A color photograph taken underwater showing a scuba diver in profile, facing right. The diver is wearing a dark wetsuit and fins, and is equipped with a tank, a light, and various monitoring equipment attached to a line. They are positioned next to a large, rocky artificial reef structure. In the lower-left foreground, a fish with vertical stripes游过 (swims past). The water is a clear blue.

# *Artificial Reef Monitoring in Florida Coastal Counties*

*William Seaman*

The logo for Sea Grant Florida. It features the word "Sea" in a serif font, "Grant" in a larger, bold serif font, and "Florida" in a smaller serif font below it. A stylized graphic of three curved lines of increasing length is positioned above the "Sea" and "Grant" text.

**Sea Grant**  
Florida

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# Artificial Reef Monitoring in Florida Coastal Counties

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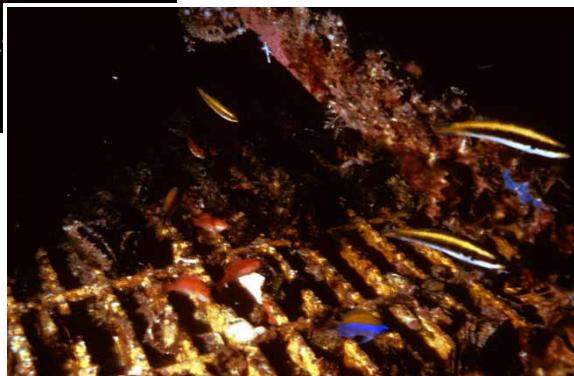
## Contents

Setting and Terminology .....	5
Objectives .....	7
Methods .....	7
Results .....	7
County Reef Program Census .....	7
Reef Assessment and Data Management .....	9
Geographic Information System Applications .....	11
Conclusions and Opportunities .....	11
References .....	14
Appendix: Census Questionnaire .....	15

Figure 1 Enhancing the sport fishery.



A



Photos courtesy V. Reggio and R. Brantley



B



Photos courtesy W. Lindberg

*The principal purpose of the hundreds of human-made reefs in Florida has been to enhance sportfishing. A relocated petroleum platform is deployed in southeast Florida (A). Materials of opportunity are increasingly being augmented by designed structures (B) in county reef programs. Below, custom-made modules are used in Florida's Big Bend.*

*This bulletin describes artificial reef monitoring programs in Florida. At least half the nation's human-made marine reefs are estimated to be in Florida waters and high interest exists statewide among fishing, diving, governmental, economic and other stakeholders in the performance of these structures and the habitats that they create. Further, the level and breadth of activity in Florida makes it a bellwether, nationally and worldwide, for interests concerned with aquatic science, ecosystem management and environmental technology for habitat restoration or creation.*

*Recent developments in Florida have prompted increased interest and effort in "monitoring" of reefs. These include extensive studies and disseminating results by the academic research community and the advent of governmental funding for monitoring projects in Florida counties. In response, this study was undertaken to gauge this growing field. Assessment of reef performance—including evaluation of how well they meet objectives for which they were created—has been a neglected subject in many areas of the world. More immediate issues of reef materials selection, siting and deployment usually take precedence in the short-term.*

*A principal readership for this paper is the network of county-level organizations and individuals whose largely independent efforts, taken as a composite, make up much of the Florida reef "program." Information presented here describes the extent and nature of reef monitoring in Florida counties, how data are managed and aspects of communication about reefs.*

## Setting and Terminology

An artificial reef is "one or more objects of natural or human origin deployed purposefully on the seafloor to influence physical, biological or socioeconomic processes related to living marine resources" (Seaman and Jensen, 2000, p. 5). Often the intent is to mimic the natural environment. Two types of reefs from Florida are depicted in Figure 1. In Florida the focus has been on developing recreational fisheries. Secondarily, recreational diving enhancement and habitat restoration have been goals in certain localities. Around the world, meanwhile, human-made reefs are utilized in a broader variety of situations, to protect or restore aquatic habitats, enhance marine ranching or tourism, and produce seafood.

In Florida, local initiative is the hallmark in the planning and construction of human-made reefs. To this day, county-level efforts and

programs determine who builds reefs and where they are placed, subject to Federal and State regulations. This contrasts with many other areas where a designated state governmental agency has primary responsibility for siting and deployment of reefs. The usual procedure for reef construction in Florida is for a county governmental entity to provide an established organizational base to address and resolve, at a minimum, regulatory, permitting and administrative issues. Some county agencies also physically handle reef materials and operate professional natural resources departments able to measure attributes of the reef on-site (Figure 2). Stakeholders such as recreational fishing and diving interests are active partners, commonly securing free or surplus materials, volunteering labor and equipment and participating in and sometimes leading field observations of reef sites. University scientists and state agency experts round out the effort.

## Figure 2 County programs have range of available resources.



Photos courtesy  
Florida Fish and Wildlife Conservation Commission



*County technical staff, college faculty and students, and volunteer citizens all contribute to making observations and recording data at Florida reef sites. At left, county-owned waterfront staging areas and seagoing vessels are available in some Florida reef programs. Above, on-site investigation of artificial reef attributes is often done by scuba divers employed in a county agency.*

In the 1990s, the Florida Fish and Wildlife Conservation Commission (FWC) expanded efforts to coordinate and facilitate the loose network of local independent efforts growing around the state. The State Legislature began funding reef construction in 1980 (J. Dodrill, personal communication), augmented by Federal monies. To date 514 construction grants have been awarded. As of October 2003 the FWC listed 2,010 deployments on its website. (The earliest was built in 1959; not all were built with FWC grants.) Because this number (2,010) connotes “deployments” of individual items, which in fact may be located over time at one common geographic reef site as opposed to a unique isolated position, it is higher than the actual number of “reefs” (estimated at several hundred) in Florida waters. Many reefs result from multiple deployments at or very close to one point.

