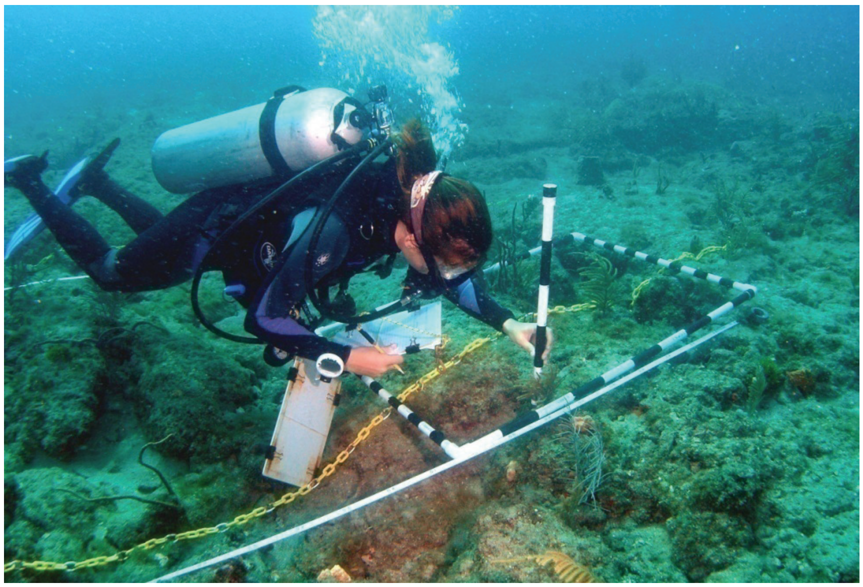
Evaluation of Past Coastal Construction Project Monitoring in Southeast Florida and Recommendations to Improve Future Monitoring



Southeast Florida Coral Reef Initiative
Maritime Industry and Coastal Construction Impacts (MICCI) and Fishing, Diving, and Other Uses (FDOU) Focus Teams
Local Action Strategy Project 27, 47, 48

Southeast Florida Coral Reef Initiative
Acting above to protect what's below.

Evaluation of Past Coastal Construction Project Monitoring in Southeast Florida and Recommendations to Improve Future Monitoring

Prepared By:

Alison Moulding
Nova Southeastern University Oceanographic Center
800 North Ocean Dr.
Dania Beach, FL 33004

June 2011

Completed in Fulfillment of Contract RM094 for

Southeast Florida Coral Reef Initiative
Maritime Industry and Coastal Construction Impacts (MICCI) and
Fishing, Diving, and Other Uses (FDOU)
Local Action Strategy Project 27, 47, 48

and

Florida Department of Environmental Protection
Coral Reef Conservation Program
1277 N.E. 79th Street Causeway
Miami, FL 33138

This report should be cited as follows:
Moulding, Alison L. 2011. Evaluation of Past Coastal Construction Project Monitoring in Southeast Florida and Recommendations to Improve Future Monitoring. Nova Southeastern University Oceanographic Center. Dania Beach, Florida. iv and 92 pp.

This report was prepared for the Florida Department of Environmental Protection (FDEP), Office of Coastal and Aquatic Managed Areas. Funding for this report was provided in part by a Coral Reef Conservation Program (CRCP) grant from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management Award No. NA06N0S4190100, and by the FDEP, through its Coral Reef Conservation Program. The total cost of the project was $119,990, of which $95,000 was provided by the NOAA CRCP. An additional $24,990 was provided from the NOAA CRCP, through the NOAA National Marine Fisheries Service Southeast Region. The views, statements, findings, conclusions and recommendations expressed herein are those of the author and do not necessarily reflect the views of the State of Florida, U.S. Department of Commerce, NOAA or any of its subagencies.

Cover Photo: David Gilliam, National Coral Reef Institute

Table of Contents

APPENDICES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The close proximity of coral reef communities in the southeast Florida region (Miami-Dade, Broward, Palm Beach, and Martin counties) to heavily-developed coastline puts them at risk of impact from coastal construction projects such as beach nourishment, dredging, and cable placement. The purpose of this project was to develop guidelines for future monitoring of permitted coastal construction and mitigation activities in the southeast Florida region. Guidelines were developed based on 1) interviews with local, state, and federal agencies, consultants, and universities, 2) a review of monitoring design efficacy of past permitted coastal construction, mitigation, and non-mitigation artificial reef projects in the southeast Florida region, and 3) a literature review of monitoring protocols. The goal of this project was to identify factors in past project monitoring designs that may have limited the capability to detect impacts and to provide alternative approaches and suggestions for future monitoring projects that will increase the ability to detect project-related change. The recommendations proposed in this report are intended to provide resource managers and contractors with methods for effective monitoring strategies.

In order to determine the effectiveness of local monitoring projects, reports were evaluated based on 21 criteria in the following three categories: experimental design, statistical analysis, and interpretation of results. Experimental design was revealed to be the area most in need of improvement followed by statistical analysis and interpretation. On average, non-mitigation artificial reef monitoring reports scored lowest (least criteria met), and mitigation artificial reef monitoring reports generally scored highest (most criteria met). Even though cable placement projects scored on the lower end, most of the recommendations for improving monitoring are associated with beach nourishment projects due to the relative frequency of the projects and current difficulty of defining and detecting impact.

Interviews of personnel involved with monitoring project development revealed that review of post-construction reports by agencies was often lacking or restricted due to time, agency mandates, and staffing constraints and that efficient methods of transferring knowledge gained from past project monitoring, and recommendations to improve future monitoring, were needed. Many of those interviewed agreed that sampling design needed to be improved, but they expressed concern over the ability to achieve this due to limited budgets and lack of previously un-impacted areas for appropriate controls.

The most important recommendation to improve future monitoring is to define impacts, effect sizes (limit of acceptable change due to impact), and limits of probability of committing a Type I (rejecting a true null hypothesis) or Type II

(accepting a false null hypothesis) error. Many of the issues of experimental design could be improved if these elements are defined before a project begins. Other recommendations include increasing the frequency and duration of pre-construction monitoring surveys, adding individual organism-based measurements of impact to monitoring design, considering alternative mitigation projects to artificial reef (e.g., limestone boulder) placement, examining ways to incorporate a more regional management approach for monitoring of large beach nourishment projects, and providing more formal training opportunities on experimental design for all parties involved.

1. INTRODUCTION

The coral reefs (including nearshore hardbottom communities with reef-associated biota) offshore the southeast Florida counties of Martin, Palm Beach, Broward, and Miami-Dade are located adjacent to a heavily-developed and populated region of the state. Their close proximity to various coastal development and construction activities, such as beach nourishment, channel dredging, and fiber optic communication cable placement, puts them at risk of degradation and habitat loss. Biological monitoring of natural resource impacts during coastal construction activities and of artificial reefs installed as mitigation for unavoidable hardbottom impacts is often required as part of the permitting process. However, monitoring protocols typically have not been standardized nor evaluated for their effectiveness of detecting environmental response. Therefore, it is unknown whether historical monitoring efforts have been able to adequately identify environmental impacts from construction activities or determine if the goals of mitigation actions have been met.

