all NOAA programs supporting research, management, and international cooperation activities on deep-sea coral and sponge ecosystems. This workshop focused primarily on Section I (exploration and research strategy) of the Strategic Plan to identify critical information needs for Pacific Islands waters under U.S. jurisdiction.

ABOUT THE WORKSHOP

The goal of the workshop was to identify exploration and research priorities for 3 years, commencing in Fiscal Year (FY) 2015, that address management needs for deep-sea coral and sponge ecosystems in U.S. Pacific Island waters. The workshop was scheduled in FY 2014 and organized by the Pacific Islands Fisheries Science Center (PIFSC) and NOAA's DSCRTP. A Steering Committee (Appendix A) consisting of representatives from NOAA (OAR, ONMS and NMFS), the University of Hawaii, and the WPFMC developed the workshop's goals, objectives, schedule, logistics, and final summary.

The workshop consisted of two parts: 1) presentations providing a general overview on the goals of the national DSCRTP, followed by presentations on the state of knowledge on deep corals in the Pacific, the associated management responsibilities, and potential tools for future investigations, and 2) a series of breakout group discussions to identify and refine critical information needs followed by plenary discussions (Appendix B).

Presentations

To set the context for identifying critical information needs, several presentations were given to provide an overview of national and regional plans, as well as background information on the current state of Pacific Islands deep-sea coral and sponge ecosystems and management actions.

The presentations of national and regional plans included:

- **An overview of NOAA's Deep-Sea Coral Research and Technology Program in the context of the Strategic Plan for Deep-Sea Coral and Sponge Ecosystems** (Tom Hourigan, NOAA DSCRTP). Research, Management, and International Cooperation, all of which have already been covered in this document.

- **An overview of the known taxonomy and depth distributions in the Pacific Region** (Chris Kelley, University of Hawaii School of Ocean and Earth Science). In the central Pacific, there are at least 289 known species of deep-water cnidarians and 59 species of deep-water sponges. Families that have the most records (i.e., numerically dominant) are Isididae, Primnoidae, Corallidae, Parazoanthidae, Antipathidae, Chrysogorgiidae, Aphanipathidae, and Plexauridae, for corals, and Pheronematidae and Euplectellidae for sponges. For corals, the Plexauridae, Isididae, and Primnoidae have the most undescribed species, whereas 58 of the 59 species of sponges have not been described. The biggest gap in our knowledge of their depth distributions is below 2000 m, where available vehicles such as the HURL submersibles and remotely operated vehicles (ROVs) have not been able to operate.

- **The precious coral fishery** (Joshua DeMello, Western Pacific Fishery Management Council). The precious coral fishery management plan was the first to manage the fishery when the Western Pacific Fishery Management Council was formed. It has since been folded into the Hawaiian Archipelago Regional Ecosystem Fishery Management Plan, as all the sanctioned harvest activity to date has been at 2 coral beds in the main Hawaiian Islands. The only other

coral fishery has been by foreign fleets that conducted some illegal dredging at the northwest end of the Hawaiian EEZ in the 1980s targeted at *Corallium*. The fishery management plan employs an area-based management approach with maximum sustainable yield and designation of Habitat Areas of Particular Concern under the Essential Fish Habitat mandate. At first dredges were used and now all harvest must be selective using a ROV or submersible. At shallower depths, there is a black coral fishery (*Antipathes* spp. and *Myriopathes* sp.) that has been operating since the 1950s in the channel between the islands of Maui and Lanai, with harvesting conducted by scuba divers. Currently there is a moratorium on the gold coral fishery, the pink coral fishery is dormant, and there is one permit for the harvesting of black corals.

