Modeling Mesophotic Coral Distributions in the Au'au Channel, Hawaii

To Support the Hawaiian Islands Humpback Whale National Marine Sanctuary's Management Plan Review Process

Project Workplan

FINAL

Prepared
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By

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Biogeography Branch and the
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PROJECT OBJECTIVES

Mesophotic coral ecosystems (MCEs) are light-dependent communities comprised of corals and other associated organisms found between approximately 30 to 150 m in depth (Figure 1; Hinderstein *et al.* 2010). Mesophotic corals are thought to have some special adaptations, including flattened morphologies and lower metabolic demands, which allow them to live in low light environments (Kahng *et al.* 2010). In the Hawaiian archipelago, Kahng and Kelley, 2007 and Rooney *et al.* 2010 found that different types of MCEs dominated specific depth ranges, and their presence declined overall with increasing depth and latitude. In 30 to 50 m of water, Upper MCEs were dominated by a low diversity of hard corals found in shallower reefs (*Pocillopora meandrina*, *P. damicornis*, *Montipora capitata*, and *Porites lobata*). In 50 to 80 m of water, Branching/Plate Coral MCEs were dominated by hard corals with a singular morphology. In 80 to 130 m of water, the coral species, *Leptoseris hawaiiensis*, was prevalent, giving the MCEs at this depth their name: *Leptoseris* Coral MCEs. Several physical factors are assumed to influence the distribution of these MCEs, including temperature, hard substrate availability and the availability of photosynthetically active radiation at depth (Kahng and Kelley, 2007).

Figure 1. MCE dominated by colonies of *Leptoseris hawaiiensis* at a depth of 90 m in the Au'au Channel. Adapted from Rooney *et al.* 2010. Photo credit: Hawai'i Undersea Research Laboratory.

Mesophotic coral distributions are important for resource managers to understand because they play a pivotal role (separate from their shallow-water counterparts) in shaping ecological communities, including providing habitat for reef fish and invertebrate species, refugia for certain shallow-water species and residence for some species not seen outside the mesophotic zone (Glynn 1996; Riegl and Piller 2003; Bak *et al.* 2005; Boland and Parrish, 2005; Armstrong *et al.* 2006; Kahng and Kelley, 2007). Despite this unique ecological role, there has been limited exploration of these moderate-depth ecosystems because they are difficult and expensive to access using traditional underwater sampling techniques (Pyle 1996; Menza et al. 2008). Additional research is needed to better understand these mesophotic communities (Kahng and Maragos, 2006), as they are increasingly threatened by numerous anthropogenic stressors (Wilkinson, 1999; Klyepas and Eakin, 2007). In the interim, spatially explicit predictive models maybe used to fill these informational gaps, and provide valuable baseline data on MCE distributions for unexplored regions. This baseline data may then be used to more effectively plan and refine future research efforts in support of ecosystem based management.

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The primary objective of this study is to produce a spatially explicit model of mesophotic scleractinian coral presence for 30 to 150 meter depths in the Au'au Channel (Figure 2). Other live benthic cover, including azooxanthellate assemblages, are beyond the scope of this project and will not be included in this modeling effort. The model will be developed using readily-available bathymetry and optical validation data for the Au'au Channel. These datasets will be the primary inputs for all subsequent analysis. A suite of predictor variables will be developed from the bathymetry surface, including mean depth, standard deviation of depth, rugosity, plan curvature, profile curvature, curvature, slope, slope of slope and other environmental variables, as needed. These predictors will used to model the potential distribution of mesophotic scleractinian corals in the Au'au Channel. The predictor variables will be quantitatively linked with the response variable (i.e., mesophotic scleractinian coral presence) extracted from the optical validation data to develop a spatially explicit predictive model. A range of modeling approaches will be evaluated early in the project. This evaluation may include techniques such as: MaxEnt (Maximum Entropy), BRT (boosted regression trees) or Random Forests (Elith *et al.* 2006). The optimum modeling approach will be selected based upon an evaluation of input data, exploratory analysis and consultation of project partners. Cross validation techniques will be used to assess the quality of the final model output. This mesophotic coral distribution model will expand the Hawaiian Islands Humpback Whale National Marine Sanctuary's (HIHWNMS) assessment capabilities and support ecosystem-based management practices within the Sanctuary.