The availability of State construction grants prompted centralization of reef planning activi-

ties at the county level because of the need for a contact point to apply for, receive and administer FWC funds. Further, as the grant process evolved, the FWC Artificial Reef Program developed both an in-house capability to monitor reef sites and a process for funding grantees to monitor reefs in their counties. Six monitoring grants were awarded in the 2002-2003 fiscal year by FWC, complementary to the more numerous construction grants.

The term “monitoring,” while well established in the vocabulary of resource managers, scientists and stakeholders, often has different meanings. For the purposes of this bulletin, it is defined broadly as making rigorous scientific observations at varied levels of complexity and for different subjects. This might include, for example, recording presence or absence of plant, invertebrate and fish species at a given reef site; measuring physical attributes, such as water temperature or subsidence of reef materials; or surveying usage or economic expenditures by

anglers and divers. The National Research Council (2000), taking a fairly broad view, refers to monitoring as “observation or measurement of an ecosystem variable to understand the nature of the system and changes over time” (p. 198), while noting that its role extends to “compliance monitoring,” research, and modeling. Lindberg (2003) discussed differentiation among types of assessment studies in a keynote presentation to volunteer reef monitors. He reflects that the term monitoring “has often been used to describe inventories and baseline studies,” while discussing it as one narrower aspect of the field of assessing and “accountability for management actions” (p.5).

## Objectives

This report summarizes features of reef monitoring practiced within the coastal counties of Florida, as conducted or contracted by the designated county-level organizations providing leadership for reef development. Individual research efforts of particular laboratories or scientists are not addressed; nor are pre-deployment site selection practices. The focus is on technical questions that relate to reef performance, the assessments conducted to answer them, and how data are managed. The use of Geographic Information System (GIS) methods to depict spatial data in aquatic sciences has grown (e.g., Nishida and Booth, 2001), and thus part of the study determined GIS practices and interest related to Florida artificial reefs.

The profile of county reef monitoring practices contained within this study is meant to enable comparisons between counties, foster exchange of information and techniques among counties, and facilitate coordination between counties and State interests. Identification of research and training needs and opportunities provides guidance to academic, agency and extension/outreach professionals in the planning of future artificial reef efforts in Florida.

## Methods

Data for this study were obtained in the answers to 17 questions presented to individuals — reef coordinators — who are responsible for leadership of part or all of the artificial reef programs in the coastal counties of Florida. These individuals were identified by the FWC Artificial

Reef Program within the Division of Fisheries, which provided a contact list of persons with whom it deals on matters of reef construction and monitoring grant funding locally. Communication with reef coordinators initially was by electronic mail, using a cover letter and attached “fill-in form” (see Appendix) to acquire information. The list was revised during the project to reflect changes in personnel. Follow-up communication to obtain missing information was by telephone and electronic mail. At the outset, FWC sent an electronic message of endorsement for the project to all active coastal counties .

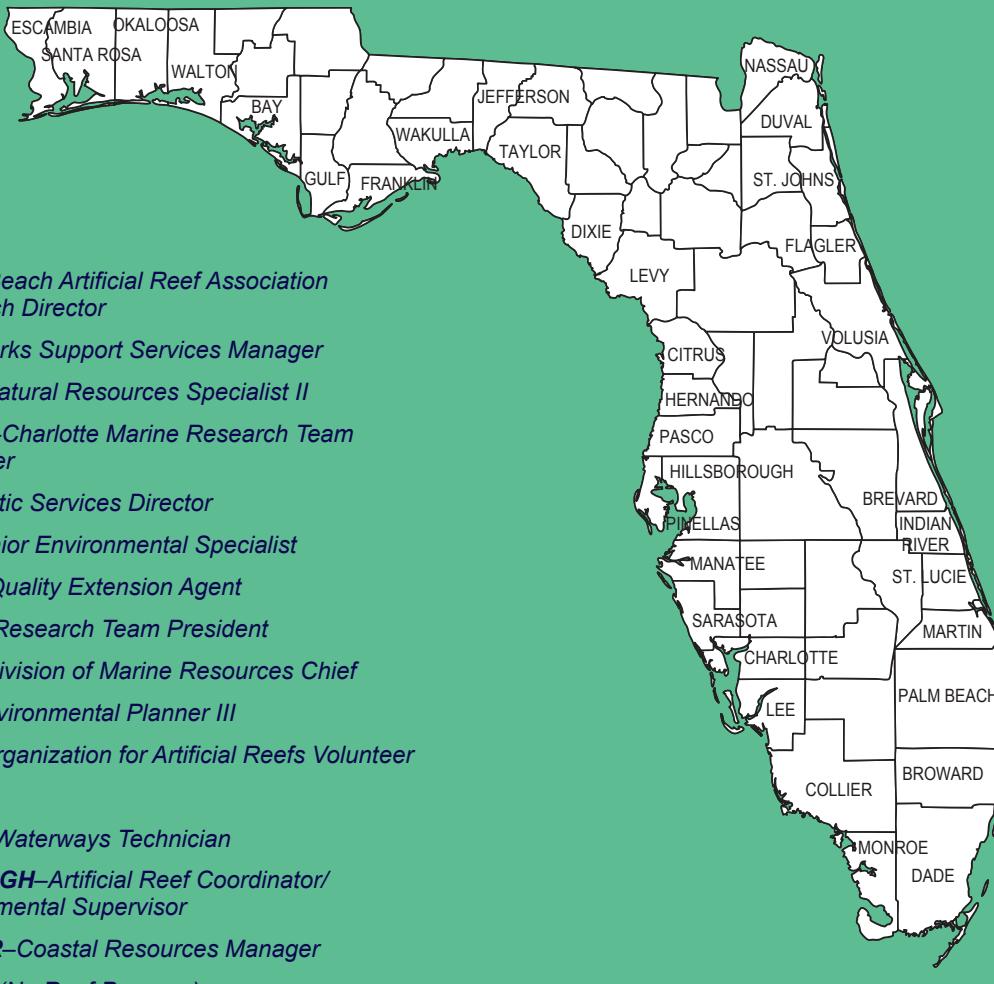
This study was conducted under the auspices of statewide reef research and outreach efforts of both the Florida Sea Grant College Program, which provided limited support staff assistance, and the Department of Fisheries and Aquatic Sciences, University of Florida. The FWC, while not directly involved, was afforded the opportunity to comment on the questions asked. The majority of responses were received between April and December 2002, with limited follow-up afterward. Responses were transposed into an ArcView GIS (version 3.2) attributes table. A project view was created containing multiple themes, each corresponding to a particular question asked. Limited supplemental information was obtained from FWC personnel and the agency website. ArcView GIS was used to report some results as a series of maps and to demonstrate this emerging data management technology.