One reason for this often inadequate identification of impacts is due to a historical disconnect from scientifically valid monitoring protocols. Individuals involved with project permitting and monitoring often have varying interpretations for, and definitions of, the relationship between "monitoring" and "research." Some argue that monitoring should not be held to the methodological standards of research, even though state permitting agencies require "reasonable assurance" of no impact due to project construction. Since the criteria used to determine reasonable assurance are not well defined, some believe that statistical analysis is not a necessity for providing reasonable assurance. However, if the goal of monitoring is to determine with reasonable assurance that a coastal construction project is not negatively impacting the environment, monitoring should be designed in a way to ensure that sufficient and valid data are collected in a manner to be able to draw accurate conclusions. Research is asking a question and designing a way to collect information to answer that question. Monitoring related to coastal construction is gathering information to determine the answer to the question "is there an impact (positive or negative) due to the project." Regardless of the term used, the process of collecting the information is the same. The only way to unambiguously assess cause and effect relationships is to employ the principles of the scientific method. Hypotheses are formulated, experiments are designed, data are gathered and analyzed, and conclusions are drawn to support or reject the hypotheses. Some regulators argue that coastal construction projects are not experiments, but an experiment can be defined as the addition of an intervention (treatment) on some objects (experimental units) and testing the response. Coastal construction is an experiment, though uncontrolled and often un-replicated, because it alters the environment through human manipulation. Proper design of monitoring projects is imperative to drawing correct conclusions about the impacts of coastal construction on the environment. In this way, there is no difference between "monitoring" and "research."

This project evaluated coastal construction monitoring of projects occurring primarily within the past ten years in the four county southeast Florida region for their ability to detect impact. Based on this evaluation, recommendations were developed for future monitoring of permitted coastal construction and mitigation activities to improve their ability to detect project related impact and to determine if mitigation is meeting its intended goals. The purpose of these recommendations is to ensure that monitoring at an individual project level is designed to be scientifically sound and relevant to resource management. Additionally, recommendations for standardized monitoring protocols are suggested for the purpose of improving the ability to compare results among projects which will aid in the holistic management of the region.

2. METHODS

This project involved three components: 1) review of published and gray literature on accepted monitoring protocols and experimental design, 2) evaluation of past coastal construction and artificial reef project monitoring reports from the southeast Florida region, and 3) interviews with agency personnel and environmental consultants. These three components are described in more detail below. Results from these three components were used to develop recommendations for improving future coastal construction, mitigation, and artificial reef monitoring in southeast Florida. The goal of these recommendations is to provide resource managers with guidance for effective monitoring strategies including experimental design and parameters to measure.

2.1 Literature review

A review of published literature was conducted to determine accepted and applicable monitoring methods and design and to ensure recommendations developed as a result of this project are scientifically sound. The Aquatic Sciences and Fisheries Abstracts (ASFA) electronic database and the internet were searched using keywords related to coral reef communities and monitoring to locate relevant published and gray literature. See Appendix 1 for a full list of key words and websites searched. Additional literature was obtained through contributions from staff of local, state, and federal agencies and from Maritime Industry and Coastal Construction Impacts (MICCI) and Fishing Diving and Other Uses (FDOU) Combined Project 27, 47, 48 team members (referred to as the project team in the remainder of the report).

2.2 Monitoring Report Evaluation

Permits, monitoring plans, and monitoring reports for coastal construction activities located near coral reef resources in the southeast Florida region were obtained from permitting agencies, local governments, and consultants. Coastal construction projects requiring Joint Coastal Permits (JCP), Environmental Resource Permits (ERP), and Coastal Construction Control Line (CCCL) permits that had direct or indirect impacts on coral reefs were targeted. Construction activities included dredging, construction of hard structures such as breakwaters and jetties, beach fill placement, and offshore placement of infrastructure such as fiber-optic communication cables. In addition, monitoring reports of permitted structures placed for mitigation purposes and for non-mitigation artificial reefs were sought. Because of the large number of artificial reefs placed for non-mitigation purposes, reports were restricted to artificial reefs placed offshore (no estuarine artificial reefs) in less than 30 meters depth.

Evaluation of recent and historical monitoring reports was difficult due to the lack of an easily accessible agency monitoring report tracking system and the practice of lumping monitoring reports together for multiple project types (i.e., nourishment and associated mitigation). All projects in the southeast Florida region within the past 10 years for which monitoring reports were available were included for evaluation. Only a portion of projects older than 10 years were incorporated due to the vast number, difficulty in locating older reports, and, presumably, less stringent requirements for monitoring environmental impacts. Because project reports are continually being submitted to the state and federal regulatory agencies in compliance with permit requirements, it was determined that monitoring reports dated after December 2009 would not be included in the project evaluation. See Table 1 for a list of projects for which monitoring reports were evaluated.

An evaluation sheet was developed to provide a standardized approach to report assessment. The evaluation sheet content was based largely on previous work performed by Peterson and Bishop (2005). Twenty-one questions assessing elements of experimental design, statistical analysis, and interpretation were formulated and approved by the project team (see Appendix 2 for evaluation form). Each question posed a range of possible answers with associated numerical scores, and higher scores represented better performance for that question. A score of zero generally represented an absence of information, even if the information was missing because it was not a permit requirement. The maximum score for a question varied from two to five points depending on the number of possible answers. There was a maximum possible score of 54 points across the 21 questions. The purpose of this scoring was not to differentiate "good" reports from "bad" reports, but to provide a method for determining trends in study weaknesses and where improvements could be made. Questions were not given weight of importance relative to each other, so overall scores cannot necessarily determine if monitoring was better for one project over another.

The term "experimental design" is used in this report to describe the conceptual framework within which the monitoring plan was designed. Coastal construction projects are "experiments" in the sense that they impose a manipulation (treatment) on the environment by altering it in some way. For instance, beach nourishment projects add sand to the beach and often dredge sand from offshore for fill. Artificial reefs add structures to the sea floor. Both of these activities alter the environment, and the purpose of biological monitoring is usually to determine if these manipulations adversely affect the biota (see paragraph below and the Results and Discussion sections regarding the purpose of artificial reef monitoring). "Monitoring design" or "study design" are terms that could have alternately been used, but "experimental design" was chosen because it encompasses aspects, such as replication, randomization, and comparison to controls, necessary for testing hypotheses to unambiguously assess cause and effect relationships. Reports were scored for the presence or absence of recognized, standard, scientific components necessary to draw correct conclusions about the impact of coastal construction on the environment and the ability of mitigation to replace lost habitat.

Table 1. Coastal construction projects and monitoring reports evaluated: 1971 – 2009. (Note: Only a portion of projects older than 10 years were incorporated due to the vast number, difficulty locating older reports and, presumably, less stringent requirements for monitoring environmental impacts.)