- **Deep-sea corals and sponges in the Sanctuaries and Monuments of the U.S. Pacific** (Daniel Wagner, Papahānaumokuākea Marine National Monument). This presentation provided an overview of geographical areas within the U.S. Pacific Islands that have been surveyed for deep-sea corals and sponges, with a focus on the Monuments and Sanctuaries of the region. Sampling effort for deep-sea fauna has been greatest in the Hawaiian Archipelago, followed by Johnston Atoll, American Samoa, Kingman Reef, Palmyra Atoll and Jarvis Island. To date, the deep-sea fauna off Wake Island, Howland Island, Baker Island and the Mariana Trench Marine National Monument have never been surveyed. However, even within regions that have been relatively well surveyed, large areas remain completely unexplored, such as the windward sides of several of the main Hawaiian Islands and numerous seamounts in the Northwestern Hawaiian Islands.

- **Deep-Sea Coral Habitat Management** (Danielle Jayewardene, Habitat Conservation Division of NOAA Fisheries Pacific Islands Regional Office PIRO). Today, a large proportion of the anthropogenic impacts to benthic habitat in the Pacific Islands Region occur in near-shore shallow waters around islands populated by humans. However, military activities and offshore development, which are likely to increase in occurrence in the future, can significantly impact deep-sea coral and sponge habitat. NOAA Fisheries has some authority to regulate impacts to mesophotic and deep-sea habitat through implementation of federal mandates such as the Magnuson Stevens Fishery Conservation Management Act and the Fish and Wildlife Coordination Act; the challenge, however, is that there is insufficient science and a lack of tools available to effectively do so.

- **Deep Coral Predictive Modeling Methods and Applications Overview** (Brian Kinlan, National Center for Coastal and Ocean Science). Modeling is an iterative process starting with available data and then revised and updated as additional data becomes available. Sources of data include historical records from museums, dive reports, published papers, fishery data, submarine and ROV video. Variable types can range from presence only to presence/absence, abundance, and diversity. Presence only data employs maximum entropy approaches, where boosted regression trees are used when absence data are also available. General additive models and general linear models are used with data sets of greater resolution such as abundance and diversity. Covariates used in the models include temperature, oxygen, slope, salinity, Chl-a, rugosity, and others. A number of models applied to deep coral systems were reviewed to highlight how it can be an essential tool for planning, synthesis, and application of field-survey effort.

- **OAR FY15 plans for the Pacific** (Craig Russell, Office of Ocean Exploration and Research) The Okeanos Explorer Program will have its vessel out in the Pacific beginning 2015 and is looking to support deep coral exploration. The vessel is equipped with multibeam, ROVs, and a telepresence capability that provides both an outreach tool and a scientific tool, so that scientists that are not onboard can participate and contribute. Operations will begin in Hawaii and then expand to other areas of the Pacific. A west coast workshop in December 2014 will identify and prioritize specific areas within the U.S. Pacific to study. It is possible to get involved by participating in the cruise planning calls and web meetings.

Breakout Group – Day 1

Workshop participants were divided into three breakout groups centered on different themes (biology and ecology, distribution and taxonomy, human impacts), and tasked with identifying and prioritizing a list of research questions within each theme. The breakout groups were instructed to use the NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems, the Reauthorized Magnuson-Stevens Fishery Conservation and Management Act that established the DSCRTP, and the background information provided in the presentations as guidance.

Plenary Discussion – Day 1

A rapporteur from each breakout group presented the list of questions for their topic (see Appendix C). Each workshop participant was then asked to identify up to three critical information needs per topic that they believed to be the highest priorities. The results of this group prioritization exercise are reviewed below.

Breakout Group – Day 2

On Day 2, the same breakout groups were tasked to develop a list of exploration and research activities for the next 3 years that would address the prioritized list of critical information needs. Breakout groups were asked to identify the location, methodology, time-frame, duration, and potential collaborators for projects addressing those activities. Prioritization of activities was based on whether 1) they addressed a gap and/or management need; 2) whether they were financially feasible; and 3) whether they had the potential to leverage funds and/or collaborate with other funded programs.

