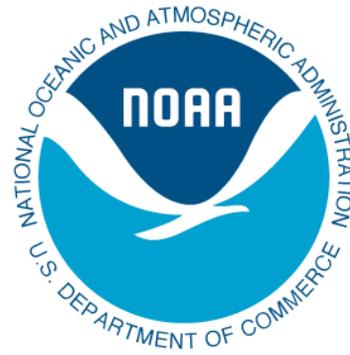


DEP AGREEMENT NO. CM619

**Coordinated Coral and Hardbottom Ecosystem Mapping, Monitoring and
Management, Year 5**

**Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute**

Annual Project Report



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December 2016- Submitted by Richard O. Flamm – FWC FWRI

Final Project Report for CM619

Coordinated Coral and Hardbottom Ecosystem Mapping, Monitoring and Management

Executive Summary

This work addresses the need for a single coordinated perspective on the mapping, monitoring and management of the Florida Reef Tract. Prior to this project, mapping of the reef tract was conducted piecemeal with limited geographic scope using a wide range of mapping methods and classification schemes. The Unified Reef Map was developed as a solution for integrating existing map data into a single, seamless map of benthic habitats from Martin County to the Dry Tortugas. The Unified Reef Map consists of a geospatial framework which includes a single GIS database for mapping, monitoring, and management data associated with the Florida Reef Tract. Another component of the Unified Reef Map framework focused on making data available to the public via online map applications, web mapping services, and other web resources. These web-based map services provide current and historical *in situ* information about Florida reef habitats as well as other relevant spatial information such as management areas, field observations, marine infrastructure, and socio-economic data. Products generated during the final year of this 5-year project include version 2.0 of the Unified Florida Reef Map, updated ancillary data for the Unified Reef Map web mapping services, and the roll out of an updated webpage which provides access to project reports, GIS data, and online map applications. To date, the Unified Reef Map framework has contributed to several management efforts including the Florida Keys National Marine Sanctuary (FKNMS) Zoning and Regulatory Review by incorporating healthy coral reefs that were not captured in the 1995 zoning effort.

This study also contributed to the Our Florida Reefs (OFR) community planning process for southeast Florida's coral reefs. Community Working Group (CWG) meetings were held and were comprised of local reef users, scientists, and representatives from non-governmental organizations as well as local, state, and federal agencies. Topics of the meetings included updates on relevant current events, mooring buoy spatial planning, MPA framework, the Marine Planner decision support tool compiling a prioritized list of recommendations for the comprehensive management strategy, and preparation for the Southeast Florida Coral Reef Initiative (SEFCRI) review. Radio and Television public service announcements, print and electronic advertisements and press releases were produced and distributed to publicize the CWGs and encourage participation in the meetings. Outreach events were also conducted. The principle outcome of the OFR process was a prioritized list of Recommended Management Actions (RMAs). These were first drafted based on the work of the stakeholder-driven CWG and augmented with suggestions from the SEFCRI Team and Technical Advisory Committee. The draft RMAs were then presented to local stakeholders for discussion at a series of community meetings in January and February 2016. The public was encouraged to comment, write letters, and draft petitions in order to share their perspectives following the meetings. In all, almost 2000 comments were received and 12 letters and petitions. The CWG reviewed all feedback received and further edited RMAs based on suggestions and comments from the public. The final result was a prioritized list of 68 RMAs that will be contained in a final process summary report that will be rolled out in June 2017.

Methodology

Unified Reef Map – Years 1 & 2:

A technical team of source map authors and benthic mapping experts was formed to review and discuss the data integration process approach and to work out technical challenges for the Unified Reef Map. The best available benthic mapping layers were compiled into an ESRI ArcGIS Geodatabase. All Feature Class attribute tables were checked and corrected to ensure data integrity and additional fields were added to accommodate attributes of the original source data.