County	Location	Project Description	Reports Evaluated
Miami-Dade	Sunny Isles	1988 Beach Nourishment and Mitigation Reef	G.M. Selby & Associates Inc. (1995)
Miami-Dade	Bal Harbor	1990 Beach Nourishment and Mitigation Reef	Sathe, et al. (2007)
Broward	Hillsboro/Deerfield	1998 Beach Nourishment	Coastal Systems International Inc. (1999)
Broward	Broward	1971 Beach Nourishment	Courtenay, et al. (1980); Marsh, et al.(1980)
Broward	Broward	1976 Beach Nourishment	Raymond & Antonius (1977)
Broward	Broward	1989 Beach Nourishment	Dodge, et al. (1991)
Broward	Broward	2005 Beach Nourishment (Segment III) and Mitigation Reef	Coastal Planning & Engineering (2009); Prekel, et al. (2009b)
Broward	Hollywood	2001-2002 Diplomat Beach Nourishment Upland Truck Haul	McGlynn (2002)
Broward	Port Everglades	1980 Port Channel Deepening	Continental Shelf Associates Inc. (1981)
Palm Beach	Jupiter/Carlin	Mitigation Reef for 1995 Jupiter Carlin Nourishment	Palm Beach County Department of Environmental Resources Management (2000)
Palm Beach	Midtown	2003 and 2006 Beach Nourishment	Ward, et al. (2008)
Palm Beach	Phipps Ocean Park	2006 Nourishment and Dune Construction and Mitigation Reef	Prekel, et al. (2009a); Hague, et al. (2010)
Palm Beach	Palm Beach Harbor	Mitigation Reef for Harbor Maintenance Dredging	Hague, et al. (2009)
Palm Beach	Ocean Ridge	2005 Beach Nourishment	Prekel, (2009)
Palm Beach	Delray	1978 Beach Nourishment	Arthur V. Strock & Associates Inc. (1983)
Palm Beach	Delray	1992 Beach Nourishment	Coastal Planning & Engineering Inc. (1997)
Palm Beach	North Boca Raton	1988 Beach Nourishment and Mitigation Reef (separate reports)	Cummings (date unknown); Coastal Planning & Engineering Inc. (1992)
Palm Beach	North Boca Raton	1998 Beach Nourishment	Coastal Planning & Engineering Inc. (2000)
Palm Beach	Central Boca Raton	2004 and 2006 Beach Nourishment	Coastal Planning & Engineering Inc. (2004); Hague, et al. (2007)
Palm Beach	South Boca Raton	2002 Beach Nourishment and Mitigation Reef	Baron, et al. (2007)

Palm Beach	Boca Raton Inlet	1980s Maintenance Dredging	Coastal Planning & Engineering Inc. (1988)
Martin	St. Lucie Inlet	2008 Maintenance Dredging	Pennell (2008)
Martin	Bathtub Beach	2010 Beach Nourishment	CSA International Inc. (2008)
Martin	Jupiter Island	2006-2007 Beach Nourishment	Pennell (2007)
Martin	Martin	Martin County Beach Nourishment Project	Harris, et al. (2008)
Broward	Hollywood	Fiberoptic Cables-AT&T	PBS&J (2004)
Palm Beach	Boca Raton	Fiberoptic Cables- CFX	PBS&J (2009)
Palm Beach	Boca Raton	Fiberoptic Cables-Telefonica formerly Emergia	Kruempel, et al. (2006)
Palm Beach	Boca Raton	Fiberoptic Cables-Globe net formerly Atlantica	Hague, et al. (2006)
Miami-Dade	Golden Beach	Artificial Reefs: 3 limerock boulder piles, 7 Eternal reef ball deployments, 2 Girl Scout reef ball deployments	Miami-Dade County Department of Environmental Resources Management (2009b)
Martin	Donaldson Reef	Artificial Reef: Texas Reef limestone rubble rock from St. Lucie Inlet Maintenance, 15 Florida Special artificial reef units, and bridge rubble	CSA International Inc. (2007)
Martin	Ernst and Sirotkin	Artificial Reefs: Evans Crary Bridge, tetrahedron (stacked and patch), railroad ties (stacked and patch)	Harris & Dillon (2006)
Miami-Dade	Key Biscayne	Artificial Reefs: DEMA Trader, Bunnell Barge, Neptune Memorial Reef, Miami River Barge	Miami-Dade County Department of Environmental Resources Management (2009a)
Martin	Ernst and Sirotkin Artificial Reef areas	Artificial Reefs: Wickstrom ship, Tree barge, High Queen and Zeppo tug and barge, Evans Crary Bridge, concrete railroad ties, tetrahedron	Harris & Dillon (2004)

Because the vast majority of reports were comprehensive over the life of the monitoring project (i.e., each report included data provided in previous monitoring reports), each project received a score based on the final or most recent report. Because not all projects had an associated final report due to ongoing monitoring or the inability to obtain final reports, some projects inherently received a lower score for some questions. Also, not all questions applied to every report or type of project. For instance, mitigation reef monitoring would not have any preconstruction monitoring associated with the mitigation reef. In addition, monitoring in the permit conditions for non-mitigation artificial reefs was not required to be quantitative, so these reports would be expected to score low for questions pertaining to statistical analysis. For reports that monitored multiple types of communities (e.g., benthic and fish) or types of projects (e.g., beach nourishment and mitigation reefs) in the same document, scores were assigned based on the weakest component. For example, if the experimental design (e.g., equal numbers of control and compliance sites) was better for fish than for benthic communities, the score for benthic communities was recorded. When looking at the overall project scores, it is important to keep these caveats in mind. The goal of this project was not to critique individual project successes or shortcomings, but to learn from past trends and use those lessons to enhance the ability of future projects to detect impact and mitigate for those impacts. Therefore, it is essential to note that the overall project score is less important than any trends in weakness.

Scores for each question of each report were entered into a spreadsheet. Data were entered and checked for accuracy by different individuals for quality assurance and control (QA/QC). Reports were grouped by project type: beach nourishment and dredging, cable, mitigation artificial reef, and non-mitigation artificial reef. Beach nourishment and dredging were combined because of the low number of dredging reports evaluated. Also, reports dating before 1995 were placed into their own category so that trends for more recent reports would not be obscured by older report scores. Cumulative scores for questions of each evaluated category (design, analysis, and interpretation) were calculated per project type. In addition, each question was evaluated for frequency of scores for all reports combined. These analyses enabled a determination of where improvements are needed and for which project types.

2.3 Interviews

Most organizations and agencies that are involved with coastal construction project oversight, permitting, and monitoring in the southeast Florida region were targeted for interviews. A list of people within these organizations was developed with input from the project team. The local, state, and federal agencies included the Florida Department of Environmental Protection (FDEP) Bureau of

Beaches and Coastal Systems (BBCS) and Southeast District Office (SED); U.S. Army Corps of Engineers (USACE) Jacksonville District's Planning Division, Civil Works Program and Regulatory Division (Palm Beach Gardens and Miami Regulatory Offices); Florida Fish and Wildlife Conservation Commission (FWC); U.S. Fish and Wildlife Service (USFWS); National Oceanographic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) Protected Resources and Habitat Conservation Divisions; Miami-Dade County Department of Environmental Resource Management (DERM); Broward County Environmental Protection and Growth Management Department (EPGMD); Palm Beach County Department of Environmental Resource Management (PB ERM); and Martin County Growth Management Department, Environmental Division. The identified organizations and companies involved with monitoring included Coastal Planning & Engineering (CPE), a Shaw group company; Tetra Tech; Coastal Eco-Group; CSA International (CSA) (formerly Continental Shelf Associates); Coastal Systems International (CSI); Dial Cordy; PBSJ (recently renamed Atkins); and Nova Southeastern University (NSU). Although PBSJ recently became Atkins, reference to the former name will be kept throughout this document since reports were written under the former name. Representatives from these organizations were then placed into groups based on a number of factors including the type of organization, location of representatives, and jurisdiction. A total of nine groups were formed to enable simultaneous questioning of multiple people while still keeping the groups small enough to ensure universal participation. Maximum group size was 8 people, and the minimum group size was 2.

With input from the project team, three questionnaires were developed based on the type of organization being interviewed: 1) project sponsor, 2) agency regulator or resource trustee, and 3) consultant or university. Project sponsors (organizations responsible for construction projects and permit applications) included the USACE Planning Division and local county agencies. Regulatory agencies included FDEP and the USACE Regulatory Division. Resource trustee agencies included FWC, USFWS, and NMFS. The topics addressed in the questionnaires included capacity and jurisdiction, monitoring project design, defining and detecting environmental impacts, monitoring reports, and suggestions for improving future monitoring. Copies of the questionnaires are included in Appendices 3-5.

