

FINAL REPORT

Analysis of AUV Sonar Data from Deep-water *Lophelia* Coral Reef Habitats off Central Eastern Florida

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NOAA NMFS Contract
Andy Sherrell
Contract Order # GE133F09SE3476

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This report summarizes the results of two grants from NOAA NMFS to John Reed and Andy Sherrell. Mr. Sherrell was contracted to analyze the AUV sonar data from a survey completed on the deep-water *Lophelia* coral reef habitats off central eastern Florida, December 2008, and Mr. Reed was Principal Investigator and administrator. The original processed AUV sonar data are archived at HBOI with Mr. Reed and this Final Report is submitted to the NOAA Grant Manager, Jennifer Schull, December 18, 2009, thus completing the deliverables for these two NOAA NMFS grants. Mr. Sherrell also submitted his final report for his NMFS contract separately (December 10, 2009).

INTRODUCTION

NOAA NMFS and the Regional Fishery Management Councils as a directive of the Magnuson Fishery Management Act have requested information on the state of knowledge of Deep-sea Coral Ecosystems (DSCEs) in all U.S. waters. Data on DSCE distribution is needed because the continuing depletion of coastal fisheries may expand fishing efforts into deeper habitats in search of valuable commercial species such as royal red shrimp (*Hymenopenaeus robustus*), golden crab (*Chaceon fenneri*), wreckfish (*Polyprion americanus*) and deepwater tilefish, snappers and groupers. NOAA is currently developing sites within the US EEZ for priority mapping of deep-sea coral habitat. Data compiled during this project will provide information on deep-sea coral habitat areas within the 23,000 nmi² Deep-sea Coral Habitat Areas of Particular Concern (HAPCs) that was just approved by the South Atlantic Fishery Management Council (SAFMC) and the *Oculina* Deep-water Coral HAPC, both off eastern Florida.

There is real potential for fisheries in this region to impact the deep-water coral/hard bottom habitat. The deep-water *Oculina* Coral HAPC was severely damaged by bottom trawling for rock shrimp (Reed et al. 2007). Golden crab, tilefish, and royal red shrimp all occur within the Deep-sea Coral HAPCs and we have seen all three species on our dives with HOV and ROV (Miami Terrace escarpment, 300-600 m; deepwater *Lophelia* coral habitat in the Straits of Florida, 400-800 m; and Pourtales Terrace, 200-400 m). The newly designated Deep-sea Coral HAPCs will have allowable fishing zones for golden crab within the HAPCs and it is imperative to have good, high-resolution maps of the bottom to designate areas suitable for fishing while protecting coral habitat. The PI has over 30 years of experience on research and conservation of the deep-water reefs off the southeastern U.S. (Reed 1980, 2002, Reed et al. 2005, 2006, 2007).

OBJECTIVES

It is the purpose of this grant to administer the analysis of sonar data (side-scan and multibeam) that was collected with the deep-water Remus 6000 AUV in collaboration with the Waitt Institute of Discovery, Harbor Branch Oceanographic Institute, and Woods Hole Oceanographic Institute (WHOI), December 2008, on deep-water coral habitat off the coast of central eastern Florida and within the newly proposed Deep Coral Habitat Area of Particular Concern (HAPC) and the existing Deep-water *Oculina* Coral HAPC. As a result of some electrical interference with the original sonar data analyses, the data required reprocessing to provide the best available high-resolution maps of these sites. Andy Sherrell painstakingly removed the extraneous noise from the raw data and reprocessed it as geotiff side scan, multibeam, and contour map images. The PI worked with Mr. Sherrell to select the best sites to analyze for the priority research needs

of the SAFMC and NOAA. As a result, this report summarizes the results of both NOAA NMFS grants to Mr. Reed and Mr. Sherrell.

BACKGROUND

AUV Sonar Survey

The data that was analyzed resulted from deep-water Remus 6000 AUV dives that were conducted by the Waitt Institute of Discovery in collaboration with Harbor Branch Oceanographic Institute and WHOI from December 4 to 10, 2008. Two new Waitt REMUS 6000 AUV vehicles were used for their first scientific expedition to map deep-sea coral reefs off the central east coast of Florida and at the same time to provide test trials of these AUVs and all their systems under very difficult environmental conditions. These trial dives were conducted approximately 50 miles offshore in the axis of the Gulf Stream with currents exceeding 3 knots, at depths over ½ mile deep, and over high-relief pinnacles which are steep rugged reefs up to 200 feet tall. The surveys were conducted with 75 kHz low frequency side-scan sonar which covered swaths of 1200 yards in width; site specific high-relief reefs were surveyed with high resolution 410 kHz side-scan and multibeam sonar.

The primary objectives of the mission were to test dive the new AUVs. A spinoff of this mission was used by the PI to provide high definition side-scan sonar surveys that are critically needed in this region for the following reasons: 1) to provide detailed data on the distribution of these deep-water reefs in order to protect them from potential impacts of bottom trawls, fossil fuel exploration and development, and alternative energy development; and 2) to provide the best scientific data available in order to show where bottom trawling and energy production may be acceptable by avoiding coral habitat.

The AUVs were used to provide high definition side-scan (with backscatter) and multibeam sonar maps of the following areas off central eastern Florida:

1. Areas within the proposed Deep-Water *Lophelia* Coral HAPC where low resolution NOAA bathymetric charts (NOAA Pilsbury Chart 17-12, NOAA Chart CRM-10_m_d83) indicated the possibility of undiscovered deep-water reefs.
2. A N-S strip along the western edge of the primary *Lophelia* reef zone (580-800 m) within the proposed *Lophelia* HAPC where commercial fishery interests (royal red shrimp) overlap known and possible deep-water reefs.
3. A portion of *Oculina* Coral Habitat Area of Particular Concern where nearly 100 reef balls have been placed for restoration experiments in areas of damaged corals.

Study Sites Within the *Lophelia* HAPC (Fig. 1)

Study Sites 1 and the northern portion of Site 3 were surveyed during the mission. Site 2 was surveyed with single beam sonar (shipboard fathometer) and Site 4 was not surveyed.

Site 1

Boundaries: ~28.29 to 28.48° N, -79.70 to -79.81° W; 370 m to 540 m; peak 399 m.

30 sq.mi. of this site was surveyed. Within this site are several high-relief coral mounds (Reef Reefs #294, 339, 402) that we discovered in part with the AUV sonar surveys. All three sites were ground-truthed with *Johnson-Sea-Link* Submersible dives in which the PI found the greatest density of living coral known in this region. Site #402 does not even appear on the best available NOAA bathymetric chart but we discovered it to be a series of mounds over 1 km in width and up to 50-m tall.