Plenary Discussion – Day 2

Participants reconvened in plenary session and each breakout group presented its prioritized list of exploration and research activities. During the final plenary discussion, participants focused on identifying potential opportunities and constraints that might affect the exploration and research activities. A summary of activities identified by participants is provided below under the NOAA Strategic plan objectives.

INFORMATION NEEDS AND RESEARCH ACTIVITIES

Five priority questions were identified by the workshop participants including:

1) What are the environmental factors affecting distribution?
2) What are the biogeographic patterns at the Pacific basin scale?
3) How long for a deep-sea coral or sponge community to recover from disturbance?
4) What can be derived from existing data sets?
5) What is the vertical distribution across depths including > 2000 m?

The following section summarizes the information needs and research activities identified by the participants as they relate to the five objectives.

Question 1: What are the environmental factors affecting distribution of deep corals and sponges? The environmental variables that govern where deep coral and sponge communities colonize and develop into mature assemblages are poorly understood. Having information on the conditions needed to support these ecosystems is valuable, as this provides the parameters needed for planned modeling activities.

Specific Information Needs

Workshop participants identified the following critical information needs as they relate to this NOAA Strategic Plan objective.

- Define environmental factors, analysis of existing data, draft probable models.
- Identify places with the best environmental and coral data to build supervised models (need better taxonomy).
- Identify parameters that might be important to measure *in situ* (e.g., temperature, oxygen, carbonate chemistry parameters, substrate type, slope, rugosity, current, surface productivity, sedimentation rates). Feed these data to models to improve the quality.
- Identify at what spatial and temporal scales environmental parameters need to be studied.
- Determine whether the DSC program can be used to start a long-term monitoring effort for at least one site in the U.S. Pacific. Such a site needs to be close enough that is logistically feasible to get there on a routine basis (e.g., Cross Seamount).
- Link to ongoing long-term monitoring efforts (e.g., Station Aloha).
- Line Islands could provide good case study due to large environmental gradients in this island group.

Question 2: What are the biogeographic patterns at the basin-scale? There is a need to expand surveys to undersampled regions in the U.S. Pacific including the Marianas, the PRIAS and American Samoa. To do this effectively, the existing expertise (e.g., HURL, HIMB, USGS, Amy Baco, Scott France, Cheryl M., Les Watling, Chris Kelley) need contributions from both taxonomists and geneticists. Additionally, consistent taxonomy needs to be applied, and where possible, genetic samples need to be collected in order to evaluate the degree to which various assemblages are connected.

Specific Information Needs

Workshop participants identified the following critical information needs as they relate to this NOAA Strategic Plan objective.

- Analysis and synthesis of existing data and not limited to U.S. data (e.g., Japan, Australia). The need to link to international efforts.
- Video analysis of available sources of data. For example the *Falkor* will be going to Marianas to collect video data that needs to be analyzed, and the *Okeanos Explorer* also has future plans to go to these remote unexplored areas.
- Conduct studies in different island groups, link to current and other environmental data and presence and absence data of corals.
- Sites like the Au'au coral bed and Makapuu bed have been intensively surveyed, but may be unique in the U.S. Pacific. Can we learn something about these beds that is applicable to other regions (via models)? WPRFMC and Whales Sanctuary are interested in these areas, and could help get more data in these places to refine models.
- Identify priority groups for taxonomic refinement.
- Collecting new samples for genetic analyses. These samples could be used for studies that relate with various other questions (taxonomy, depth distribution, etc.). A ROV/manned submersible with bio-box is essential.
- Consider both within and between archipelagos connectivity.
- Study where we know deep-sea corals and sponges exist. Broad scale-initially and then finer scale later.
- Priority groups: precious corals, groups with good taxonomy.
- Consider both within and between archipelagos connectivity.
- Recruitment, resilience need to be incorporated into these efforts. Can we link this to ongoing efforts by Brendan Roark and Amy Baco-Taylor?
- Are there refugia where impacts occur (e.g., areas close to black coral and precious coral harvesting)?