3. RESULTS

3.1 Literature Review

Approximately 850 references, including monitoring reports, monitoring plans, and permits, were located. No reports were found associated with CCCL permits that monitored project effects on coral reefs.

A bibliography was created by entering citation information, abstracts (when possible), and keywords into EndNote bibliographic software for easy search and retrieval capabilities. Information gained from the literature review was used to evaluate past monitoring reports and to support recommendations made in this document. References to the literature are included in the discussion and recommendations sections of this report.

3.2 Monitoring Report Evaluation

There were a total of 39 monitoring reports included in the project evaluation results. Although more reports were obtained, the scores were based on the most recent report as described in the methods. Also, a number of documents had information relevant to individual projects but were not reports required by the permit (e.g., theses, unofficial reports, etc.). Because the purpose of this project is to evaluate the ability of coastal construction monitoring to detect impacts and mitigate for those impacts, these reports were read as background information but were not included in the scoring process.

Reports were categorized according to the type of project: beach nourishment and dredging (n=14), mitigation artificial reef (n=7), cable placement (n=4), and non-mitigation artificial reef (n=5). In addition, reports dated earlier than 1995 (n=9) were separated into their own category so as not to confound the results for more recent projects. Of the 14 nourishment and dredging reports, only one was for dredging alone, and one was a combined report for nourishment and mitigation monitoring. Of the nine pre-1995 reports, one was for mitigation, two were for dredging, and six were for nourishment projects. Mean scores were calculated for each of the evaluation topics: experimental design, statistical analysis, and interpretation.

Experimental Design

The maximum cumulative score possible for questions addressing experimental design (12 questions total) was 37. Results ranged in value from 2 (a pre-construction report) to 22. Reports for mitigation artificial reefs on average scored higher than other types of projects (Figure 1). Non-mitigation artificial reefs on average scored lower than other project types.

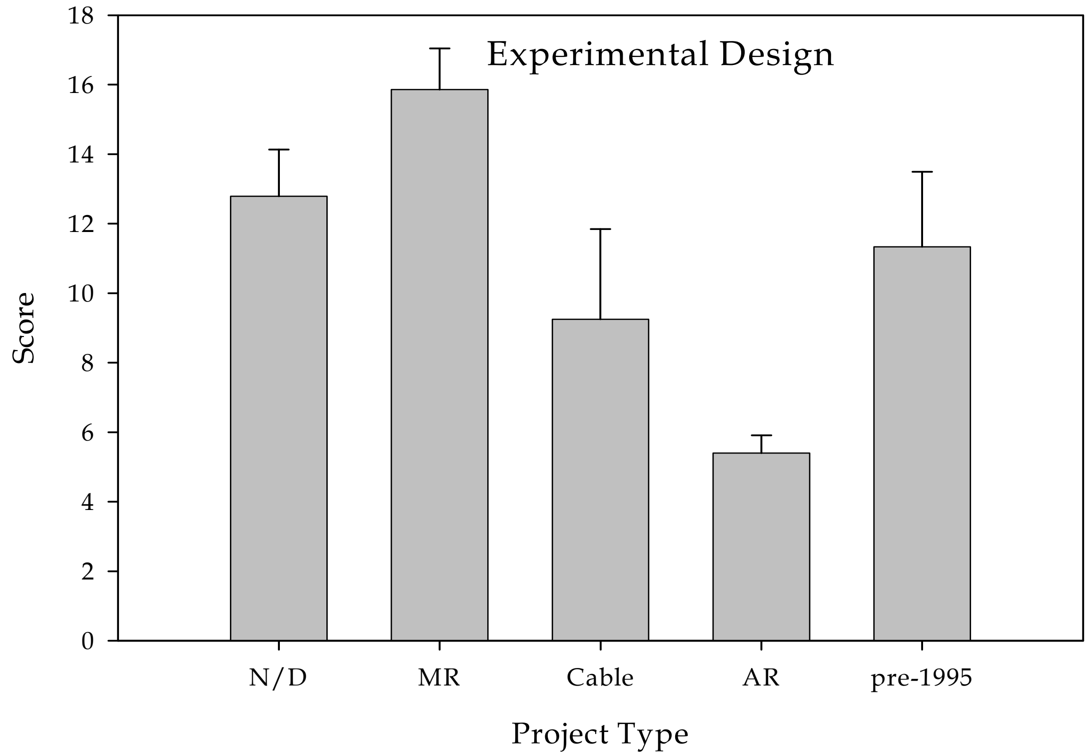


Figure 1. Mean (+SE) cumulative score of experimental design evaluation for each monitoring project type. The maximum score possible was 37 (note y-axis only goes to 18). N/D = nourishment and dredge, MR = mitigation artificial reef, AR = non-mitigation artificial reef.

There were a number of experimental design questions for which the majority of reports evaluated received low scores. More than a third (39%) of the reports did not state any hypotheses, questions, or objectives of the study (Table 2). Only 10% of the reports used sampling methods that had a high ability to measure response, i.e., how the variable tested would change. Evaluation of ability to measure response is somewhat subjective and involves both the variable chosen to monitor and methods used to detect change. For example, when percent cover is the response variable tested, using categories of cover (<5%, 5-10%, 11-25%, etc.) would produce a lower ability to detect change than using actual values of cover. Only 15% of the projects had more than one pre-construction sampling event, and approximately one third (36%) employed a before-after, control-impact (BACI) sampling design. Ninety percent of the monitoring projects did not perform an *a priori* power analysis to determine if the sample size was sufficient to detect change. Only 28% of the monitoring projects surveyed an equal number of reference and treatment sites while 31% and 36%, respectively, surveyed much fewer or no reference sites. Only 21% had reference sites that were in similar habitat, independent of each other and the treatments (project), and were located on both sides of the project (north and south).

Statistical Analysis

The maximum cumulative score possible for questions addressing statistical analysis (5 questions total) was 9. Reports ranged in value from 0 (no statistical analysis) to 7. Average scores for mitigation artificial reef and nourishment and dredge monitoring reports were similar and higher than those for cable monitoring and reports dating pre-1995, which were also similar to each other (Figure 2). No statistical analysis was conducted for any of the non-mitigation artificial reef reports.