Site 2

Boundaries: 28.36 to 28.45° N, -79.85 to -79.90° W; 250 to 310 m.

Region adjacent to the Deep-sea Coral HAPC which shows possible deep-water sink hole based on NOAA bathymetry chart. A series of fathometer transects over the site found nothing but flat bottom.

Site 3

Boundaries: 27.00 to 28.50° N, -79.59 to -79.69° W; 580 to 800 m.

Region within the Deep-sea Coral HAPC with overlap of fishing interests. The northern 30 sq.mi. of this site was surveyed.

Site 4

Boundaries: 28.75 to 28.81° N, -79.76 to -79.79° W; 570 to 590; peak 570 m.

Region within the Deep-sea Coral HAPC which shows possible high-relief, live habitat based on low-resolution NOAA bathymetry. This site was not surveyed.

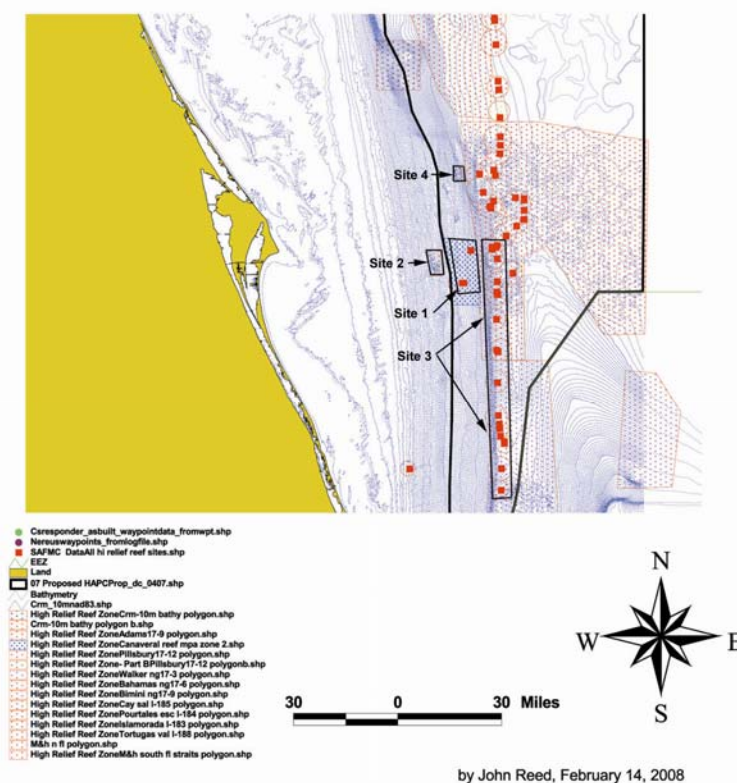


Figure 1. Deep-water *Lophelia* coral sites off central eastern Florida discovered and mapped by J. Reed. Site 1 and the northern portion of Site 3 were mapped with the Remus 6000 AUV.

Study Sites of Deep-water *Oculina* Coral HAPC (Fig.2)

Over 100 coral restoration Reefball modules were deployed between 1997 and 2000 (C. Koenig, Florida State University) to test the hypothesis of providing substrate for new coral larval recruits and habitat for grouper/snapper populations. The Reefballs are concrete, hollow, hemispheres, ~1 m in diameter and deployed in 85 m of water. The total area for *Oculina* Site #1 is 3 km x 0.5 km = 1.5 km². These Reefballs did not show up on the 2002 ship-board multibeam survey (240 kHz system which had ~3 m resolution at that depth). The 2008 AUV survey used high-resolution multibeam to survey this site and also Jeff's Reef which has the remaining large concentration of living *Oculina* coral. If possible, we will re-analyze the AUV data from these two sites to provide accurate maps for future dive operations.

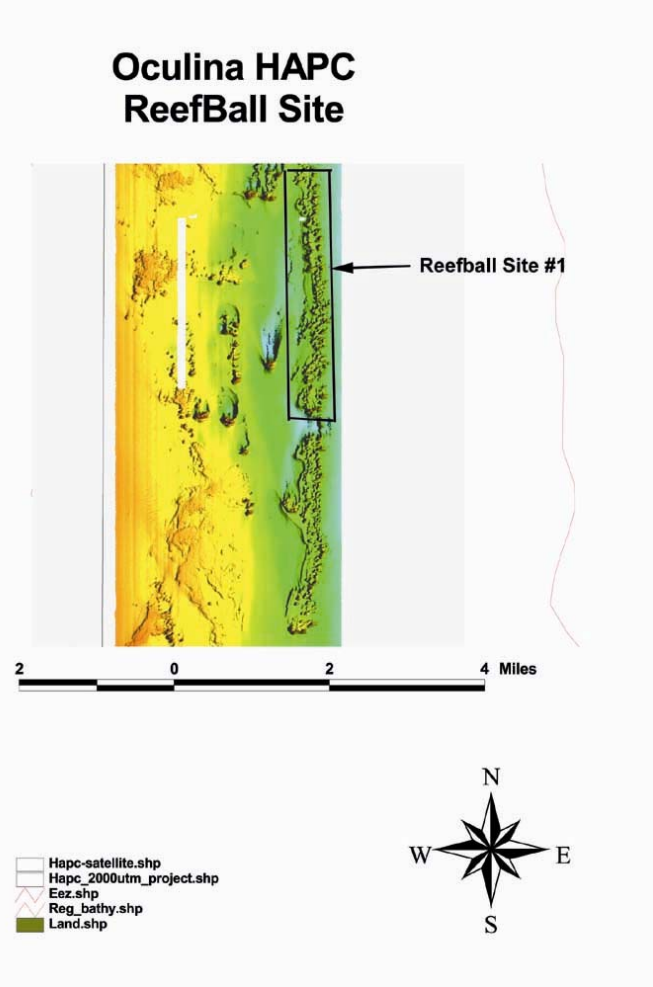


Figure 2. Portion of Deep-water *Oculina* HAPC with artificial Reefballs that was mapped with AUV.

METHODS

Processing AUV Sonar Data

The original AUV sonar data were reprocessed by Mr. Andy Sherrell by analyzing, filtering and combining the data sets into appropriate mosaics and compilations. This included processing the navigational data as well as the specific instrument data files, namely side-scan sonar and multibeam data. Each AUV dive was processed and delivered as an individual mosaic or compilation unless it proved more useful to the end user to combine the dives. File output types consist of Geo-referenced TIFFs, XYZ files, TIN models, Matrix files, and general JPGs, TIFFs, and Bitmaps of various maps allowing non-specific software to view the processed maps. Software and computer hardware were made available for the project courtesy of the Waitt Institute for Discovery (excerpt from A. Sherrell, Final Report to NOAA NMFS, Dec. 10, 2009).