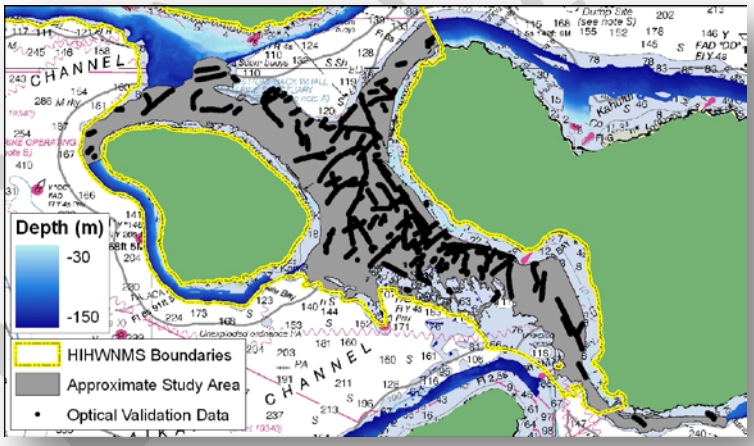

Figure 2. Project area for modeling potential mesophotic coral presence in the Au'au Channel.

PROJECT SCOPE & TASKS

Geographic area: The Au'au Channel (i.e., the marine area between Lanai and Maui)
Depth area: 30 – 150 meters

The specific tasks for this project are as follows:

1. Acquire readily-available bathymetry of varying resolutions (i.e., 5x5, 10x10, 50x50

meter resolutions and others if necessary) and optical validation data for the Au'au Channel. These datasets will be the primary inputs for all subsequent analysis.

2. Format and organize these datasets in a common spatial framework (i.e., geodatabase) in ArcGIS.
3. Develop a suite of predictor variables from the 5x5 or the 10x10 m bathymetry surface for the Au'au Channel and from the 50x50 m bathymetry surface for the MHI. A 20x20 m bathymetry surface may be used in place of the 50x50 m surface if it is provided to the Biogeography Branch before December 23. The predictor variables will include mean depth, standard deviation of depth, rugosity, plan curvature, profile curvature, curvature, slope, slope of slope. Midwater tidal current velocity (at 85 m depth) and other predictors may be included as needed.
4. Quantitatively link these predictor variables with mesophotic scleractinian coral presence (i.e., the response variable) extracted from the optical validation data to develop a spatially explicit predictive model for the Au'au channel area.
5. Develop maps depicting the potential spatial distribution of mesophotic scleractinian corals.
6. Develop report summarizing the analytical methods and key findings.
7. Provide guidance to the Sanctuary GIS staff about conducting a characterization of the sea floor topography around the Main 8 Hawaiian Islands using the 50x50 m (or if possible, 20x20 m) derived products. If funds are available, provide face-to-face support for sanctuary GIS staff to assist the transfer of project deliverables (dates and staff to be determined).

PROJECT DELIVERABLES

The final deliverables will be transferred at a date to be determined by the BB and HIHWNMS. The specific deliverables for this project are as follows:

1. GIS files
    a. Shapefile of HIHWNMS boundaries
    b. Shapefile of classified ROV transects
    c. GeoTiff of 5x5 and 10x10 m bathymetry for the Au'au Channel region
    d. GeoTiff of 50x50 m bathymetry (or possibly 20x20 m) for the Main 8 Hawaiian Islands
    e. GeoTiffs of predictor variables, including mean depth, standard deviation of depth, rugosity, plan curvature, profile curvature, curvature, slope and slope of slope and other environmental variables (like tidal current velocities), as needed. Work with sanctuary staff to further develop synthesized product.
    f. GeoTiff or shapefile denoting potential mesophotic scleractinian coral presence in the Au'au Channel from 30 to 150 m in depth.
    g. GeoTiff or shapefile denoting uncertainty of the model spatially, if possible.
    h. Metadata for each GIS file
2. Report summarizing results of tasks listed above (including relevant maps, figures and tables), methods used, and discussion of the potential uses described below.
3. Updated project website: http://ccma.nos.noaa.gov/ecosystems/sanctuaries/hwnms/

POTENTIAL USE OF DELIVERABLES BY HIHWNMS

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The products listed above will help the HIHWNMS answer specific management questions related to ecosystem based management practices. These management questions include, but are not limited to:

1. Where are mesophotic corals potentially located within in the Au'au Channel?
2. Should these potential mesophotic coral areas be zoned differently within the HIHWNMS boundaries?
3. What significant gaps exist in our knowledge about the mesophotic corals within the HIHWNMS boundaries, and the Main Hawaiian Islands?
4. Discussion of the potential to improve this model and expand its spatial extent in the future.

PROJECT PERIOD

3 months

PROJECT TEAM

The National Center for Coastal and Ocean Science (NCCOS) Biogeography Branch and the HIHWNMS staff will co-lead this collaborative effort with participation from the Pacific Island Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED), PIFSC Protected Species Division (PSD), PIFSC Ecosystem and Oceanography Division (EOD) and Hawaii's Division of Aquatic Resources (DAR).

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