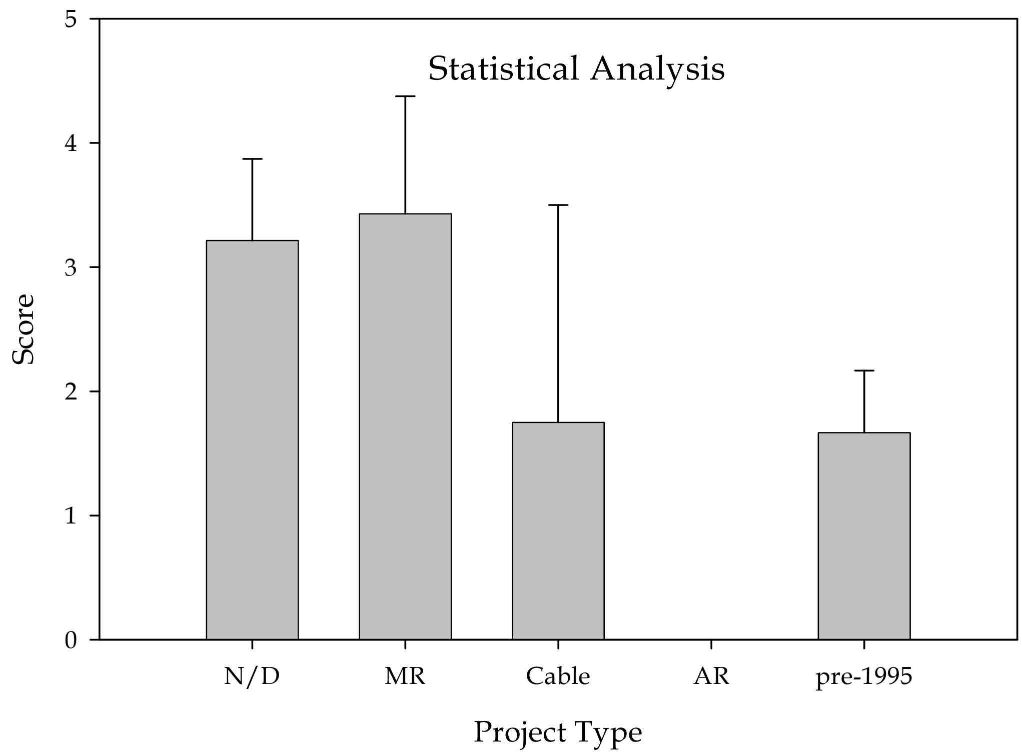


Figure 2. Mean (+SE) cumulative score of statistical analysis evaluation for each project type. The maximum score possible was 9 (Note: y-axis only goes to 5). N/D = nourishment and dredge, MR = mitigation artificial reef, and AR = non-mitigation artificial reef.

When no significant difference was found, no reports included a *post hoc* power analysis to determine the power of the statistical tests performed. Twenty-six percent of the reports could have used more appropriate statistical tests (factor out more variation), and only 8% used a BACI analysis even though 36% of the monitoring projects had BACI designs (Table 2). Only 13% of the reports performed any analysis linking physical habitat with biological response (e.g., regression analysis of sediment depth with biological cover).

Table 2. Monitoring report scores. Column values represent the percentage of reports that received each score, and shaded cells indicate no possible score (e.g., if 4 and 5 are shaded cells, the maximum score for the question was 3). See the evaluation sheet in Appendix 2 for the criteria each score represented.

		Percentage of Reports					
Evaluation Topic	**Evaluation Question** / **Score**	**0**	**1**	**2**	**3**	**4**	**5**
Experimental design	1. Stated hypothesis	38.5	43.6	0	17.9		
	2. Sampling methods employed	2.6	41.0	46.2	10.3		
	3. BACI sampling design	33.3	30.8	35.9			
	4. Nested sampling	100	0	0			
	5. Sampling frequency pre-construction	48.7	35.9	7.7	7.7		
	6. Sampling frequency post-construction	2.6	64.1	20.5	12.8		
	7. Duration pre-construction sampling	87.2	5.1	2.6	0	5.1	
	8. Duration post-construction sampling	30.8	28.2	23.1	17.9		
	9. *A priori* power analysis	89.7	2.6	7.7			
	10. Sufficient replication	35.9	30.8	5.1	28.2		
	11. Random sampling design	71.8	12.8	10.3	5.1	0	
	12. Appropriate controls	35.9	2.6	15.4	2.6	23.1	20.5
Statistical analysis	13. Statistical analysis	64.1	0	25.6	10.3		
	14. *Post hoc* power analysis	100	0				
	15. BACI analysis	53.8	38.5	7.7			
	16. Link physical habitat and biological response	87.2	12.8				
	17. Test long-term vs. short-term effect	53.8	7.7	38.5			
Interpretation	18. Statistics interpreted correctly	61.5	2.6	35.9			
	19. Conclusions properly supported	7.7	12.8	79.5			
	20. Credible explanation of biological response	10.3	0	89.7			
	21. Citations and synthesis of literature	28.2	43.6	28.2			

Interpretation

The maximum cumulative score possible (total of 4 questions) for interpretation was 8. Scores for individual reports ranged from 0 (no interpretation given) to 8. Similar to experimental design and statistical analysis, non-mitigation artificial reefs scored lower on average than all the other report types (Figure 3). Mitigation artificial reef reports scored slightly higher but were similar to nourishment and dredge, cable, and pre-1995 monitoring reports.

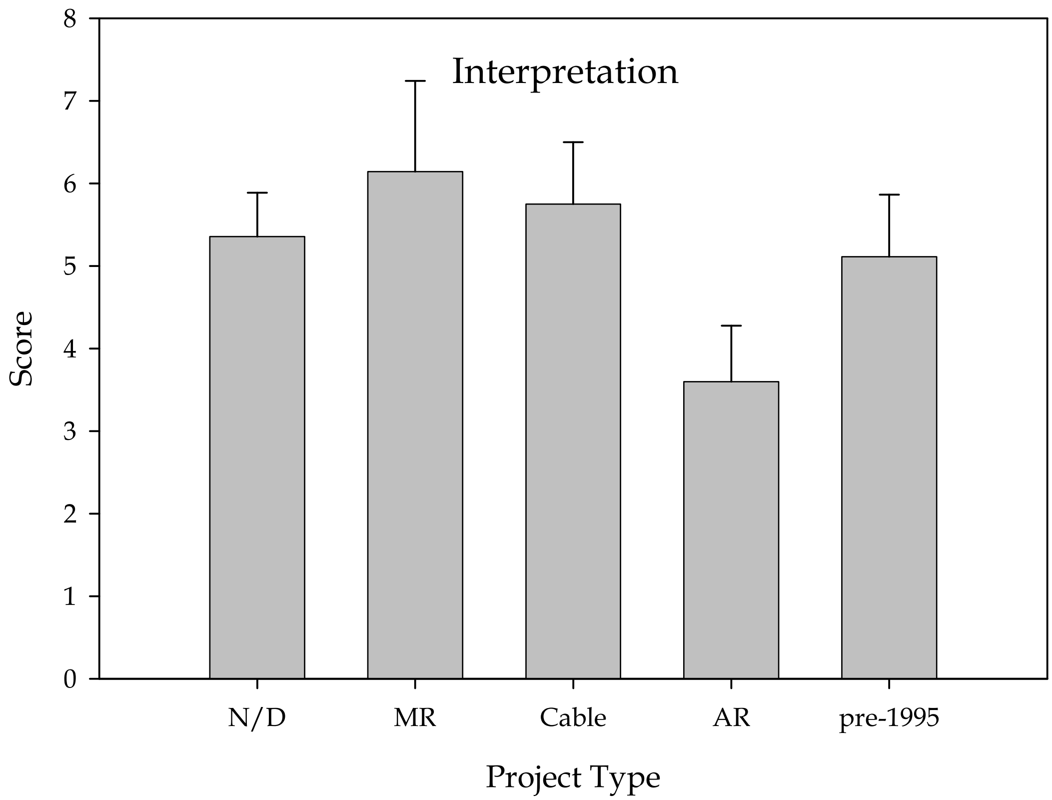


Figure 3. Mean (+SE) cumulative score for interpretation evaluation for each project type. The maximum score possible was 8. N/D = nourishment and dredge, MR = mitigation artificial reef, and AR = non-mitigation artificial reef.

One of the only apparent trends for interpretation is that a small percentage of reports (3%) interpreted statistical tests incorrectly (Table 2). Most reports included properly supported conclusions based on observations and statistical results (80%) and a credible explanation of biological response (90%) based on the data collected. However, only a quarter of the reports (28%) had an adequate synthesis of results and supported conclusions with sufficient references to the literature.