Data Source

After discussions with contract manager, Jennifer Schull, and considering the time constraints of the contract with Mr. Sherrell, it was decided to prioritize these data sets for re-analysis in the following order:

1) Site 1 (AUV Dives 001A, 002A, 003A, 004A, 005A)

Boundaries: ~28.29 to 28.48° N, -79.70 to -79.81° W; 370 m to 540 m; peak 399 m; 30 sq.mi. total area.

Side-scan sonar data was re-analyzed with 3-5 m resolution for the entire region. Within this site we discovered several high-relief coral mounds (Reed Reefs #294, 339, 402). These sites were reprocessed to produce high resolution (1 and 3 m) side scan, multibeam, and bathymetric contour maps. Dive 003A had no data.

2) Site 3 (AUV Dives 006A, 007A, 008A)

Boundaries: 27.00 to 28.50° N, -79.59 to -79.69° W; 580 to 800 m; 30 sq.mi. total area.

Side-scan sonar with 3-5 m resolution was re-analyzed for the entire region. Within this site were several regions with high-relief features. Two high-relief sites within this site were reprocessed to produce high resolution (1 and 3 m) side scan, multibeam, and bathymetric contour maps. Dive 006A had no data.

RESULTS

AUV Survey Summary

The cruise resulted in the following side-scan and multibeam sonar surveys:

- Two 30 sq.mi. regions (Fig. 1, Site 1 and part of Site 3) were mapped with side-scan sonar within the proposed Deep-sea *Lophelia* coral HAPC and two sites were mapped within the *Oculina* coral HAPC (Fig. 2).
- A total of 10 AUV dives were conducted for a total bottom time of 77.4 hours.
- The total area surveyed was 60.5 mi² and consisted of 240 miles of AUV track lines; 5 surveys were conducted with 75 kHz low frequency side-scan sonar which covered

swaths of 1200 yards in width; 5 surveys of site specific high-relief reefs were conducted with high resolution 410 kHz side-scan and multibeam sonar.

Table 1. Remus 6000 AUV dive missions, dive sites, and sonar types, December 4-10, 2008.

Mission	Site # Figs. 1 & 2	Reef Name	Purpose	Sensor	SSS (kHz)	Range Scale (m)	Depth (m)	Area Covered (Sq NM)	Linear Dist. (nmi)	Duration (hr)
001A	Site 1	Reed Reef 294	low res survey	Delta-T	75	600	420	6	14.8	4
002A	Site 1	Reed Reef 294	hi res survey	Delta-T	410	125	420	6	17.2	5
003A	Site 1	No Data	low res survey	Delta-T	75	600	580	0		4
004A	Site 1	Reed Reef 402 (new) and Reed Reef 339	low res survey	Delta-T	75	600	580	15	65.2	18
005A	Site 1	Reed Reef 402 (new)	hi res survey	Delta-T	410	100	580	0.5	15.2	4
006B	Site 3	No Data	low res survey	ESC	75	600	690	0		0
007B	Site 3	Reed Reef 151 and Canaveral Reef sites	low res survey	ESC	75	600	760	27.5	58.7	16
008A	Site 3	Reed Reef 151 and Canaveral Reef sites	hi res survey	Delta-T	410	200	760	2.9	41.1	12
009A	Oculina	Sebastian Pinnacles-Reef Ball Site	Reef ball survey	Delta-T	410	120	80	2.5	25.6	10
010A	Oculina	Jeff's Reef	Jeff's Reef survey	Delta-T	410	120	80	0.06	2.1	0
Totals								60.46	239.8	73

Reprocessed AUV Data Summary

The reprocessed data are archived at HBOI with Mr. Reed. These include the georeferenced maps for the side-scan sonar, multibeam sonar, and bathymetric contours. Each dive has the following files, except for Dive 7 because only side-scan data was collected:

- Side-scan mosaic: at 1m resolution
- Contour maps: at 1m and 3m resolution, and 1m and 3m contours intervals
- Multibeam data: 1m and 3m resolution, in both xyz and mtx formats
- 3-D Tin model: 3m resolution and 3m contour intervals
- General images: various images of 2D and 3D maps for general viewing using non-specific software
- There is also an overall side-scan mosaic of the 6 dives in both 3m and 5m resolution.

All of these sites were processed to a level that improves the overall accuracy and ability to determine general bottom features and characteristics. While data can always be processed further a medium was reached between the PI and Analyst to balance the overall budget of the

project to efficiency and compliant results. Data is delivered at a stage where it can be further processed and/or used “as is” to create various maps to suit the users specific needs.

Table 2 lists all the files stored on two DVD disks. Disk 1 contains the overall side-scan mosaics, and sonar from dives 001A-005A, and also contains this file list in Excel. Disk 2 contains the sonar from dives 007A-008A. Each file is listed with the mission dive number, e.g., MSN01, 02, etc. Table 1 lists these dive numbers with the respective site location. Some filenames includes the resolution of the image (e.g., 1 or 2 m), or the resolution of the contour lines (e.g., 1 m or 3 m). Filenames for the side-scan sonar images (SSS) also indicate the beam width on each side of the AUV (e.g., R310 = 310 m width). The multibeam files include the xyz data and tin models. Images are either as tif, jpg, bmp or pdf files. Each tif file has a corresponding tfw file for georeferencing, so these may be imported into ArcMap, Fledermaus, or other viewing software.

Table 2. List of files of reprocessed AUV sonar data and georeferenced sonar and contour maps.
File List for Reprocessed AUV Data (Side Scan and Multibeam)- CATALYST 1 Mission, Florida Deep-Water Lophelia Reefs
Waitt Institute of Discovery and Harbor Branch Oceanographic Institute, December 4-10, 2008
Principal Investigator: John Reed, Harbor Branch Oceanographic Institute
Data Processed by: Sonar Analyst, Andy Sherrell, December 2009