Question 3: How long does it take a deep-sea coral or sponge community to recover from disturbance? Deep-sea corals can 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, military activities, energy exploration and development, and cable deployment. Additionally, ocean acidification may affect corals' ability to grow and maintain their structures.

Specific Information Needs and Activities

Workshop participants identified the following critical information needs and activities as they relate to this NOAA Strategic Plan objective:
- Classify potential impacts in the region into groups such as harvesting, underwater explosions (military), anchor/cable damage, landslides, lava flows, or land-based pollution.
- Classify disturbance types as lethal vs. non-lethal.

- Use existing natural gradients of impact as a natural experiment to get a sense of how populations might be recovering. There are several places in the U.S. Pacific where there are gradients in terms of how much impacts have occurred (e.g., gradient of fishing impacts from high in the MHI to low in NWHI).
- Study biological parameters that relate to recovery such as recruitment rates, connectivity (distance to nearest populations), and growth rates.
- Link ongoing projects to this effort:
  - Sam Kahng has a colonization/succession project on lava flows off Big Island
  - Project by Brendan Roark and Amy Baco this fall in NWHI addresses recovery
  - Previous black coral tagging work by Tony Montgomery could be resurveyed
  - Frank Parrish bamboo/gold coral succession studies could be expanded
  - Daniel Wagner past black coral reproduction and taxonomy work could continue
  - Rhian Waller past reproduction work could continue

Question 4: What can be derived from existing data sets? The central Pacific, particularly the Hawaiian Archipelago, has benefited from the presence of deep-water manned submersibles and an ROV operated by the Hawaii Undersea Research Laboratory (HURL). HURL maintains a video and still image archive and is one of the only facilities of its kind that has committed to annotating its archive. The HURL database created from this effort can be used to extract information on what coral and sponge species are present in the region, as well as their locations, depths, preferred substrates, and associated communities of fish and invertebrates. There are also two other types of complimentary data sets that can be analyzed in conjunction with the HURL archives. 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. 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 also help guide the research by identifying important research gaps. A sampling of the types of information that can be extracted from existing data sets was included in two of the presentations during the workshop. Finally, while actual specimens may not be considered data sets, a substantial number of physical specimens of both corals and sponges exist in various museums, many of which have not been formally described in the literature. Specimen data sets can help guide collection activities during field operations.

Specific Information Needs and Activities

Workshop participants identified the following critical information needs and activities as they relate to this NOAA Strategic Plan objective:

- Review mapping data (Chris Kelley/John Rooney)
- Review Industry data (Maui divers, black coral harvesters)
- Mineral Management data

- Shallower black coral surveys (Tony Montgomery, Daniel Wagner)
- Amy Baco-Taylor genetic data
- Rhian Waller reproduction data
- Museum specimens (Smithsonian, Bishop Museum, a few also at California Academy of Sciences)

Question 5: Obtain information on the 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.