3.3 Interviews

A total of 48 representatives from environmental consulting firms, universities, and local, state, and federal agencies participated in the interviews or filled out the questionnaire. A list of participants is provided in Appendix 6, and a summary of their responses to the questions is provided in Appendix 7. Some of the main points to emerge were:

- Substantially more emphasis and attention is paid to baseline and pre-construction monitoring reports than to post-construction reports (i.e., very few resource trustee agencies read or review post-construction monitoring reports, and not all post-construction monitoring reports are reviewed by permitting agencies);
- Agency staffing levels (number of qualified personnel) and agency mandates or protocols affect the ability to review reports;
- Monitoring at the state level is for "reasonable assurance" against project effects, and robust statistical analysis is not currently a requirement;
- Monitoring at the federal level may not require statistics to determine functional loss versus functional gain;
- There is a lack of *a priori* definitions of project monitoring goals and impacts and of reasoning behind monitoring requirements;
- There is a lack of funding for monitoring, particularly pre-construction surveys, due to cost-sharing limitations. Most agree more pre-construction monitoring is needed to determine natural variability;
- Though regulatory agencies indicate monitoring results are used to consider modifications to minimize impacts of future projects, there is a perception by some project sponsors that this doesn't occur;
- It is difficult to write monitoring reports in the time allotted (60-90 days after field work completed), and there is a large window of time allowed for compliance review (up to 5 years) which is sometimes only done in conjunction with new permit applications;
- Some people questioned the value of mitigation projects as replacement habitat and especially their ability to compensate for lost ecological services;
- There is a need for alternate forms of mitigation other than limestone boulders (e.g., water quality monitoring, research, etc.);
- Size of project, scale of impact, amount of money available, and political pressure often define sample size rather than basing the decision on ability to detect impact;
- There is a need for more data on physical parameters such as wave energy, water quality, sedimentation, turbidity (dissolved oxygen and *in situ* optical sensors), and temperature because physical monitoring reports

are too coarse of a scale to be useful for detecting effects on biological communities;
- Monitoring reports are generally too long and time consuming to write due to a lack of understanding of what regulatory agencies want;
- There are differences of opinion among agencies on the definition and purpose of monitoring (views on research versus monitoring).

4. DISCUSSION

Results of the monitoring report evaluations differed by project type and are discussed below. In addition, major points that emerged from the interviews are also addressed in more detail. The findings of these two sections are discussed in reference to the literature and are used to make recommendations to improve future monitoring.

4.1 Monitoring Report Evaluation

There were no benthic resource monitoring reports associated with CCCL projects that pertained to this review. CCCL projects are usually limited to the area above the mean high water line (MHWL) and, under normal circumstances, should not impact coral reef communities due to construction on upland beach. However, in certain instances, such as dune restoration and emergency post-storm actions, activities may take place below the MHWL, and it is reasonable to assume that the sand from CCCL projects has the potential to erode into the coastal marine environment and impact coral reef communities. Therefore, sand used for projects requiring CCCL permits should be held to the same standards as those used in JCP beach nourishment permits when placed near regions with sensitive coral reef communities.

In general, all evaluated reports scored lower for questions relating to experimental design than those for statistical analysis and interpretation. Thus, experimental design needs to be targeted for improvement in future monitoring projects. Experimental design is of the utmost importance because it establishes how data will be collected and analyzed. If the design is poor, the result will likely be the inability to detect differences or environmental impact. This can lead to the potentially faulty conclusion that no difference or environmental impact occurred. It is important to note that the inability to detect impact is not the same as absence of impact.

Non-mitigation Artificial Reefs

Non-mitigation artificial reef monitoring reports generally scored lower than other project types. Non-mitigation artificial reefs are placed primarily for recreational purposes such as diving and fishing. Therefore, permit required monitoring is usually restricted to stability determination and lists of species present. Non-mitigation artificial reefs are not required to be evaluated for ecological functions because they are not placed or explicitly designed to offset an impact or to address biological questions. In the reports evaluated for this project, species lists were mostly derived from qualitative roving diver surveys or video rather than from quantitative sampling using traditional methods such as transects, quadrats, and stationary fish counts, and they ranged in detail from scientific names to qualitative descriptions such as "orange sponge" or "unidentified tunicates." Usually only abundance classes were used for fish species (e.g., 1-5, 6-10, 10's, >100).

A grant program is available though the FWC Artificial Reef Program to deploy artificial reefs and perform biological monitoring, but the latter is not a grant requirement. Several monitoring reports associated with these grants were included as part of the literature review but were not included in the scoring process since biological monitoring was not required. Volunteer diver groups provided mostly summary data such as percent composition for juvenile and adult fish families and inventories of benthic organisms with abundance and percent cover categories (Florida Oceanographic Society Palm Beach County Reef Research Dive Team, 2002; Palm Beach Reef Research Team, 2004; Florida Oceanographic Society Palm Beach County Reef Research Team, 2006, 2008). Agencies and universities mostly performed quantitative assessments of fish abundance, size classes, and species composition or benthic quantification to address hypothesis-driven research questions on such topics as natural versus artificial reef fish species composition, effectiveness of artificial reefs at attracting juvenile and economically important fish species, effectiveness of differing artificial reef materials at attracting fish, importance of depth as a factor in site selection for artificial reefs, and seasonal patterns of fish use of artificial reefs (Spieler, 1994, 1995, 2000, 2003; Light, et al., 2003). Obviously, there is a wide range in purpose, data analysis, and expertise of those performing the monitoring for studies conducted under these grants.

There has been debate as to whether artificial reefs help natural reefs by adding habitat to support additional fish or whether they pull fish away from natural reefs and concentrate them to be more easily extracted by recreational fishers (Bohnsack & Sutherland, 1985; Bohnsack, 1989). Alternately, artificial reefs may help natural reefs by reducing fishing pressure on natural areas. Additionally, the extent to which artificial reef placement affects reef fish populations, through either loss of potential foraging grounds or, alternately, through increased access to foraging areas not formerly accessible due to lack of appropriate reef habitat, has not been well documented in the literature. These are not questions that can be answered through traditional monitoring programs of species presence, abundance, and size. Their resolution will require targeted research such as range movement tracking of adults before and after artificial reef placement, larval and juvenile settlement quantification on artificial and natural reefs, and fishing effort comparisons of artificial versus natural reefs. A list of research questions was developed by FWC and included in the MICCI Project 18 & 19: *Guidelines and Management Practices for Artificial Reef Siting, Use, Construction and Anchoring in Southeast Florida* (Lindberg and Seaman, 2011). Perhaps addressing these questions can be incorporated into grant-funded monitoring through the FWC Artificial Reef Program, but it is unrealistic to believe that they can or will be required for permit monitoring.

Mitigation Artificial Reefs

Mitigation reefs are expected to replace services lost due to coastal construction impact. However, "ecological services" is a nebulous term, and evaluation of mitigation reef effectiveness would benefit by defining some minimum performance criteria for determining success or relating mitigation services gained to services lost due to project impact. Currently, mitigation reefs are surveyed for benthic and fish community structure, but maximum required monitoring is usually 5 years. Based on the findings of the monitoring reports evaluated, there is no doubt that organisms will settle onto limestone boulders and that fish will use the resulting structure. However, there is question about how closely the community structure of mitigation reefs mimics that of the impacted habitat and if mitigation reefs are sufficiently replacing lost ecological services. Mitigation reefs and reference sites will likely never be the same due to the higher and more varied topography of boulders compared to reference sites (Thanner et al., 2006), but a determination of how much similarity is required to replace lost ecological services is needed in order to evaluate their effectiveness. Depending on the time scale necessary for recovery of the expected services, annual monitoring may not be necessary, and longer-term surveys at less-frequent intervals (e.g., surveys every 5 years over a 20-year period) may provide more useful information.