Folder	File Name	Description
CATALYST 1 MISSIONS 1-8		
	Overall SideScan Mosaic Missions 1-2-4-5-7-8.jpg	Low resolution image of all side scan mosaics together
	Overall SideScan Mosaic Missions 1-2-4-5-7-8.pdf	Low resolution image of all side scan mosaics together
	Overall SideScan Mosaic_3m-Missions 1-2-4-5-7-8.tif	3 meter resolution geo-referenced image of all side scan mosaics together
	Overall SideScan Mosaic_5m-Missions 1-2-4-5-7-8.tif	5 meter resolution geo-referenced image of all side scan mosaics together
MSN001A-MSN002A\CONTOURS		
	MSN01-02_1mRes_1mContours.DXF	Missions 1&2 combined multibeam data, 1 m resolution, 1 m contour intervals, 10 meter max triangle length
	MSN01-02_1mRes_3mContours.DXF	Missions 1&2 combined multibeam data, 1 m resolution, 3 m contour intervals, 10 meter max triangle length
	MSN01-02_3mRes_3mContours.DXF	Missions 1&2 combined multibeam data, 3 m resolution, 3 m contour intervals, 10 meter max triangle length
	MSN01-02_3mRes_3mContours_125tin.DXF	Missions 1&2 combined multibeam data, 3 m resolution, 3 m contour intervals, 125 meter max triangle length
MSN001A-MSN002A\IMAGES		
	MSN01-02_3m_2D.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_3m_Contour.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_MB-SSS-10TIN.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_MB-SSS-125TIN.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_1X1 125TIN SCREEN GRAB.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_2X2 10TIN SCREEN GRAB.tif	Miscellaneous low resolution images of the multibeam data
	MSN01-02_3m_125tin.bmp	Miscellaneous low resolution images of the multibeam data
	MSN01-02_3m_125tin_3D.bmp	Miscellaneous low resolution images of the multibeam data
	MSN01-02_5m.jpg	Miscellaneous low resolution images of the multibeam data

MSN01-02_3m_Contour.tfw	Miscellaneous low resolution images of the multibeam data
MSN001A-MSN002A\MultibeamData	
MSN01-02_1m.mtx	Missions 1&2 combined multibeam data, 1 m resolution, matrix file
MSN01-02_1m.xyz	Missions 1&2 combined multibeam data, 1 m resolution, xyz file
MSN01-02_1m_Reduced.xyz	Missions 1&2 combined multibeam data, 1 m resolution, xyz file reduced to 1 point per 1m square
MSN01-02_3m.mtx	Missions 1&2 combined multibeam data, 3 m resolution, matrix file
MSN01-02_3m.xyz	Missions 1&2 combined multibeam data, 3 m resolution, xyz file
MSN01-02_3m_Reduced.xyz	Missions 1&2 combined multibeam data, 3 m resolution, xyz file reduced to 1 point per 3m square
MSN001A-MSN002A\MultibeamData\Tin Models	
MSN01-02_Tin_3mRes_3mContours_125tin	Missions 1&2 combined multibeam data, 3-D Tin model, 3m resolution, 3m contour intervals
MSN001A-MSN002A\SideScan	
MSN001A_1m_R600m.tif	Missions 1 sidescan mosaic, 1 m resolution, range plotted = 600m
MSN001A_1m_R310m.tif	Missions 1 sidescan mosaic, 1 m resolution, range plotted = 310m
MSN002A_1m_R220m.tif	Missions 2 sidescan mosaic, 1 m resolution, range plotted = 220m
MSN001-002_OVERLAYED.tif	Missions 1&2 overlaid sidescan mosaics
 MSN004A\CONTOURS	
MSN004_Reef339_1mRes_1mContours.DXF	Mission 4 multibeam data, 1 m resolution, 1 m contour intervals, 10 meter max triangle length
MSN004_Reef339_1mRes_3mContours.DXF	Mission 4 multibeam data, 1 m resolution, 3 m contour intervals, 10 meter max triangle length
MSN004_Reef339_3mRes_1mContours.DXF	Mission 4 multibeam data, 3 m resolution, 1 m contour intervals, 10 meter max triangle length
MSN004_Reef339_3mRes_3mContours.DXF	Mission 4 multibeam data, 3 m resolution, 3 m contour intervals, 10 meter max triangle length
 MSN004A\IMAGES	
MSN004A_Reef339_MB-SSS_Overlay.tif	Miscellaneous low resolution images of the multibeam data
MSN004A_Reef339_3m_2D Legend.tif	Miscellaneous low resolution images of the multibeam data
MSN004A_Reef339_3m_2D Contours.tif	Miscellaneous low resolution images of the multibeam data
MSN004_Reef339_3m.jpg	Miscellaneous low resolution images of the multibeam data
MSN004_Reef339_1m_legend.bmp	Miscellaneous low resolution images of the multibeam data
MSN004_Reef339_1m_3D-legend.bmp	Miscellaneous low resolution images of the multibeam data
 MSN004A\MultibeamData	
MSN004_Reef339_1m.mtx	Mission 4 multibeam data, 1 m resolution, matrix file
MSN004_Reef339_1m.xyz	Mission 4 multibeam data, 1 m resolution, xyz file
MSN004_Reef339_1m_Reduced.xyz	Mission 4 multibeam data, 1 m resolution, xyz file reduced to 1 point per 1m square
MSN004_Reef339_3m.mtx	Mission 4 multibeam data, 3 m resolution, matrix file
MSN004_Reef339_3m.xyz	Mission 4 multibeam data, 3 m resolution, xyz file
MSN004_Reef339_3m_Reduced.xyz	Mission 4 multibeam data, 3 m resolution, xyz file reduced to 1 point per 3m square
 MSN004A\MultibeamData\Tin Models	
MSN004_Tin_3mRes_3mContours_125tin	Mission 4 multibeam data, 3-D Tin model, 3m resolution, 3m contour intervals
 MSN004A\SideScan	
MSN004A_Reef402_R285m_1m.tif	Mission 4 Reef 402 sidescan mosaic, 1 m resolution, range plotted = 285m
MSN004A_Reef339_R260m_1m.tif	Mission 4 Reef 339 sidescan mosaic, 1 m resolution, range plotted = 260m
MSN004A_Entire_Mission_Mosaic-1m.tif	Mission 4 entire mission sidescan mosaic, 1 m resolution

MSN005A\CONTOURS

MSN005_Reef402_1mRes_1mContours.DXF
MSN005_Reef402_1mRes_3mContours.DXF
MSN005_Reef402_3mRes_1mContours.DXF
MSN005_Reef402_3mRes_3mContours.DXF

Mission 5 multibeam data, 1 m resolution, 1 m contour intervals, 10 meter max triangle length
Mission 5 multibeam data, 1 m resolution, 3 m contour intervals, 10 meter max triangle length
Mission 5 multibeam data, 3 m resolution, 1 m contour intervals, 10 meter max triangle length
Mission 5 multibeam data, 3 m resolution, 3 m contour intervals, 10 meter max triangle length

MSN005A\IMAGES

MSN005_Reef402_1m_2D Legend.tif
MSN005_Reef402_1m_3D-legend.bmp
MSN005_Reef402_3m.jpg
MSN005_Reef402_3m_2D Contour.tif
MSN005_Reef402_3m_2D Legend.tif
MSN005_Reef402_3m_3D-legend.bmp
MSN005_Reef402_3m_3DRotated-legend.bmp
MSN005_Reef402_5m.jpg

Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data
Miscellaneous low resolution images of the multibeam data

MSN005A\MultibeamData

MSN005_Reef402_1m.mtx
MSN005_Reef402_1m.xyz
MSN005_Reef402_1m_Reduced.xyz
MSN005_Reef402_3m.mtx
MSN005_Reef402_3m.xyz
MSN005_Reef402_3m_Reduced.xyz

Mission 5 multibeam data, 1 m resolution, matrix file
Mission 5 multibeam data, 1 m resolution, xyz file
Mission 5 multibeam data, 1 m resolution, xyz file reduced to 1 point per 1m square
Mission 5 multibeam data, 3 m resolution, matrix file
Mission 5 multibeam data, 3 m resolution, xyz file
Mission 5 multibeam data, 3 m resolution, xyz file reduced to 1 point per 3m square

MSN005A\MultibeamData\Tin Models

MSN005_Tin_3mRes_3mContours

Mission 5 multibeam data, 3-D Tin model, 3m resolution, 3m contour intervals

MSN005A\SideScan

MSN005A_Reef402_1m_R100m.tif
MSN005A_Reef402_1m_R100m_Trimmed.tif

Mission 5 Reef 402 sidescan mosaic, 1 m resolution, range plotted = 100m
Mission 5 Reef 402 sidescan mosaic, 1 m resolution, range plotted = 100m, AUV turns removed

MSN007B\SideScan

MSN007B_1m_R460m.tif

Mission 7 sidescan mosaic, 1 m resolution, range plotted = 460m

MSN008A\CONTOURS

MSN008_West_1mRes_1mContour.DXF
MSN008_West_1mRes_3mContour.DXF
MSN008_West_3mRes_1mContour.DXF
MSN008_West_3mRes_3mContour.DXF
MSN008_East_1mRes_1mContour.DXF
MSN008_East_1mRes_3mContour.DXF
MSN008_East_3mRes_1mContour.DXF

Mission 8, West reef, multibeam data, 1 m resolution, 1 m contour intervals, 10 meter max triangle length
Mission 8, West reef, multibeam data, 1 m resolution, 3 m contour intervals, 10 meter max triangle length
Mission 8, West reef, multibeam data, 3 m resolution, 1 m contour intervals, 10 meter max triangle length
Mission 8, West reef, multibeam data, 3 m resolution, 3 m contour intervals, 10 meter max triangle length
Mission 8, East reef, multibeam data, 1 m resolution, 1 m contour intervals, 10 meter max triangle length
Mission 8, East reef, multibeam data, 1 m resolution, 3 m contour intervals, 10 meter max triangle length
Mission 8, East reef, multibeam data, 3 m resolution, 1 m contour intervals, 10 meter max triangle length

MSN008_East_3mRes_3mContour.DXF	Mission 8, East reef, multibeam data, 3 m resolution, 3 m contour intervals, 10 meter max triangle length
MSN008A\IMAGES	
MSN008_East_2D_Contour.tif	Miscellaneous low resolution images of the multibeam data
MSN008_East_2D_Legend.tif	Miscellaneous low resolution images of the multibeam data
MSN008_East_3D.bmp	Miscellaneous low resolution images of the multibeam data
MSN008_West_2D_Contour.tif	Miscellaneous low resolution images of the multibeam data
MSN008_West_2D_Legend.tif	Miscellaneous low resolution images of the multibeam data
MSN008_West_3D.bmp	Miscellaneous low resolution images of the multibeam data
MSN008A_East_3m.jpg	Miscellaneous low resolution images of the multibeam data
MSN008A_West_3m.jpg	Miscellaneous low resolution images of the multibeam data
MSN008A\MultibeamData	
MSN008_West_1m.mtx	Mission 8, West reef, multibeam data, 1 m resolution, matrix file
MSN008_West_1m.xyz	Mission 8, West reef, multibeam data, 1 m resolution, xyz file
MSN008_West_1m_Reduced.xyz	Mission 8, West reef, multibeam data, 1 m resolution, xyz file reduced to 1 point per 1m square
MSN008_West_3m.mtx	Mission 8, West reef, multibeam data, 3 m resolution, matrix file
MSN008_West_3m.xyz	Mission 8, West reef, multibeam data, 3 m resolution, xyz file
MSN008_West_3m_Reduced.xyz	Mission 8, West reef, multibeam data, 3 m resolution, xyz file reduced to 1 point per 3m square
MSN008_East_1m.mtx	Mission 8, East reef, multibeam data, 1 m resolution, matrix file
MSN008_East_1m.xyz	Mission 8, East reef, multibeam data, 1 m resolution, xyz file
MSN008_East_1m_Reduced.xyz	Mission 8, East reef, multibeam data, 1 m resolution, xyz file reduced to 1 point per 1m square
MSN008_East_3m.mtx	Mission 8, East reef, multibeam data, 3 m resolution, matrix file
MSN008_East_3m.xyz	Mission 8, East reef, multibeam data, 3 m resolution, xyz file
MSN008_East_3m_Reduced.xyz	Mission 8, East reef, multibeam data, 3 m resolution, xyz file reduced to 1 point per 3m square
MSN008A\MultibeamData\Tin Models	
MSN008_Tin_West_3mRes_3mContours	Mission 8, West reef, multibeam data, 3-D Tin model, 3m resolution, 3m contour intervals
MSN008_Tin_East_3mRes_3mContours	Mission 8, East reef, multibeam data, 3-D Tin model, 3m resolution, 3m contour intervals
MSN008A\SideScan	
MSN008A_West Side_1m_R200m.tif	Mission 8, West reef, sidescan mosaic, 1 m resolution, range plotted = 200m
MSN008A_East Side_1m_R200m.tif	Mission 8, East reef, sidescan mosaic, 1 m resolution, range plotted = 200m

Although the figures for this report have to be compressed, the original images when viewed in ArcMap or Fleddermaus show much greater detail especially when zoomed on the color-coded multibeam maps and the contour maps.

Initially, low resolution, wide swath side-scan sonar was used at each site (Fig. 3). Then high frequency, high resolution side-scan and multibeam were followed up over individual target sites that appeared to be high-relief reef features. The first high resolution, multibeam sonar was completed on Reed Reef 294, which turned out to be three individual high-relief *Lophelia* reefs that were lined up E-W (Fig. 4).