## Results

This section describes activities associated with Florida county reef programs, summarizes practices to assess reef characteristics and manage data, and profiles the use of and interest in GIS. Most of the database is derived from information supplied by 29 individuals representing 30 counties.

### County Reef Program Census

Of the 35 coastal counties in Florida (Figure 3), all except Jefferson have artificial reefs located in their marine waters. Thirty-two counties have reef “programs”—which are characterized by county organizations involved in reef planning and deployment recognized by the FWC. Each of these has an individual serving as a designated FWC contact. The two remaining

**Figure 3** Positions of Florida counties reef program coordinators.

**BAY**—Mexico Beach Artificial Reef Association  
Research Director

**BREVARD**—Parks Support Services Manager

**BROWARD**—Natural Resources Specialist II

**CHARLOTTE**—Charlotte Marine Research Team  
Volunteer

**CITRUS**—Aquatic Services Director

**COLLIER**—Senior Environmental Specialist

**DIXIE**—Water Quality Extension Agent

**DUVAL**—Reef Research Team President

**ESCAMBIA**—Division of Marine Resources Chief

**FLAGLER**—Environmental Planner III

**FRANKLIN**—Organization for Artificial Reefs Volunteer

**GULF**—(None)

**HERNANDO**—Waterways Technician

**HILLSBOROUGH**—Artificial Reef Coordinator/  
Environmental Supervisor

**INDIAN RIVER**—Coastal Resources Manager

**JEFFERSON**—(No Reef Program)

**LEE**—Marine Biologist

**LEVY**—Unofficial Reef Coordinator (Faculty Volunteer)

**MANATEE**—Environmental Manager

**MARTIN**—Coastal Engineer

**MIAMI-DADE**—Special Project Administrator

**MONROE**—Marine Resources Director

**NASSAU**—County Coordinator\*

**OKALOOSA**—Environmental Services Manager

**PALM BEACH**—Environmental Program Supervisor

**PASCO**—Parks Division Manager