The Unified Class (UC) schema was developed to integrate different classification schemes throughout the region into a common framework while maintaining original source information. The UC system was adapted from several schemes throughout the area including; FWC's SCHEME (Madley, Sargent, & Sargent, 2002), NOAA Puerto Rico and US Virgin Islands Scheme (Kendall, et al., 2001), NOAA Florida Scheme (National Oceanic and Atmospheric Administration, 2008) and CMECS (Federal Geographic Data Committee, June 2012). Five hierarchical UC Level classes were added and attributed. Lower UC Levels represent more generalized classes. Higher UC Levels (Levels 3 and 4) provide more detailed information such as the type and extent of biological cover.

In order to spatially integrate data, individual source map Feature Classes were merged into a single Geodatabase Feature Class. The overlapping area of the layer with the most current information was kept. If overlapping areas were of a comparable time period (within approximately 5 years), priority was given to the layer which best matched the overall mapping area in terms of classification scheme and mapping resolution. Polygon geometry and classification were edited where features were incongruent along boundaries between maps using the best available imagery. Ancillary fields were added to document edits. Fields were also added and attributed to identify geographic region, reef map zone, and CMECS attributes including Geoform, Substrate and/or Biology.

The Unified Reef Map, *in situ* observation data, historic benthic maps, management areas, and other relevant ancillary layers are available through the map data service. An open source [REST endpoint](#) for this map data service allows for access by third party mapping applications. Updates to data services are maintained by FWC staff and automatically pushed to all clients and applications accessing the map data service. Additionally, URM map services are also available for viewing in a dedicated ArcGIS Online web map.

Management-focused meetings were held in South Florida and Key West to introduce the map product to local, state, and federal resource managers. The objective of the meetings was to demonstrate how resource managers can access and use the Unified Reef Map and associated spatial data to support decision making. These meetings and related correspondences between the technical team and managers resulted in a vetted Unified Reef Map product that provides a GIS-based framework for management, research, monitoring, and other uses.

Unified Reef Map – Year 3:

Data gaps in Boca Grande and Hawk Channel were mapped using photo-interpretation methods comparable to those used for surrounding areas in the Florida Keys. Photointerpretation was made using the best available satellite imagery, Lidar, side-scan sonar, ground verification information, and additional ancillary data where available. Edits to existing maps were made

where there were differences in classification with neighboring maps. In addition to these data gap areas, the Unified Reef Map was updated with new data for Biscayne Bay Aquatic Preserve provided by the National Park Service.

The most recent updates of *in situ* data from the Coral Reef Evaluation and Monitoring Project (CREMP) were incorporated into the ancillary data sets and used to evaluate existing map classifications. Documentation, metadata, GIS data/layer packages and CMECS crosswalk tables were updated in the web mapping applications and are available for download from the FWC website at <http://ocean.floridamarine.org/IntegratedReefMap/>.

ArcGIS server web map services were created for distribution of the Unified Reef Map, LiDAR, and other ancillary spatial data. These web map services were directly fed into the OFR Marine Planner web based mapping tool. Source GIS files and documentation were also made publicly available for download through the FWC website. Documentation made available on this web site includes accuracy assessment reports, final grant reports, related peer reviewed publications and links to source satellite imagery and *in situ* data.

Unified Reef Map – Year 4:

Data gaps in the northern Marquesas and Back Country areas were mapped using photo-interpretation methods comparable to those used for surrounding areas in the Florida Keys. More recent, higher resolution satellite imagery, LiDAR, and ground verification information were identified as data sources for mapping these historically unmapped areas. LiDAR reflectance and relative depth data provided information in deeper areas of the Marquesas where satellite imagery was inadequate. Additional ancillary data including field observations acquired by NOAA, FWC, and National Park Service (NPS) were referenced as necessary to assist with photo-interpretation. Existing maps of the surrounding area were considered during classification, and line-work was matched at map boundaries. Additional QA/QC of the Unified Reef Map was conducted to edit and correct topology errors throughout the entire study area. Approximately 820km² were mapped in the Marquesas and Back Country gap areas and integrated into the Unified Reef Map.