Specific Information Needs and Activities

- Characterize what species of deep-sea corals and sponges are found in the U.S. Pacific with an emphasis on species found below 2000 m.
- Determine the vertical distribution of deep-sea corals and sponges at depths below 2000 m.
- Mine existing data to build an inventory of species and depth ranges. Archived video data of previous deep-sea explorations in the U.S. Pacific is available from HURL, the Monterey Bay Aquarium Research Institute (MBARI-Hawaii data set), dives by the ROV Jason off the Kilo Moana, and JAMSTEC dives (HURL has copies of those VHS tapes). Several HURL dives performed in locations outside of Hawaii (American Samoa and Line Islands) are not yet annotated and could provide important new information for these locations. Additionally, the following museums contain deep-sea corals and sponges collected in the U.S. Pacific and could be reviewed: (1) National Museum of Natural History, Smithsonian Institution; (2) Bernice P. Bishop Museum; and (3) California Academy of Sciences.
- Opportunistically conduct deep-sea surveys and collections using vessels of opportunity. The following vessels will be operating in the Pacific in the coming years and could be used to survey deep-sea corals and sponges: *Falkor* (Schmidt Ocean Institute), *Okeanos Explorer* (NOAA), *Sette* (NOAA), *Hi'ialakai* (NOAA), *Nautilus* (Ocean Exploration Trust) and *Kilo Moana* (University of Hawaii).
- Conduct dedicated vertical transects at depths below 2000 m in locations where the shallower fauna (< 2000 m) has been well surveyed (e.g., main Hawaiian Islands, Cross Seamount, American Samoa). To facilitate analyses, target study sites should have steep slopes and well known fauna at depths shallower than 2000 m. Both video data and specimens should be collected during transects to study the taxonomic identity and vertical distributions of corals and sponges.
- Compare the vertical distributions of corals and sponges in the U.S. Pacific to other locations on the continental slope, to understand whether there are fundamental differences between these two systems. The Caribbean deep-sea fauna has been relatively well studied, and those studies could be used for comparison.

CONCLUSION

The Pacific Islands Deep-Sea Coral and Sponge Research and Management Priorities Workshop brought together over 20 researchers and resource managers to identify and prioritize information needs to increase our understanding of deep-sea coral and sponge ecosystems in the Pacific Island Region. Workshop participants discussed each information need focusing on both applied research activities and those that were logistically feasible for current and future management needs. Participants acknowledged that limited resources are available to address the wide geographic area of the Pacific Islands Region. Consequently, a coordinated approach and targeted activities will be required to enhance our understanding of deep-sea corals and sponges ecosystems of the region.

The information provided by the participants is an initial step that will help to inform future budget allocations, ensure that research activities address management needs, maximize opportunities to utilize regional expertise, leverage and complement existing regional efforts, and share information on these habitats. The goal for future research activities in the Pacific Islands will be to provide a better understanding on the vertical and geographical distribution of deep coral and sponges, as well as on the environmental conditions on which they depend.

APPENDIX A—PARTICIPANTS LIST

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APPENDIX B—WORKSHOP AGENDA

NOAA Pacific Islands Deep-sea Corals
Research and Management Needs Workshop
April 22-23, 2014
Honolulu, Hawaii
Agenda

Goal
- To develop a list of critical information needs and a proposed plan of action to guide NOAA's 3-year research program that will address deep-sea coral and sponge science and management needs, in the U.S. Pacific Islands.

Objectives
- Review and understand existing science for deep-sea coral and sponge ecosystems in the U.S. Pacific Islands.
- Identify critical information needs for science and management in the U.S. Pacific Islands
- Develop a concise description of priority activities that will address those needs

Day 1—Review of Available Information and Prioritization of Research Needs

8:30   Arrival and Welcome

8:45   Overview of NOAA's Deep Sea Coral & Sponge Program (Tom Hourigan)

9:00   Status of Deep Sea Cora & Sponge knowledge in the Pacific Islands (Chris Kelley)

9:20   Deep Sea Corals and Fisheries (Josh DeMello)

9:35   Deep Sea Corals and Marine Sanctuaries and Marine National Monuments (Dan Wagner)

9:50   Deep coral habitat management (Daniel Jayewardene)

10:05 Break

10:35 Modeling approaches for deep corals (Brian Kinlan)

10:45 OAR upcoming plans in the Pacific (Craig Russell)

11:00 Wrap up for the morning (Plenary)

11:30 Lunch

12:30   Identify information needs in breakout groups–three concurrent groups

2:00   Breakout group summaries; 15–20 mins for each group

2:45   Break

3:05   Prepare a listing of the combined group research questions/needs

3:45   Prioritize research needs

4:15   Finalize the priorities list of critical research questions/needs

4:35   Review day 1 accomplishments and discuss what will be done on day 2

4:45   Adjourn

Day 2—Planning Research Activities for Deep-sea Corals and Sponges

8:30   Summarize day 1 and review agenda for day 2

8:45   Develop science activities in break out groups

10:40   Break

11:00   Breakout Group summary Presentations (Plenary)