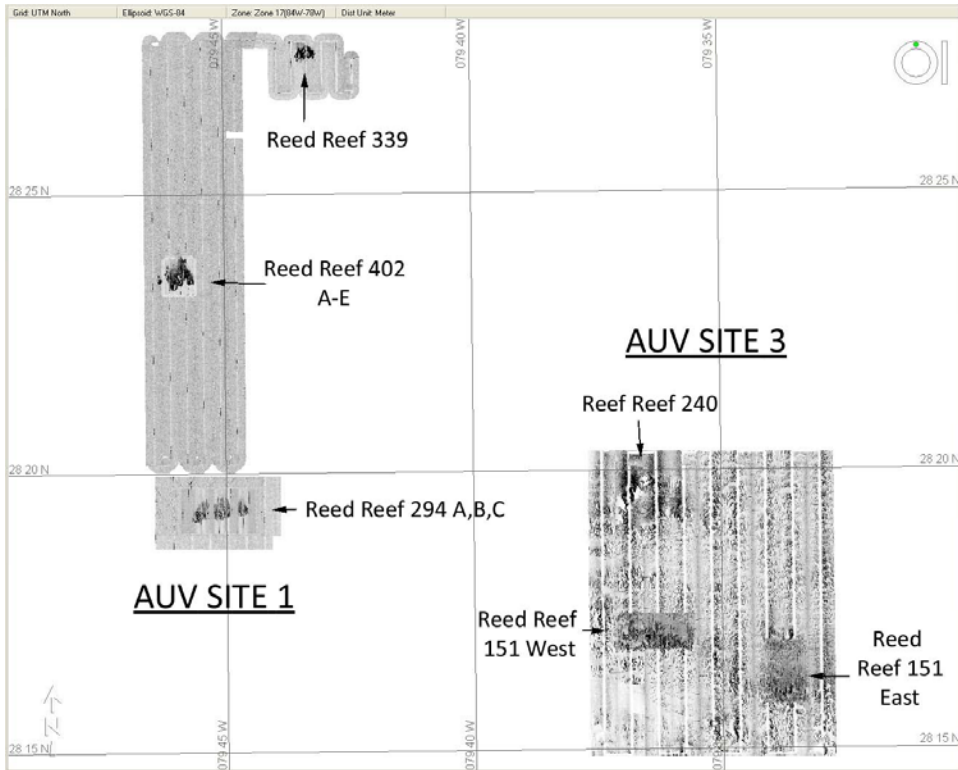


Figure 3. Overlay of side-scan sonar mosaic of all AUV mission dives combined showing individual high-relief *Lophelia* coral reef sites.

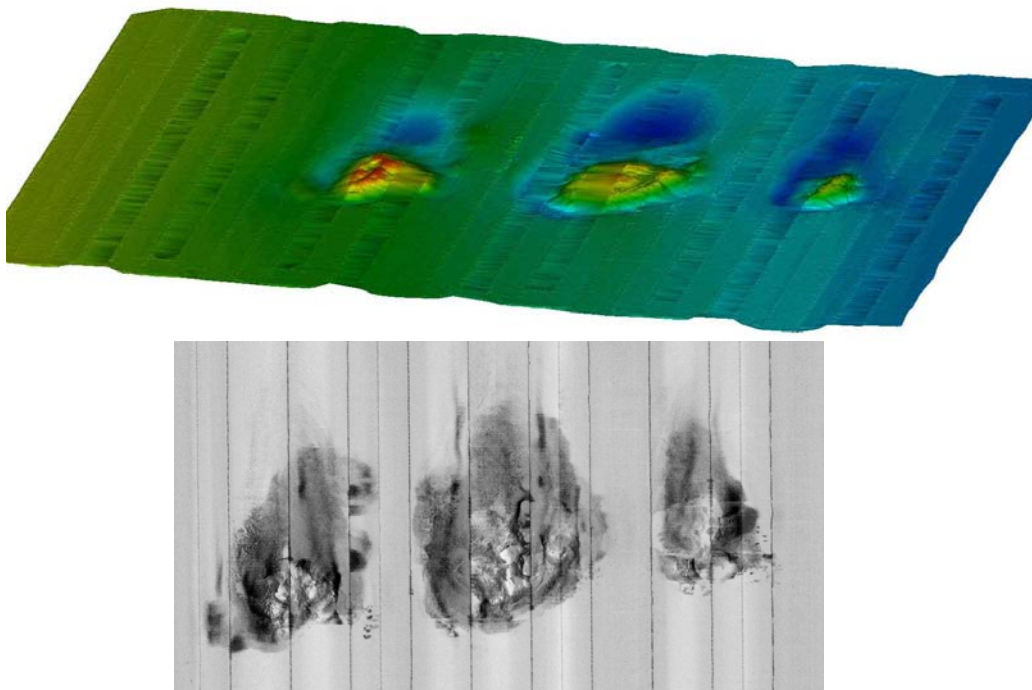


Figure 4. Multibeam (top, 3-d view) and side-scan sonar (bottom, plan view) of Reed Reef 294 showing three *Lophelia* reefs lined up E-W, approximately 60 m tall, depth 420 m.

Just north of Reed Reef 294 a new reef (Reed Reef 402) was discovered during this AUV mission that does not show up on any NOAA bathymetric chart (Fig. 5).

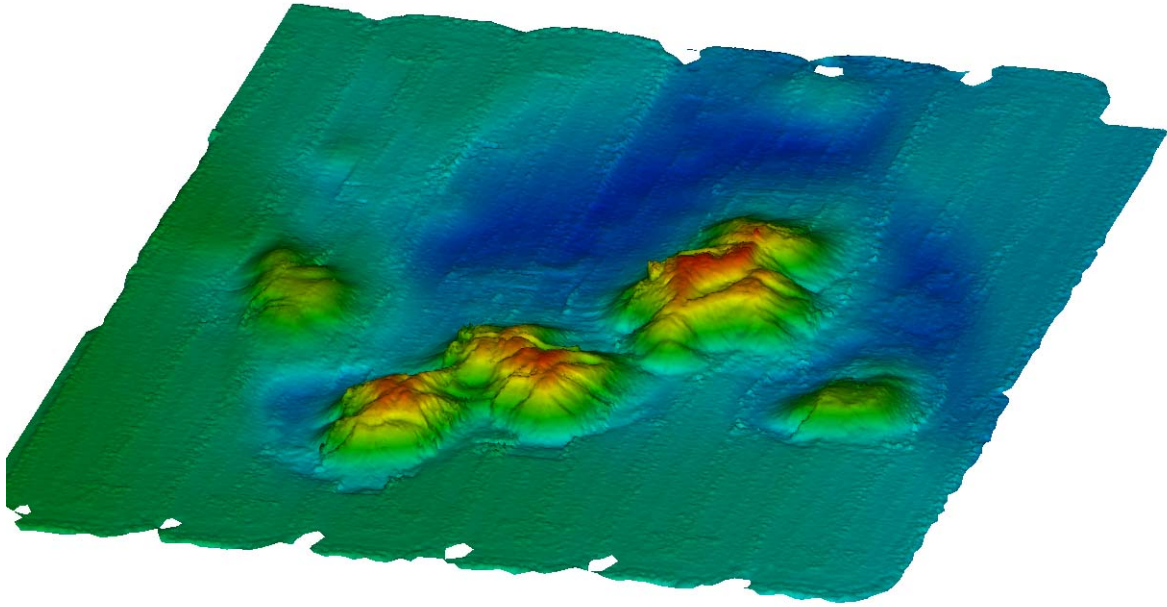


Figure 5. Multibeam of Reed Reef 402 which is a series of five individual reefs (depth 420 m). The colors indicate relative depth, brown is the shallowest and blue the deepest. The top of the figure is north, and the basins north of the reefs indicate a scouring effect of the Florida Current from the reefs. The majority of living coral faces the current on the south slopes and peaks of these reefs.