Additionally, a standalone patch reef data layer was also generated for the Unified Reef Map study area. The Unified Patch Reef Map provides a continuous and consistent spatial representation of individual and aggregated patch reefs in Southeast Florida and the Florida Keys. The Unified Patch Reef Map was created by extracting patch reef features from several maps throughout the Keys including NOAA, Nova Southeastern University (NSU), NPS, and FWC. Following compilation of datasets, patch reef features were extensively reviewed and edited using updated and higher resolution imagery, LiDAR, acoustic side-scan data, and ancillary patch reef mapping data to ensure map accuracy and consistency. The resulting GIS layer consists of 14,196 patch reefs identified using the best available imagery and a consistent minimum mapping unit and scale throughout the Unified Reef Map study area.

Unified Reef Map – Year 5:

Version 2.0 of the Unified Reef Map was released during Year 5 which included two major updates: 1) integration of the Unified Patch Reef Map into the Unified Reef Map, and 2) addition of new mapping data provided by NSU. Integration of the Unified Patch Reef dataset required extensive review and editing using updated high resolution imagery, LiDAR, acoustic side-scan, and ancillary patch reef mapping data. Intersected patch reef features from the Unified Reef Map were either merged or reclassified at a mapping scale comparable to the original

source map. All edits were documented in the attribute table of the Unified Reef Map. Topology errors, including gaps and overlaps generated from the intersection, were reviewed and corrected. In addition to the Patch Reef features, updated map data of Southeast Florida benthic features were provided by NSU and integrated into the Unified Reef Map. Version 2.0 of the Unified Reef Map and additional layers depicting reef zones, regions, and map footprints were compiled into a geodatabase along with metadata and custom symbology for distribution. Online resources including the Unified Reef Map website and web mapping services (i.e. REST endpoints) were also updated during Year 5. Updates to the Unified Reef Map were made to improve consistency and accessibility to the most critical information and data. The primary Unified Reef Map web service was updated with Version 2.0 map data. Staff also coordinated with project partners to obtain the most current monitoring and management data to update the Ancillary Map Service.

Another deliverable for Year 5 included an accuracy assessment of the broader Unified Reef Map. A comprehensive accuracy assessment of the Unified Reef Map would require additional collection of in situ observations, particularly in recently mapped areas and in areas where maps are likely out of date (e.g. FKNMS hasn't been mapped since 2006). In the absence of funds to acquire additional in situ data, accuracy was assessed by compiling existing accuracy assessment results for individual maps and findings from FWC's review of integration issues which was a product of additional CMP special merit funding during Year 3. Findings suggest that most maps meet recommended accuracy standards with some exceptions for ephemeral habitats (e.g. seagrass) and certain hard bottom habitat classes (e.g. pavement v. reef, aggregated v. individual patch reef). Despite relatively high accuracy of individual maps, there were considerable differences between neighboring and/or overlapping maps and discrepancies revealed during the patch reef integration efforts. Most discrepancies were attributed to differences in mapping methods, map scale, resolution of source imagery, and conflicting interpretations of broadly defined classes. In effect, results suggest that one map is not necessarily more accurate than another, rather, both maps are often correct based on their respective mapping scale and methods. Detailed accuracy assessment results are summarized in Appendix I.

A final meeting was held with resource managers and mapping partners to acquire input on mapping issues and future monitoring needs. The meeting was held on April 14, 2016 at Nova Southeastern University in Dania Beach. Discussions with managers and map end users provided valuable feedback for addressing consistency in mapping scale, methods for new mapping efforts, classification issues, filling data needs (gaps), and acquiring future support for the Unified Reef Map. These discussions and lessons learned over the course of this 5-year project contributed to the creation of the Mapping Guide for Partners of the Florida Reef Tract (Appendix II). The Mapping Guide provides recommended best practices for resolving existing map issues and promoting consistent methods for future mapping efforts.