**PINELLAS**—Ocean Operations Supervisor

**SANTA ROSA**—Grants Coordinator (No Reef Program)

**SARASOTA**—Environmental Specialist III

**ST. JOHNS**—Facilities Maintenance Manager

**ST. LUCIE**—Central Services Project Manager

**TAYLOR**—County Extension Director IV

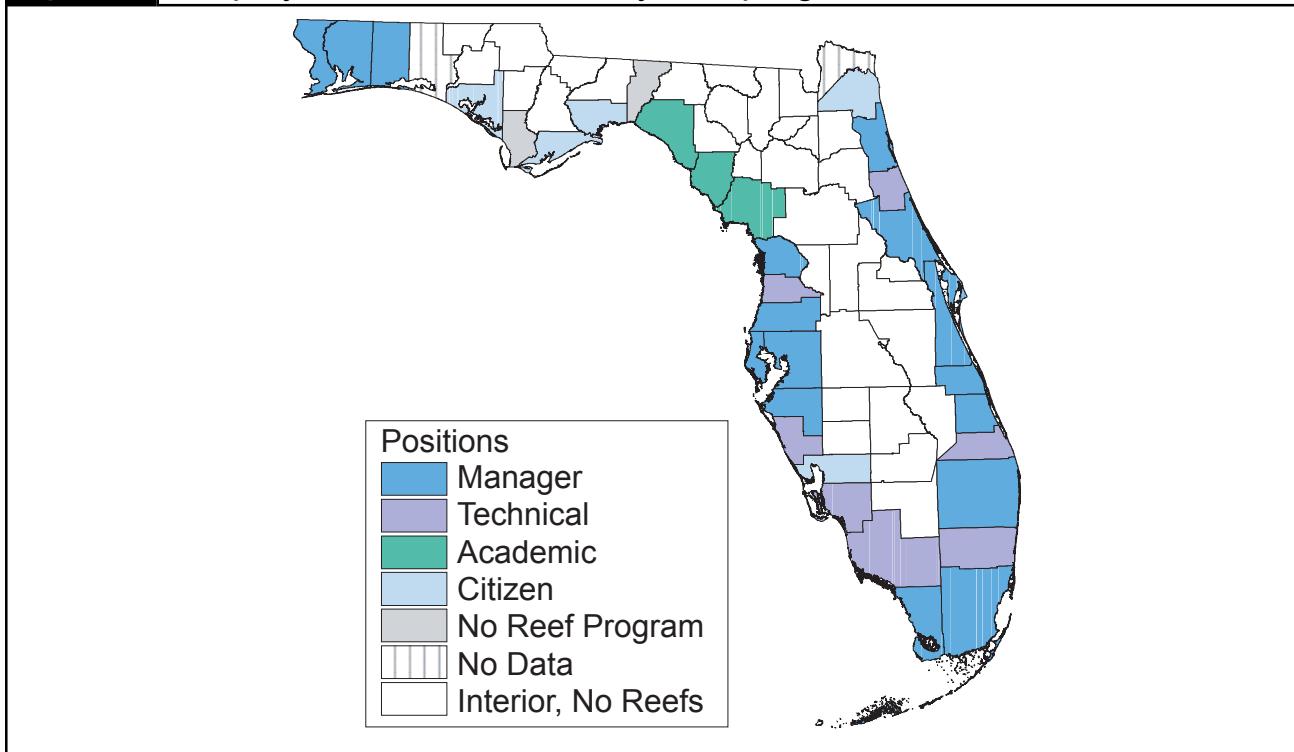
**VOLUSIA**—Inlet and Port District Manager

**WAKULLA**—Organization for Artificial Reefs Volunteer

**WALTON**—Grants Coordinator\*

\* Titles for two positions are not confirmed.

**Figure 4 | Employment status of county reef program coordinators.**



counties (Gulf, Santa Rosa; the latter with a contact) are served by adjacent county programs that deploy reefs in or near their waters and boating access points. Some county programs are government-sponsored or funded, while private organizations take the lead elsewhere. For detailed description of artificial reef deployments and materials in the counties see FWC website:

<http://marinefisheries.org>

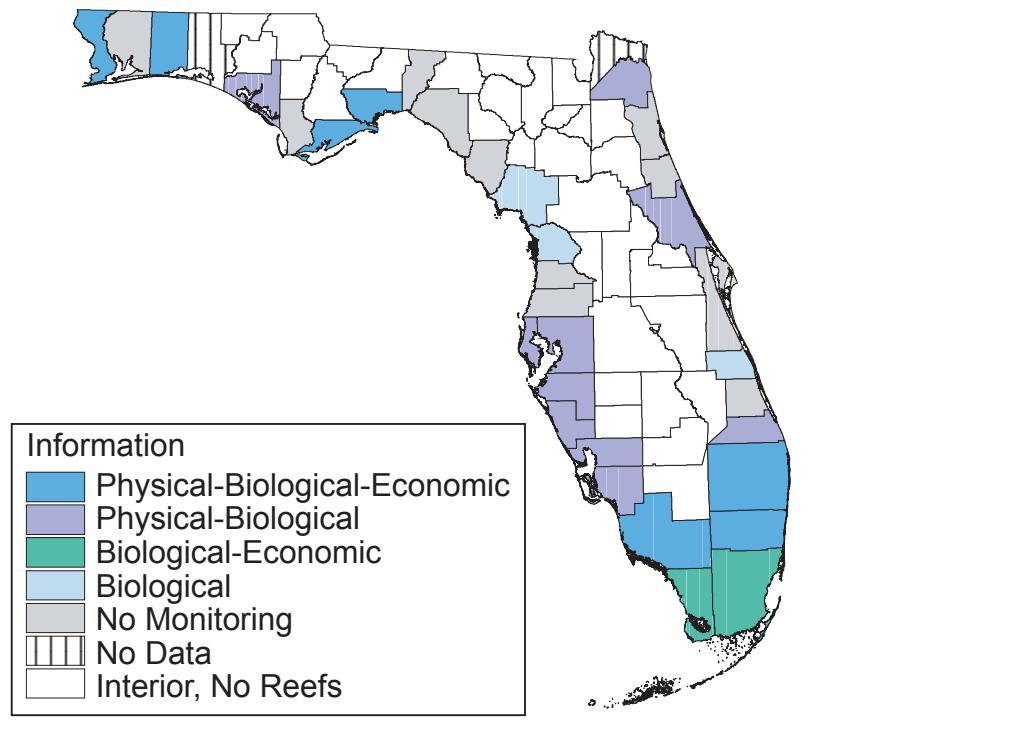
Florida's county reef coordinators have diverse backgrounds, and as a whole, there are a variety of paid and a few unpaid positions (Figure 3). Typically they devote only part-time effort to reef program leadership. The majority are professional staff, employed in either a managerial/administrative (15 individuals) or a technical/scientific (7) capacity (Figure 4). To illustrate the positions held, the managerial group includes a "division manager" and "environmental supervisor," while the technical group includes a "natural resources specialist" and "marine biologist". In addition there are three counties where university faculty (one in research, two in extension) coordinate the reef program. Four private citizens, including a high school teacher and a retired oceanogra-

pher, volunteer as coordinators and also lead environmental monitoring efforts in five other counties.