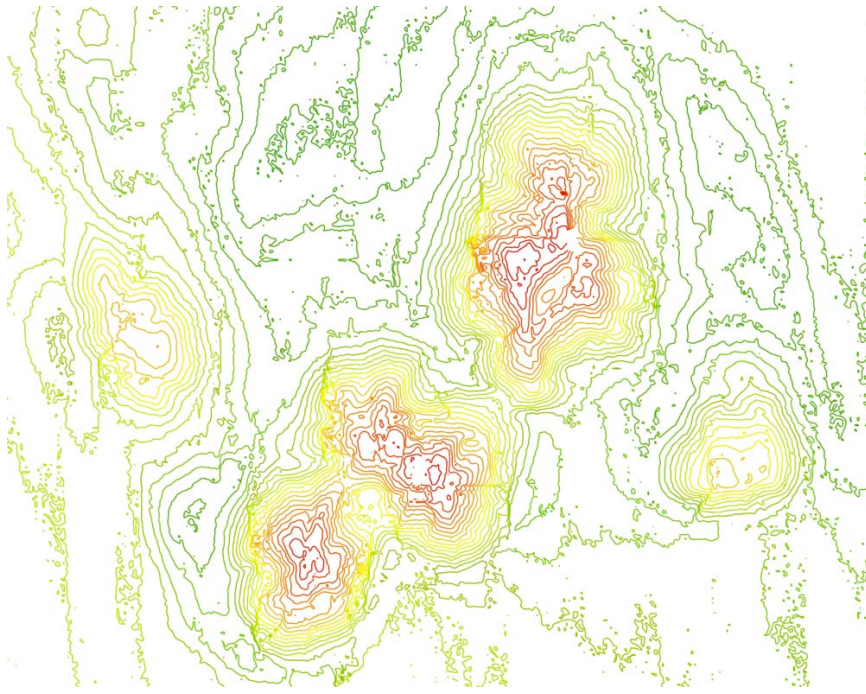


Figure 6. Contour map (3-m resolution) of Reed Reef 402; plan view. ArcMap shows the individual lines very distinctly.

The northeast corner of AUV Site 1 is Reed Reef 339. The multibeam survey of this reef had too widely spaced swaths causing gaps in the data and prevented complete coverage (Fig. 7). Reprocessing of the data can not repair this.



Figure 7. Multibeam of Reed Reef 339 (depth 580 m). Gaps are from too wide swath width.

Within AUV Site 3 are three main reef sites although the entire 30 sq.mi. site is filled with high-relief features. Reed Reef 151 West and East were surveyed with high resolution side-scan and multibeam sonar (Figs. 8 and 9).

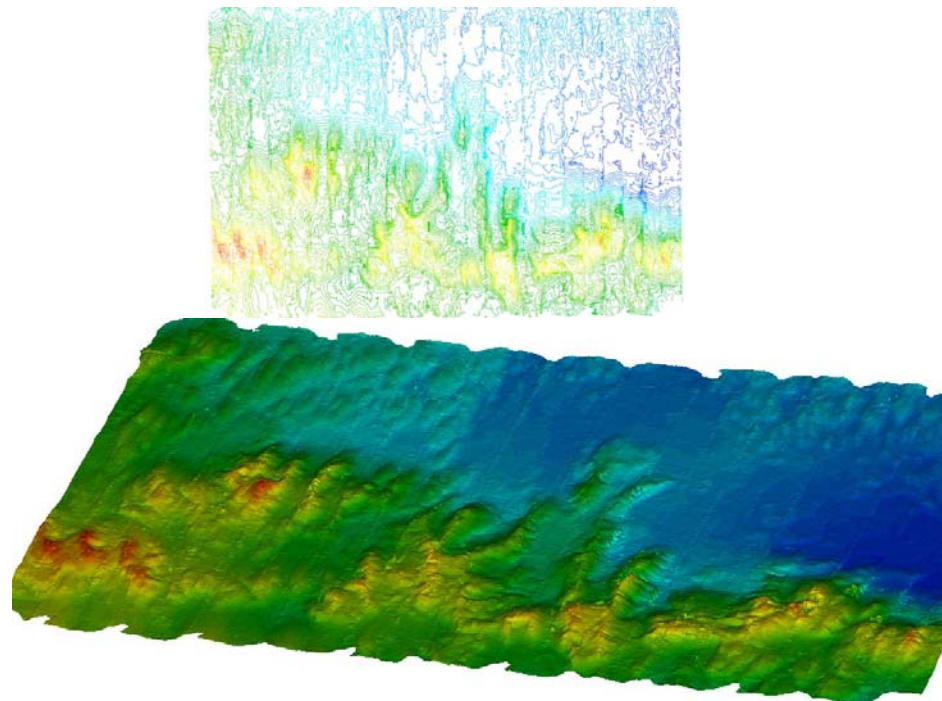


Figure 8. Bathymetric contour of Reed Reef 151 West (top, plan view) and multibeam (bottom, 3-d view), 760 m depth.