11:30   Generate summary group list of activities (Plenary)

12:00   Lunch

1:00   Identify Opportunities and Constraints for Activities (Plenary)

2:00   Review workshop Accomplishments and Discuss Final Recommendations and Report

2:30   Adjourn

Appendix C—Research Questions Identified in the Breakout Groups

Biology and Ecology Group

- Are deep-sea corals and sponge habitats important to commercial fisheries or endangered species?
- Can different types of communities of deep-sea corals and sponges (DSCS) be identified?
- What do we know of the distribution of DSCS communities or species, and what are the data gaps?
- What other faunal species are found associated with DSCS communities or species?
- How can DSCS be used to understand impeding climate change impacts?
- Are there natural predators of deep-sea coral/sponge species or genera in the USPI?
- Can changes in climate and the recent sea-level history be seen in the skeletal record and discerned from varying oceanic productivity?
- To what degree do other marine organisms (large and small) impact or affect the condition and survival of deep corals?
- What is the seasonal change in reproduction and life history of deep corals that may influence patterns of recruitment?
- How will calcification rates in deep-sea corals respond to changing ocean pH (ocean acidification)?
- What biogeochemical proxies can be developed for paleo oceanographic/climatic reconstructions and what new applications can be used to determine age and growth rates in deep-sea corals?
- What is the genetic connectivity of different deep-sea coral populations?
- Do DSCS communities or species serve as important habitat for other species?
- What are the energy pathways and sources to and within deep-sea coral beds?

Distribution and Taxonomy Group

- What is the distribution of deep-sea corals and sponges?
- Are there certain areas that deserve particular emphasis from either a management or research perspective?
- Are there geophysical conditions that can be used to explain the distributions?
- What species of deep-sea corals exist among specimens that have been collected in the U.S. Pacific in the past? (i.e., taxonomic descriptions of existing specimens)
- What species of deep-sea sponges exist among specimens that have been collected in the U.S. Pacific in the past? (i.e., taxonomic descriptions of existing specimens)
- What U.S. Pacific areas have high abundances and diversities of deep-sea corals and sponges?
- What corals and sponges occur in this region and how are they distributed?
- What are the environmental parameters that characterize areas where specific groups of corals/sponges occur and how do those vary temporally?
- How does the community structure of corals/sponges vary with environmental parameters?
- What is the degree of connectivity of the coral/sponge beds on a given feature to other features—dispersal distances of individual species, etc.—at the scale of island/seamount to

the next island/seamount and at the scale of each island/seamount chain to others, e.g., Hawaii to the rest of the Pacific
- Fundamental taxonomy of corals and sponges is desperately needed, both morphologic and genetic. How do we get this funded and at what taxonomic level do we start?
- Are there known dense monospecific populations of corals/sponges in the USPI like that of *Sericolophus hawaiicus* off Hawaii's west coast?
- What explains the patchiness in deep corals and the taxonomic differences between assemblages?

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- What are the greatest threats to DSCS in the various island groups?
- What are the primary threats to DSCS communities or species, now and over the next few decades?
- What management needs, and opportunities to actually improve their condition or mitigate threats, exist for DSCS communities or species?
- What areas containing DSCS are most vulnerable to future anthropogenic impacts?
- What is the capacity of corals/sponges to recover?
- Is human exploitation of coral/sponge populations being effectively managed in USPI?
- Are corals/sponges in USPI endangered/threatened?
- Are deep-sea corals/sponges being damaged as byproduct of fishing or mining activities in USPI?
- Even though they are slow growing, how resilient are they?
- What is the resilience, and recovery rates of deep-sea coral beds exposed to fishing pressures?
- Are there refugia populations important to potential recovery?