Cable Projects

Cable projects installed over hardbottom habitats result in direct contact or shading of benthic organisms, so impacts are much easier to detect and define than for beach nourishment or dredging projects. Cable projects generally scored lower than nourishment and dredging projects because, in general, they did not use control sites, did not perform statistical analysis, and did not perform quantitative pre-construction monitoring. These elements may not have been included since impact is relatively easy to detect if the cable remains stationary. However, some monitoring reports indicated that cable movement, likely due to vessel anchoring, occurred. The result was that some of the previously monitored colonies could not be located in subsequent surveys because they were mapped using the cable as a reference point. The potential for movement indicates that impact may occur to a larger area and over a longer time period than is currently required to be monitored since cables are a permanent fixture once installed. Better management practices such as cable anchoring and creation of no vessel anchor zones, coupled with existing specific corridors for cable placement in southeast Florida, may be needed to reduce impacts. Because of the potential for continual impact due to permanent placement of cables, it is recommended that cable monitoring be required for a longer time period in cases where the cable is not fixed to the seafloor. Additionally, it is recommended that gorgonians and sponges be included in impact monitoring since these organisms can be impacted more frequently than corals (Sultzman, et al., 2002).

Beach Nourishment

Beach nourishment projects have the potential to cause large impacts due to dredging of sand from offshore borrow areas near adjacent reef communities and filling of long stretches of beach that may erode and chronically re-suspend and deposit sand in the adjacent nearshore environment. Impacts, even burial of organisms, can be very difficult to link to nourishment projects because of natural sand movement that periodically covers and uncovers some hardbottom habitat. Most of the reports evaluated were of monitoring associated with beach nourishment projects, and the following discussion applies primarily to these types of projects. However, some of the recommendations discussed apply to multiple project types (e.g., dredging or mitigation reefs in addition to beach nourishment.

Benthic Community Assessment

Many of the monitoring reports that evaluated benthic community structure used analyses of percent cover estimated from randomly placed points on non-overlapping frames of video surveys (point counts) or *in situ* measurements from quadrats placed along permanent transects. For the surveys that used both methods, this is redundant unless there is a specific reason for using both such as calibration of the two methods (though this was not encountered in any of the monitoring reports evaluated). The two methods for estimating percent cover have differing advantages and disadvantages. However, point counts with low numbers of points per frame, the method typically used in monitoring studies, often do not reflect an accurate assessment for low cover benthic habitats (Pante and Dustan, unpublished data). For most of the benthic invertebrate functional groups assessed in the monitoring reports, cover was generally 5% or less. Many of the consultants interviewed indicated that *in situ* measurements, especially in nearshore environments of Martin and Palm Beach counties, provided higher resolution data than video point counts when both types of surveys were performed. Therefore, *in situ* measurements are likely a better choice than video point counts in habitats with low (<10%) cover of individual functional groups of interest unless there are restrictions that warrant use of video like strong currents or deep depths that limit bottom time. In these instances, more points per frame (potentially > 50) or more transects may need to be evaluated to accurately determine percent cover.

An approach that might be more informative than percent cover would be to evaluate changes in density and size classes of organisms. These values can give a better indication of what the population is doing (e.g., changes in recruitment, growth, partial mortality) and can also be used more readily in predictive models of change, such as population matrices that use the progression of individuals into different size or age classes to predict effects on the population (Leslie, 1945) and agent based models that use the actions and interactions of individuals to assess their effect on the system as a whole (Osenberg et al., 1996). However, many colonial encrusting organisms would be excluded from this type of analysis due to the difficulty of discerning individuals. Data collected in many of the monitoring projects using the Benthic Ecological Assessment for Marginal Reefs (BEAMR) methodology (Makowski et al., 2009) include density and size of scleractinian and gorgonian corals, yet these data were rarely analyzed. The reason may be that population densities were low in nearshore habitats examined for impacts from nourishment, especially in Martin and Palm Beach counties. A recommendation would be to continue to collect video data as a record of conditions but to use *in situ* data of percent cover, density, and size class for analysis of community structure unless it can be shown that point count data are sufficient to detect the effect size (difference in level of response variable like change in cover) deemed appropriate to measure (e.g., number of samples needed to detect a 50% change in percent cover at a 95% confidence level). Effect size is discussed in more detail later.

Regulatory agencies and resource trustees are generally interested in community-level responses as indicators of impact since population attributes reflect ecological consequences (Osenberg, et al., 1996). However, these changes are often difficult to discern, especially with the low number of replicates generally used in monitoring projects (Osenberg, et al., 1992, 1996). Sublethal and cumulative effects that can degrade the system and impair populations are generally not evaluated. Most evaluated studies in this review examined community structure using categories of organisms (e.g., corals, sponges, tunicates, etc.), but no direct evaluation of changes in individual organisms were monitored (e.g., growth, fecundity, physiology, gene expression). These types of studies are rarely performed, yet it should be recognized that changes in individual organisms are often more easily detected and can give a better (more sensitive) indication of the environmental impacts of coastal construction projects than measures of community level response (Osenberg, et al., 1992, 1996). Depending on the variable monitored, they also may require smaller sample sizes to detect change and thus, require less monitoring (reduced costs). However, costs to analyze lab samples may be expensive and negate any savings from reduced field work. There have been some efforts recently to include more information on individual coral colonies by incorporating colony condition observations such as disease, bleaching, and signs of stress like tissue swelling, lesions, excessive mucus production, and tissue thinning (Fisher, et al., 2008). This is a step in the right direction, but more studies looking at individual based biological parameters are needed to fully understand the biological and ecological ramifications of coastal construction projects.

Physical Data Collection

Although physical data were often collected along with biological data, particularly in the BEAMR methodology (Makowski, et al., 2009), there was rarely any analysis linking the two. Often the data were pooled, so the ability to tie physical and biological data was lost, though a couple of reports did perform a regression analysis to examine the effects of sediment on biological cover or coral stress condition (Coastal Planning and Engineering, 2004, 2009). This link is difficult to make but is very important when evaluating project effects. Another difficulty is determining the source of the sand when burial occurs, especially in dynamic nearshore environments. For some of the reports evaluated, burial of permanent monitoring sites occurred prior to beach nourishment construction. In these cases, additional sites should have been established so that monitoring occurred in hardbottom habitat and not just sand. Any approach needs to recognize the shifting nature of sediments in nearshore environments. Sand movement due to storms and natural processes that periodically bury and unbury some hardbottom was often cited as an explanation of burial and loss of benthic biological cover. Better methods of tracking sand movement from beach placement to biological habitats is difficult but much needed. Additional physical measurements that might allow for more insight include sedimentation, sand grain characteristics, turbidity, volume of discharge and distance from nearby inlets, water depth, distance from shore, and typical wind and wave activity (Hart, et al., 2005, Jordan et al., 2010).

Experimental Design

Although many reports did have broad statements about the purpose of monitoring, such as to "detect potential impacts of beach nourishment" or to "determine if mitigation reefs were suitable replacement habitat," most reports did not have a clear statement of what questions were being asked or what hypotheses were being tested to draw conclusions about impacts or suitability of mitigation. Of those that did state hypotheses, they were often located in the results section instead of in the introduction or methods section. The questions and hypotheses are important because they define what variables and measurements are going to be used to support conclusions about the broadly defined objectives of detecting impact or determining suitability of mitigation to replace lost habitat and services. Thus, one recommendation to improve future monitoring is to specifically state the hypotheses in the methods section of both monitoring plans and monitoring reports.