#### Reef Assessment and Data Management

Twenty-two Florida counties (of 32 reef programs; two not reporting) conduct "monitoring" of artificial reefs in their coastal waters (Figure 5). The three broad categories of reef attributes assessed by them are physical (e.g., temperature, reef movement; by 17 counties), biological (e.g., species abundance; 22) and socio-economic (e.g., expenditures, usage; nine). Almost a third of the counties are making observations for all three categories, and almost half combine physical and biological assessment. In no case were physical and economic measurements ever made alone, but always in concert with biological observations. Three of the remaining ten counties with reef programs were either considering or developing monitoring efforts.

The assessment practices reported by counties reflect the information needs of their county reef programs. Table 1 indicates the subject areas identified by reef contacts in response to the

**Figure 5** Extent and nature of monitoring artificial reefs.

question, “By monitoring, what are the three most important questions you hope to answer?” Seventy percent of all questions were biological, with 47 questions stated by county contacts fitting 12 categories. Most commonly, individuals wanted to know about species assemblages, including diversity, abundance and recruitment (13 questions); the ecological effects of and species preferences for reef materials, designs and habitats (12 questions); and the overall productivity and performance of reefs relevant to ecology and fisheries (eight questions). Another six questions focused on the response of selected species (e.g., target species, gamefish) to habitat. Twenty-one percent of questions dealt with physical attributes of the reef, principally with stability (12 questions) and also with mapping to verify site coordinates and accuracy of placement. Finally, nine percent of questions addressed socioeconomic issues, such as usage, benefit and productivity of reefs. As an initial study of reef monitoring, this project did not gather more specific information on the actual attributes measured nor the methods employed to acquire data.

Once field data are in-hand, storage at the county reef program is by means of electronic, paper and video practices (Figure 6). Electronic storage of data is done by 18 counties, either exclusively (10) or in concert with either paper (four) or video records (three) or both (one). Two counties maintain paper and video records. Two counties that monitor reef attributes were revising procedures at the time of this study, so did not report on methods. The computer software used in electronic data storage included Microsoft (MS) Excel (used by nine counties), MS Access (five), MS Word (three), ArcView (two), MS Office (one), Map Info (one), Chartview Tracker (one), and Real Player (one). Four counties using Excel indicated that they used the FWC format for data spreadsheets.

Information about artificial reefs and addresses is provided on websites by 15 county programs (Figure 7). Note that websites are subject to change.

**Table 1** Subject areas for which reef monitoring information is sought.

Category of General Information	
Biological	
Assemblages of organisms	
• Species presence and diversity .....	11
• Baseline species diversity and abundance .....	1
• Recruitment and colonization .....	1
Habitat structure and function	
• Productivity/effects of materials and configurations/designs .....	10
• Overall biological/fishery productivity/performance/effectiveness .....	8
• Response of target species .....	6
• Species habitat and material preference .....	2
Impacts	
• Longevity of habitat .....	2
• Impact of fishing on community structure .....	2
• Artificial vs. natural reefs (habitat complexity, community/assemblage structure) ...	2
• Role of no-take reefs .....	1
• If harm done .....	1
	47
Physical	
• Stability (durability, longevity) .....	12
• Mapping .....	2
	14
Economic	
• Use of reefs .....	2
• Quality of reefs .....	1
• Benefits of reefs .....	1
• Cost and biological productivity .....	1
• Needs of public .....	1
	6