Our Florida Reefs Community Working Group

OFR CWG - Year 1: July 1, 2013 – December 31, 2014

Florida LLC (Carol Lippincott, Ph.D.) was contracted to provide professional facilitation services for the Our Florida Reefs (OFR) community working group meetings. The OFR-contracted facilitator worked with DEP's Coral Reef Conservation Program (CRCP) staff to coordinate community working groups. Facilitation of collaboration and information exchange between working groups was necessary to ensure the management options identified by the

groups targeted the entire northern third of the Florida Reef Tract. Responsibilities included the development of meeting structure and agendas, creation of a working group charter with consensus approval by working group members, identification of background materials as needed, coordinating follow-up tasks from community working group meetings to ensure continued participation between meetings from working group members and, assisting working group members in coordinating additional informal efforts to further discuss and develop work as needed.

OFR CWG -Year 1: October 1, 2013 – 12/31/2014 Special Merit

The OFR Assistant activities included booking venues for OFR community working group meetings, ordering supplies, preparing meeting materials, and providing assistance to CRCP staff and the OFR facilitation contractor. Outreach included a total of 31 social media posts, 68 web updates, and 13 education/outreach events. Meeting minutes were recorded and compiled for 26 OFR community working group meetings. 6,031 total 30-second PSAs aired (11 total with 8 in English and 2 in Spanish) between December 1, 2014 and March 9, 2015. A total of 15 advertisements, including 6 newspaper and 9 magazine advertisements were produced and published.

OFR CWG - Year 2: July 1, 2014 – September 30, 2015

CWG meetings were held from July 2014 through June 2015. Working group meeting accomplishments included CWG member education about coral reef issues in southeast Florida often having guest speakers, development of shared interest and vision for southeast Florida coral reefs, introduction and use of the Marine Planner tool, compilation and prioritization of management actions for inclusion into the Marine Planner tool, and taking of public comment. Documentation of the OFR facilitation services was provided in the form meeting minutes, and progress reports.

Six outreach events run by the outreach coordinator were conducted during the contract period. During 2015, web postings, including blog updates, resource updates, and meeting announcements were produced continuously between January 5 and March 30, May 11 and July 16, and August 14 and September 15 of 2015. Twenty-five printed or electronic advertisements/meeting announcements were published regularly from January into September. Between July 1, 2015 and September 1, 2015 2,594 radio and television public service announcement were produced and distributed.

OFR CWG - Year 3: July 1, 2015 and September 30, 2016

Six outreach events were held between November 2015 and April 2016 and 4 presentations given between October 2015 and February 2016 to different stakeholder groups. Additional meetings included fish ID and coral ID classes in April 2016. There were 7 SEFCRI meetings, 5 of which spanned 2 days and one was the Bi-annual meeting on August 18, 2016. There were 4 Process Planning Team meetings held between October 2015 and January 2016. There were a total of 170 web postings including blog posts and website updates. There were 8 OFR ads distributed to print media and 1,192 OFR Rack Cards, SEFCRI pens, and/or ESRI App cards distributed at 22 additional outreach events. PSAs totaled 1,641 for TV with 290 in Spanish and 496 for radio with 86 in Spanish. The goal was to distribute 3,500 brochures, pamphlets, rack cards, pens, etc. That number was not reached and we believe for a few reasons. First, while these materials were made available at all outreach events, they were not necessarily picked up by many of the attendees. Second, expected attendance was lower than expected at

some outreach events, which reduced the expected amount of materials distributed. The SEFCRI DEP program will continue to distribute the materials and they will also be available at their June 2016 roll-out of the RMAs.

OFR-CWG - Total project summary

There were over 14,000 PSAs aired on television and radio (including English and Spanish) throughout the OFR process that promoted the Community Working Group (CWG) meetings to the public. There were a total of 37 CWG meetings between March 2014 and June 2016, including a Decision Support Tool Workshop. Twelve Community Meetings held in 2016 were designed to acquire input on the Recommended Management Actions. During these 2016 meetings, there were a total of 517 attendees. At the close of the public comment period following 2016 Community Meetings, a total of 1,942 comments as well as 12 letters and petitions were received. Two CWG subcommittees were formed at the final June 2016 CWG meeting. A “Report Committee”, which will be working with DEP staff to edit and augment the final report, and a “Fishing Liaison Committee”, which will be engaging in outreach to their stakeholder group to disseminate information about OFR outcomes and other local efforts. The CWG achieved their goal of creating a prioritized list of RMAs, with some RMAs having already been implemented or on the verge of implementation.