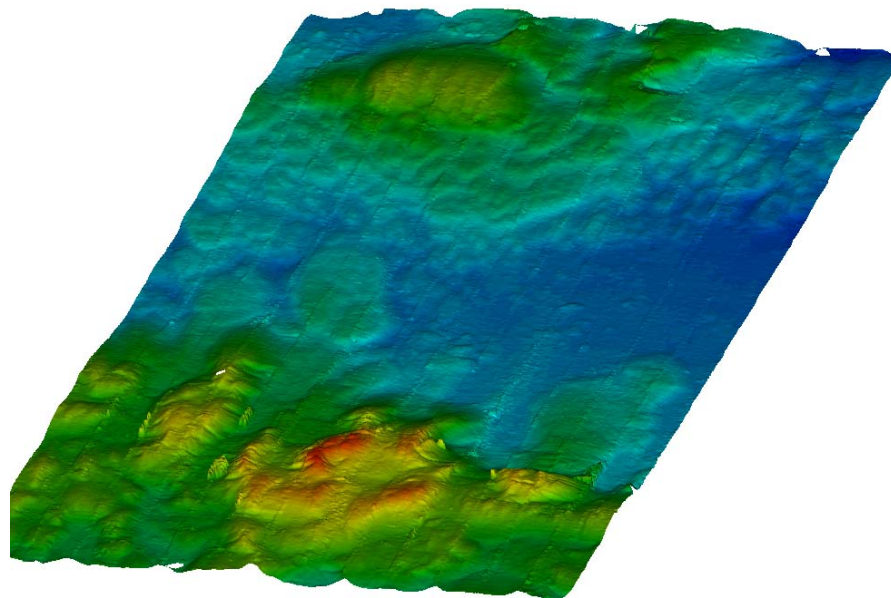
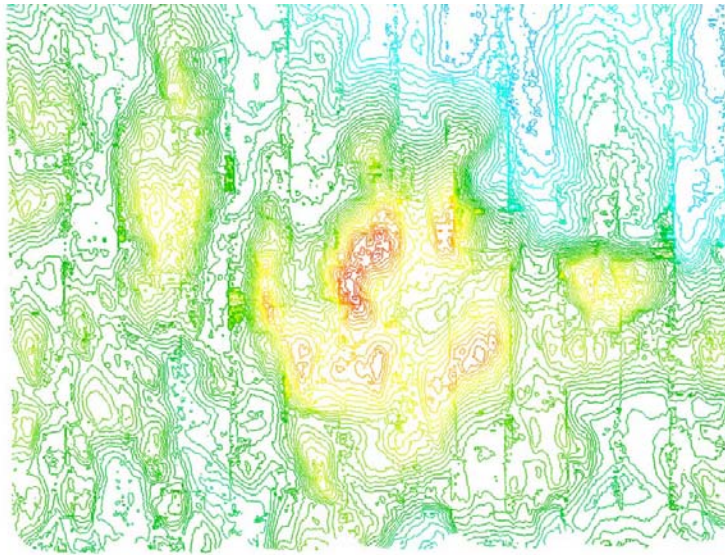


Figure 9. Bathymetric contour of Reed Reef 151 East (top, plan view) and multibeam (bottom, 3-d view).

CONCLUSIONS

The processing of these AUV sonar data provides new, detailed imagery of a 60-sq.mi. region of deep-water *Lophelia* coral reef habitat within the newly designated Deep-sea Coral Habitat Area of Particular Concern. Within this region we have provided high resolution side-scan sonar, multibeam sonar, and bathymetric contour maps for individual reefs that have never been mapped before. Mapping and habitat characterization of these deep-water reef habitats are the top research priorities for NOAA's new Deep-sea Coral Program (Lumsden et al., 2007, The State of Deep Coral Ecosystems of the United States). Further submersible dives are needed to provide detailed habitat characterization and ground truthing for these maps. However, geo-

referenced maps like these will allow benthic video surveys to be much more precise while ground-truthing the data.

Two dives remain that are in need of further processing if funding or resources should become available. They are *Oculina* Reef dives (AUV Dives 009A, 010A). An estimated 40 hours of processing time is projected to achieve similar deliverables by Mr. Sherrell. Dive 009A is especially important to try to locate the dozens of 1-m Reefballs which have been placed on the reef for habitat restoration which is a research priority of the South Atlantic Fishery Management Council. We propose to NOAA NMFS for future funding to complete the processing of these important AUV sonar data sets and also to analyze all data sets for habitat characterization.

BUDGET (J. Reed)

Total Budget = \$2,500

PIs Salary= \$1,322 (=30.4 hours)

Base + 30.8% Fringe + 44.5% IDC = \$2,500

Leverage

Mr. Reed's salary for this project was leveraged by the Robertson Coral Reef Research and Conservation Program at Harbor Branch Oceanographic Institute.

ACKNOWLEDGMENTS

The Waitt Institute for Discovery is gratefully acknowledged for offering use of their two Remus 6000 AUVs for this mission. Harbor Branch ship and submersible personnel provided excellent service as always. The PI sincerely thanks the Robertson family and the Banbury Foundation for funding the PI's research and the Robertson Coral Reef Research and Conservation Program at Harbor Branch Oceanographic Institute. This is Harbor Branch Oceanographic Institute Technical Report Number 124.

LITERATURE CITED

- Lumsden, S.E., T. Hourigan, A. Bruchner, G. Dorr (eds.), 2007. The state of deep coral ecosystems of the United States. NOAA Technical Memorandum CRCP-3, Silver Spring, M.D.
- Reed, J.K. 1980. Distribution and structure of deep-water *Oculina varicosa* coral reefs off central eastern Florida. Bulletin of Marine Science 30(3): 667-677.
- Reed, J. K. 2002. Deep-water *Oculina* coral reefs of Florida: biology, impacts, and management. Hydrobiologia 471: 43-55.
- Reed, J. K. 2002. Comparison of deep-water coral reefs and lithoherms off southeastern U.S.A. Hydrobiologia 471: 57-69.
- Reed, J.K. 2004. General description of deep-water coral reefs of Florida, Georgia and South Carolina: A summary of current knowledge of the distribution, habitat, and associated fauna. A Report to the South Atlantic Fishery Management Council, NOAA, NMFS, 71 pp.

- Reed, J.K., S. Pomponi, A. Wright, D. Weaver, and C. Paull. 2005. Deep-water sinkholes and bioherms of South Florida and Pourtales Terrace- Habitat and Fauna. *Bulletin of Marine Science* 77:267-296.
- Reed, J.K., A. Shepard, C. Koenig, K. Scanlon, and G. Gilmore. 2005. Mapping, habitat characterization, and fish surveys of the deep-water *Oculina* coral reef Marine Protected Area: a review of historical and current research. Pp. 443-465, In (A. Freiwald, J. Roberts, Ed.), *Cold-water Corals and Ecosystems*, Proceedings of Second International Symposium on Deep Sea Corals, Springer-Verlag, Berlin Heidelberg.
- Reed, J.K., D. Weaver, S.A. Pomponi. 2006. Habitat and fauna of deep-water *Lophelia pertusa* coral reefs off the Southeastern USA: Blake Plateau, Straits of Florida, and Gulf of Mexico. *Bulletin of Marine Science* 78(2): 343-375.
- Reed, J. K., C. C. Koenig, and A. N. Shepard, 2007. Impacts of bottom trawling on a deep-water *Oculina* coral ecosystem off Florida. *Bulletin of Marine Science* 81: 481–496.