### Geographic Information System Applications

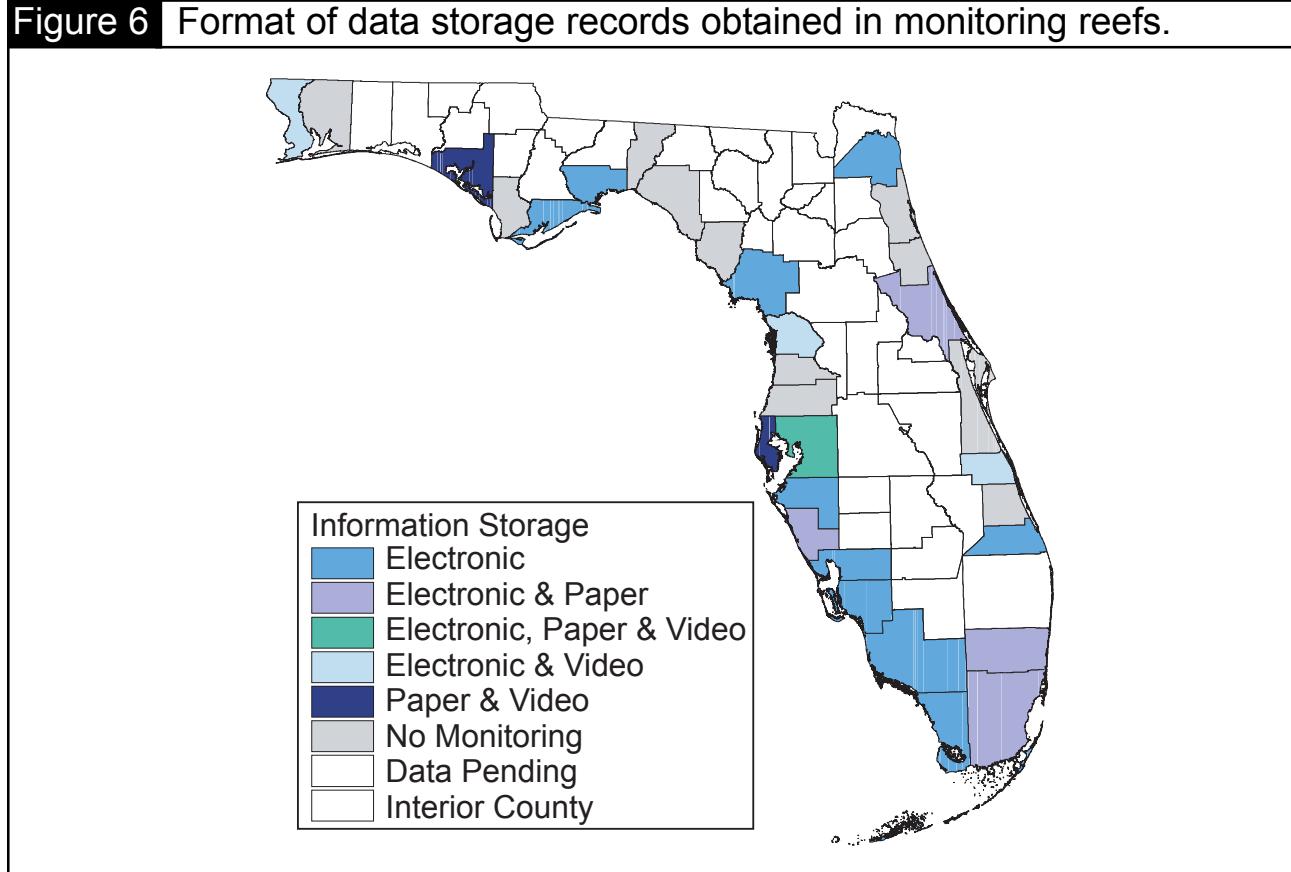
The use of GIS in county reef programs is depicted in Figure 8. Fifteen counties use this methodology, principally for mapping of reef sites. In these counties, nine (64%) of the reef contacts are “experienced” with GIS, while the others were less familiar but could rely on colleagues for GIS procedures. In the counties not using GIS for reef applications, three individuals (19%) regarded themselves as experienced, while seven were “aware” of it. Interest in learning more about GIS was expressed by eight counties, with six interested in training opportunities.

The FWC reef program also maintains a GIS database. It principally serves in-house data management and subsequent presentations of information to county audiences. Without having a description of its content or applications, 21

county contacts expressed interest in learning more about it.

### Conclusions and Opportunities

In its entirety the Florida “artificial reef program” is a quilt of local and mainly independent initiatives coordinated by 32 individual counties, which in turn are not so much linked as undergirded to varying degrees by the statewide FWC Artificial Reef Program. This concluding section identifies possible ways for both sectors, county-based and state-level, to coordinate and cooperate in enhancing programs. Based on reports from 94% of Florida coastal counties, this paper determined that two-thirds of Florida counties with reef deployment efforts also conduct monitoring. These efforts result from interest on the part of stakeholders that build (e.g., county government) or use (e.g.,

**Figure 6** Format of data storage records obtained in monitoring reefs.

anglers, divers) reefs, are led by paid staff and volunteers, and have been enhanced by FWC reef monitoring grants.

Principal features shared in common by the Florida county reef programs include part-time leadership by designated coordinators, a focus on biological attributes in reef monitoring, and the use of electronic storage media for reef data. Differences, meanwhile, include wide variations in the backgrounds of reef coordinators, the scope of reef monitoring (or lack thereof), and degree to which websites and GIS practices are used to communicate information. There is a trend to start or revise monitoring and growing interest in expanding the use of computer-based information management and dissemination.

In keeping with the emphasis of this study on monitoring, the following opportunities are suggested:

For county reef programs that may be in earlier stages of development, there is a good