Outcome

Unified Reef Map

Years 1 and 2 of this project produced and implemented a vetted methodology for integration and distribution of Florida Reef Tract spatial data. Extensive spatial edits and adjustments were completed around source map boundaries to create a seamless map. Presentations and discussions with marine resource managers provided valuable input which helped refine a distributable map product. General feedback from the management perspective confirmed that the tools and map products would be helpful in supporting decision making needs. During Years 3 and 4, significant data gaps in the Unified Reef Map were filled in Boca Grande Channel, Hawks Channel, northern Marquesas and the Back Country region west of Florida Bay. Also during Year 4 and in response to stakeholder requests, patch reefs were re-mapped at a consistent classification methodology and map scale. The standalone patch reef map was subsequently integrated with the Unified Reef Map during Year 5. Throughout the duration of the 5 year project, web mapping services and the Unified Reef Map website were kept current with updated data from map providers.

Stakeholders and other end users of the Unified Reef Map can access the updated map products and project information via several on-line sources:

- Unified Reef Map website (<http://ocean.floridamarine.org/IntegratedReefMap/UnifiedReefTract.htm>);
- Downloadable geodatabase available at FWC’s new online data portal, <http://geodata.myfwc.com/>;
- Java-based web map viewer hosted by FWC (<http://ocean.floridamarine.org/InDevelopment/IntegratedReefMap/#>);
- ArcGIS Online web map (<http://arcgis.is/1L0NJUs>); and

- Web mapping services for the Unified Reef Map and ancillary data which can be accessed directly by ArcGIS users and support FWC’s online map viewers as well as other map applications including the Our Florida Reef’s Marine Planner web map.

Differences in methods between map providers continues to be a factor influencing the accuracy, consistency, and comparability of mapped habitats. Collaborative meetings with map providers have been an effective tool for developing strategies to improve consistency between methods and identify mapping needs. Coordination among mapping partners has also helped to fill data gaps, ensure map information is current, and facilitate the use of new imagery and mapping technologies. These issues are discussed in the Accuracy Assessment Report (Appendix I) which summarizes existing accuracy assessment efforts and issues encountered during map integration efforts. While accuracy issues are inherent with any mapping process and may vary with habitat type, most discrepancies between individual source maps were not necessarily indicative of one map being more accurate than another. Rather, accuracy assessment results suggested that source maps are often correct according to their respective mapping scale and methods. For this reason, source information was maintained whenever possible and very few edits were made during the integration process. Instead, recommendations were proposed to improve consistency in mapping scale, classification methodology, and source imagery between map providers as maps are updated in the future.

Our Florida Reefs

The OFR communication strategy was supported by the production and distribution of products used to inform stakeholders and user groups on the stakeholder-driven OFR process. This communication strategy also improved the rates of participation by stakeholders in the northern four coastal counties along the reef tract through education and outreach efforts. Stakeholders were solicited for their input and participation in the OFR process. The OFR process provided stakeholders the opportunity to take part in coastal and marine spatial planning for the region’s coral reefs in order to develop a management strategy that seeks to better balance the use and protection of southeast Florida’s coastal and ocean resources. This communication strategy allowed CRCP to reach specific audiences that could not be targeted otherwise. Increased stakeholder participation provided support to management options identified and increased awareness at the state and federal level.

The principle outcome of the OFR process was a list of Recommended Management Actions (RMAs). These were first drafted based on the work of the stakeholder-driven Community Working Groups (CWG). The draft RMAs were then presented at community meetings for discussion with stakeholders during January and February 2016. The public was allowed to comment, write letters, and draft petitions. In all, almost 2000 comments were received and 12 letters and petitions. The CWG reviewed the comments and modified prioritized RMAs will be available in their final report to be released in 2017.