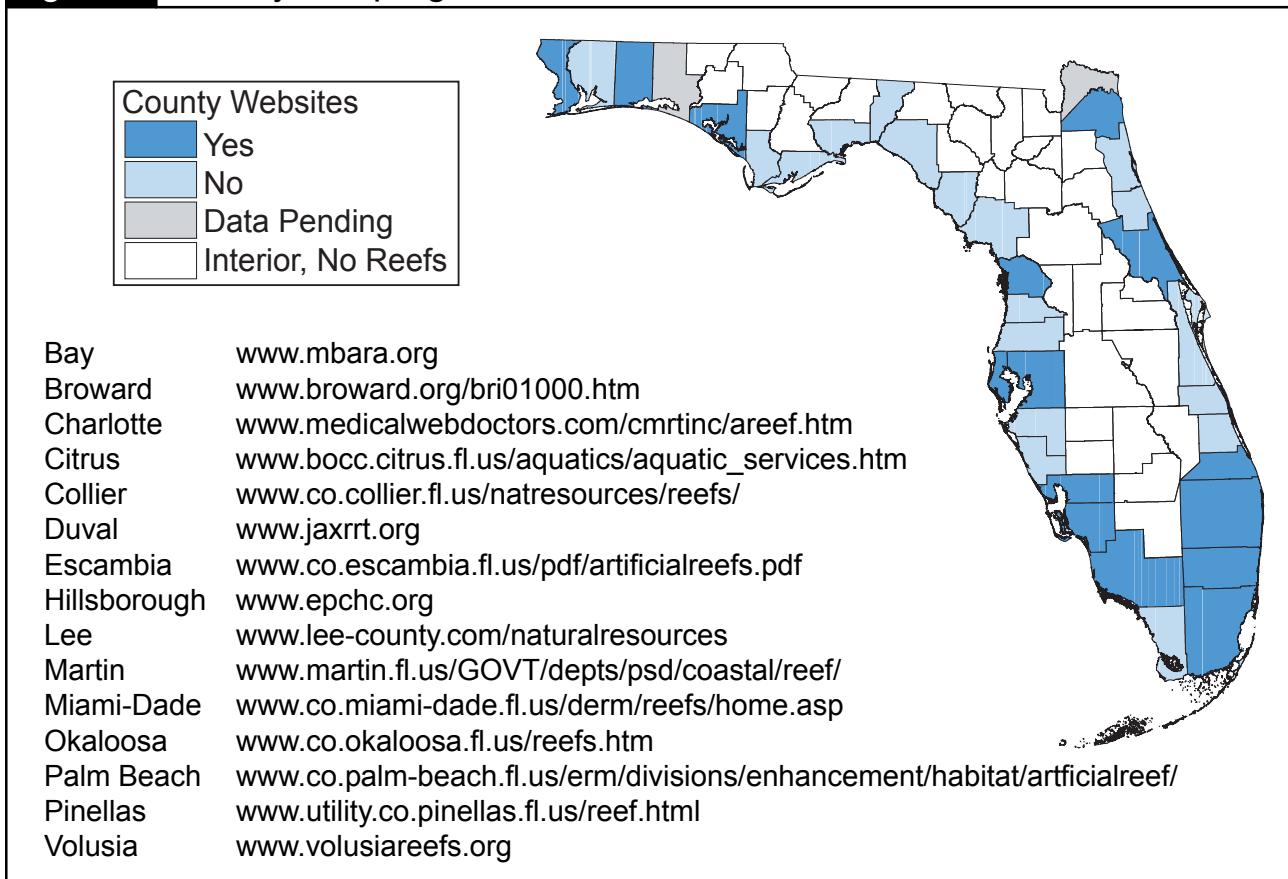
opportunity to learn from and coordinate with monitoring practices in the 22 counties where they are established at some level. There are numerous possibilities for sharing experiences, such as in organizing field work, and applying standard observational and data management techniques.

For county reef programs already conducting monitoring, there is opportunity to expand from the biological observations made in all 22 counties to include physical and socio-economic data gathering.

The expressions of interest made by some counties to learn about monitoring in other counties are matched by statements from other counties of being quite willing to share experiences. Thus, there are opportunities regionally and statewide to bring reef monitoring interests of varying expertise together.

Among active reef monitoring programs there is an opportunity to standardize data recordkeeping—or at least debate its merits. This

**Figure 7** County reef program websites in Florida.



applies, for example, to the use of different software (e.g., Excel, Access, Word) for similar purposes in different counties, and to the variable use of the FWC format for data spreadsheets.

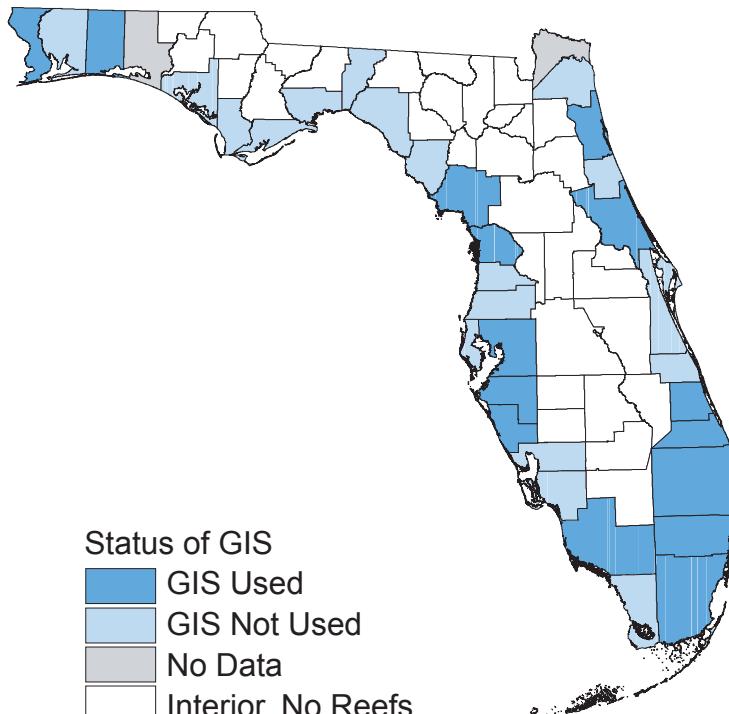
The opportunity for more experienced county programs to share experiences with others extends to the use of websites to publicize information about reefs. Examination of the 15 websites reported for this study reveals wide variability in the content provided and how it is managed. Photographs of reef materials and sites, for example, are notably lacking. A county that is about to develop or revise a reef website could benefit by surveying existing sites to develop categories of information to address.