Further Recommendations

This project has successfully established a GIS framework for integrating information from throughout the Florida Reef Tract and a comprehensive set of tools for making data available to stakeholders and the broader public. Additionally, this project initiated and facilitated a cooperative network of managers and scientists to coordinate mapping and monitoring efforts. As the final year of this project ends, a major challenge is continued

coordination to sustain these established resources. Based on previous coordination efforts, we recommend annual meetings attended by both management and technical staff, list-serve updates distributed to the Unified Reef Map user community, and more frequent correspondence between key GIS staff. Collaborative meetings with map providers and interested stakeholders during the initial and final phases of this project have been an effective tool for developing strategies to improve consistency and identify mapping needs. Maintaining coordination between mapping interests will help to address data gaps, ensure map information is current and as consistent as possible across the Florida Reef Tract. The Mapping Recommendations Guide (Appendix II) will also promote consistent methods and help to streamline the integration process for future map updates.

A major recommendation made during the mapping stakeholder meeting held in 2016 was to expand mapping efforts beyond the reef tract to include nearshore waters and contributing watersheds (Appendix III). This is an important consideration because the reef tract does not exist in isolation. The geospatial framework of the Unified Reef Map is uniquely suited to address these gaps and link watershed stressors with the condition and productivity of reef resources.

Similarly, we recommend integrating the reef tract and nearshore areas with those uplands whose drainages have influence over the health of the reef tract. These areas can be integrated through expansion of the mapping effort (nearshore bays and estuaries) and engaging uplands communities, organizations, and agencies need to be joined with the reef tract and treated as a single system.

We recommend that the reef tract, nearshore bays and estuaries, uplands, be operationalized as a social-ecological system (SES) (Berkes and Folke 1998; Ostrom 2009; Tabara and Chabay 2013). Most simply, a SES is the combined ecological and human components and their interactions in a complex managed landscape. By complex we are referring to the large number of components and the likelihood of unpredictable system behaviors. In an SES an ideal landscape-level management unit is a watershed because they bound the ecological and socioeconomic patterns and processes that shape the watershed and ultimately impact the Florida reef tract. For the Florida reef tract, the landscape extends from Martin County, Florida down through the Florida Keys and includes the nearshore as well as the upland areas that drain into the Atlantic and can influence the health of the reef. While managing the reef track without considerations of the other system components will likely be inefficient at best and futile at worst, it is a very difficult task because of its size, variety of ecosystems, and large number of political jurisdictions, social institutions, and beliefs and values of millions of residents and visitors.

Given that the southeast Florida reef tract SES would be large, with different habitats, with many socioeconomic and political regions, expertise and resources that span the region, and the simple fact that this research-management system is complex, an operations management (OM) approach to implement the SES is recommended (Krajewski and Ritzman 1999). By operations management we are referring to planning, organizing, and coordinating in the context of producing a desired outcome: a sustainable Florida reef tract. One of the strengths of OM is that it presents a structured platform from which to tackle complex problems, including organizational structure and function. Possible benefits include more highly structured problem solving; more efficient resource use; stronger and better defined partnerships; elimination of ineffectual legacy activities; removal of barriers between programs that hinder productivity and

innovation; increasing creativity and staff morale by nurturing desired behaviors that emerge from employees in the lower half of the organizational hierarchy; and providing internal and external benefits through increased transparency and simplified reporting and accountability.

Success of the OFR process required effectiveness in two areas: stakeholder management and knowledge management. Stakeholder management involves recruiting and retaining, at a minimum, a core set of participants that represent a broad spectrum of the stakeholder community. Much of this stakeholder management was associated with the CWGs. Knowledge management, as it relates here, is a mechanism for managing both environmental data as well as input and information collected from stakeholders. Knowledge management also extends to developing strategies for communicating this information to the public. Knowledge management involved both the CWGs and the Marine Planner tool. Significant progress has been made in both these areas, in this regard, we recommend continued stakeholder engagement and the continued support of tools, like the marine planner, that help manage data and build knowledge. Finally, we suggest, that the OFR process be integrated into the SES described above and serve as a focal point for Florida reef tract collaborative decision making.

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