The use of Geographic Information Systems can be expanded both quantitatively and qualitatively. The expression by several reef coordinators of high interest in GIS training represents an obvious continuing education opportunity. Meanwhile, the principal use of GIS for reef site

mapping indicates an opportunity to develop other applications of this information management and portrayal tool, such as in the depiction of biological trends for assemblages of reef organisms. Again, counties with GIS efforts are willing to assist others.

At the regional level, there is opportunity to compare monitoring results among counties. This could build up the size of datasets for given species or reef types, and extend the geographic basis for interpreting results. Ultimately, compilation of all county data in the FWC system could afford both analysis of regional and statewide information and access by local users to data from one or more counties. The software used for data records should be considered carefully for versatility and usefulness. County interest in the FWC website suggests that standardization of data sets may better facilitate the sharing of monitoring information statewide.

One rationale for monitoring is to give funding sources as well as reef-builders and

**Figure 8** Use of Geographic Information Systems in county programs.

users solid and objective information that they can use in making decisions about reef objectives, deployment and evaluation. Monitoring done consistently across county lines affords greater comparability, such as for the effects of reefs on given species. In addition, monitoring generates information to answer basic scientific questions and provides numerous educational opportunities. As the State of Florida Artificial Reef Strategic Plan is implemented, the role of monitoring as a means of strengthening the scientific basis for reefs must be addressed.

The opportunity for future studies of Florida reef monitoring is to provide more detail on actual practices of field observation and data analysis, perhaps including examples and case studies.

Finally, it was beyond the scope of this study to develop a history of reef-building in Florida or to inventory the numerous materials, designs, and locations used in deployments. The value of such an effort, though, would be to archive and help explain the development of current practices.

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**Appendix: Census questionnaire sent electronically to county contacts**

**Florida Study of Reef Monitoring and Geographic  
Information System Use by County Programs**

**A. COUNTY INFORMATION:**

1. Name of respondent:
2. County name:
3. Position (Job/Title) in county:
4. Number of active permitted reef sites in county waters:

**B. MONITORING INFORMATION**

5. Does your program monitor its reef sites in any way?: Yes (Go to #7) No (Go to #6)
6. If NO MONITORING, please explain in a line or two (then go to #11):
7. If there is monitoring, please indicate what kind:
  - Physical (e.g., stability, longevity)
  - Biological (e.g., diversity, production)
  - Socio-Economic (e.g., usage, costs/returns, expenditures)
8. By monitoring, what are the three most important questions you hope to answer?
  - (1)
  - (2)
  - (3)
  - (4) Others if you have them and have time to list.)
9. Once monitoring data are gathered, how do you store them? (Describe briefly)
  - A. Also, what software is used?
  - B. Also, what is the format used to store data?
10. Once monitoring data are gathered, how do you analyze them? (Describe briefly)

**C. GEOGRAPHIC INFORMATION SYSTEMS**

11. How familiar are you with "Geographic Information System" (GIS) procedures?
  - Experienced
  - Understand, but do not use
  - Aware of it
  - Unfamiliar
12. Do you or anyone in your reef program use GIS in artificial reef data management?
  - Yes (Go to #14) No (Go to #13, then 15)
13. If GIS is not used in your reef program, what is your priority to try or use it?
  - High
  - High, and would be interested in training or demonstration
  - Moderate
  - Low
  - None
14. How is GIS used in your reef program (or in a related department)?
15. If there is a website for your reef program or links to relevant GIS projects in your county, please list:
16. The Florida Fish and Wildlife Conservation Commission's Artificial Reef Program office in Tallahassee maintains a GIS.
  - A. If the GIS were available on-line, would you be interested in using it?
  - B. If so, how? (Please describe your top two interests.)

**D. OTHER**

17. If there is anything else that you'd like to mention about GIS, or any other reef-related issue, please give us your thoughts.

# Coastal Artificial Reef Habitat Technology and Extension

Developing and extending science-based information to improve artificial reef technology in Florida's coastal waters is a priority for Florida Sea Grant. Most of its coastal county-based extension faculty are involved in some activity related to artificial reefs. Through close and active engagement with citizens and organizations at the county level, they provide planning, siting, deployment, monitoring and education for artificial reef decision-making. Their work is backed by the rigorous research component of the Florida Sea Grant College Program.

Recently, extension faculty have organized the annual West Coast Reef Coordinators conference, provided hands-on assistance to secure and deploy reef materials in, among other places, Charlotte Harbor, advised volunteers in underwater monitoring, and assisted various county applications for reef grants.

Complementary to their work is the contribution of state-wide extension specialists and university-based research faculty. They develop and synthesize new information about artificial reefs, in part to address questions raised by county stakeholders and extension faculty alike about such topics as the economic impact of artificial reefs, the effects of human-made reefs on natural reefs, or methods of managing reef monitoring data. Part of the information storehouse comes from 15 major research projects sponsored over time by Florida Sea Grant.

Florida Sea Grant's Extension Program will continue to be proactive and responsive to the widespread Florida reef-building community. Examples of new efforts being considered are the organization of a workshop to offer training in GIS application to reef data management, and writing Extension publications on reef planning and design.



Photo courtesy Daniel Hughes



## Science Serving Florida's Coast

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