Approximately one third of the studies used a before-after, control-impact (BACI) study design. This method is a widely accepted way to detect environmental impact (Stewart-Oaten, et al., 1986; Osenberg, et al., 1992; Schmitt & Osenberg, 1996; Smith, 2002). However, the entire coastline in the four county southeast Florida region has been heavily manipulated and altered by dredged channels, shoreline hardening, breakwaters, and beach nourishment projects, making appropriate controls or reference sites difficult to find and define. The reference sites for a nourishment project are often in the area of influence of other beach nourishment projects. Additionally, because this region is at the northern extent of coral reef community development, sites north and south of the project area can be drastically different in community composition and abundance, thus, complicating the location of reference sites in similar habitats. Also, when a large area of coastline is nourished, appropriately located reference sites might occur in a different environment (e.g., depositional environment north of stabilized inlets and erosional environment south of inlets). All of these factors influence reference site usefulness in terms of examining community structure and demographics. However, if individual organism-based biological parameters are incorporated into monitoring plans, differences in community structure between reference and treatment sites may not be as important. This suggestion will not solve the problem of independence of reference and treatment sites. Unfortunately, this problem cannot be solved, but it may at least be improved through a more regional approach to management of beach nourishment projects rather than the piecemeal jurisdictional approach currently in place. If regional management can be incorporated, tracking of reference site locations relative to past and future nourishment projects could help to avoid overlap within the planning, construction, and monitoring time frames of adjacent projects. Another suggestion is to use a BACI paired series analysis (Osenberg, et al., 1996). In this type of analysis, the approach is to calculate the difference between control and impact values (delta) on each sampling date and test whether the mean difference changes from the before to after construction period. Deltas are expected to have similar values within periods but different values between periods. Replicates are the temporal sampling dates, so fewer sites, but more sampling dates, may be needed.

Most of the reports evaluated that included pre-construction sampling had only one such event. To determine natural variability in highly complex and dynamic systems, more pre-construction sampling is needed to be able to differentiate project-related impacts. It is even more important when, due to the lack of appropriate reference sites, more emphasis is placed on pre-construction versus post-construction survey results than comparison with control sites. The need for additional pre-construction sampling was acknowledged in one of the monitoring reports evaluated (Coastal Planning & Engineering, 2009) and by many participants during the interview process, but pre-construction monitoring is currently limited due to funding constraints. However, current cost-sharing practices need to be re-evaluated to enable more pre-construction monitoring events to differentiate project-related impacts from natural variation. Nelson (1993) suggests monthly sampling for at least 3 months pre-construction, but this would not be sufficient for detecting seasonal or inter-annual variation. Ideally, pre-construction sampling should include both seasonal and inter-annual surveys and mimic the period of post-construction sampling so that similar time frames can be examined. A scarcity in samples prior to impact is more likely to hamper detection of impacts on population demographics and physical or chemical characteristics than effects on individual organisms (Osenberg, et al., 1996), thus, providing further justification in using organism based measurements of impact over community response. A more regional approach to monitoring that is not tied to a specific project would provide more data for pre-construction monitoring and also might be more economical in the long run.

Currently, post-construction sampling for nearshore environments is required for 3 to 5 years for beach nourishment projects. Usually monitoring is required annually, but sometimes it is required semi-annually for 2 years (immediately post, 6 months post, 12 months post, 18 months post, and 24 months post-construction) and then annually thereafter. Nelson (1993) suggests surveying bi-weekly for 2 months post-construction and then monthly for 9 to 12 months. The current requirements are based on the amount of time required for the toe of fill to equilibrate and reflect the possible time frame in which impact could occur (Vladimir Kosmynin, FDEP BBCS, personal communication). The frequency and duration of the current surveys may be appropriate for community level changes which may take longer to show effects, but if more individual organism-based measurements are incorporated into monitoring programs, as previously suggested, the duration of surveys could potentially be shortened depending on the variable measured.

The vast majority of reports (90%) did not perform *a priori* power analyses to determine if samples sizes were sufficient to detect change. Some plotted species area curves to determine appropriate transect lengths or quadrat numbers to capture common species, but this analysis does not reveal anything about the number of samples needed to detect an effect. Effect size decisions are ecological rather than statistical questions since they are decisions about what amount of change is ecologically relevant (Mapstone, 1996) and determined to be acceptable. Peterson and Bishop (2005) recommend a 50% decline or 100% increase of a population to be the minimal level of effect size. To do an *a priori* power analysis requires preliminary data. These data often exist in prior monitoring reports and could also be obtained from baseline surveys needed for permits if the surveys are quantitative in nature. Therefore, it would not take a major increase in effort to perform power analyses before monitoring plans are finalized to ensure that the sampling design is sufficient for the questions being asked. Also, baseline data can give an indication of the characteristics of the habitat and help shape decisions of experimental design such as the need for nesting or stratification of samples (discussed below).

Many reports did not use equal numbers of reference and treatment sites, and more often than not, the number of reference sites was much fewer than the number of treatment sites, particularly for beach nourishment projects. There were often at least twice as many treatment sites compared to reference sites. Differences among variables (treatment versus reference sites, pre- versus post-construction, etc.) can only be demonstrated by comparisons to differences within variables (Green, 1979), so replicate samples of each variable (time, site, and any other controlled variable) should be taken. In addition, reference sites were often very close to treatment sites, thus risking influence from the project (not independent). Reference sites should be spatially distributed on both sides of the project (north and south) since interspersion of treatments and controls is not possible (Nelson 1993). A balanced design (equal number of treatment and control sites) usually equates to more powerful and useful statistical analyses and should be incorporated whenever possible. Problems with reference site selection were discussed earlier, and some suggestions on how to combat reference site issues were suggested.

Nested sampling was not used in any of the monitoring reports evaluated. Nesting can be one method of removing additional sources of variation from analysis and improving the ability to detect differences (Nelson, 1993). For instance, sites can be grouped by distance from shore, distance from project, depth, or any variety of factors that can help to factor out natural variability and possible project effects on reference sites that confound the ability to detect project impacts. Also, time can be used as a nested factor to detect seasonal variation and time relative to project construction.

Most reports did not indicate how sites were chosen, so by default, they were given a low score. Quadrats within transects were often placed systematically at a set distance based on the length of the transect and the number of quadrats surveyed per transect. Randomization of samples is a general assumption of statistical tests, and fixed distances can be argued to not be representative. Very few (5%) of the monitoring reports stratified the samples in space though this can be a very useful design for factoring out additional sources of variation (Green, 1979). For stratified random sampling, the habitat is divided into areas that are similar in characteristics (e.g., depth, distance from shore, distance from project, etc.), and more sampling effort is allocated to larger areas. Incorporating stratification and randomization of sampling units would strengthen statistical testing and ability to detect impact in areas where variation within treatments is greater than variation between treatments.

Statistical Analysis

Statistical analysis was used in 35% of the reports, but the majority of those reports could have performed more appropriate tests. A very common procedure for those projects that used a BACI design was to compare all before-after samples and all impact-control samples in separate analyses using either t-tests or one-way ANOVAs. The optimal way to test these samples is a 2-way ANOVA with time as one factor and site as another. The significant interaction of time and site indicates an impact (Green, 1979). Another common mistake was the use of a series of t-tests to compare pairs of time periods rather than performing an ANOVA to compare all time periods in the same test. Using multiple t-tests can inflate your alpha level, the probability of rejecting a true null hypothesis (Type I error) (Zar, 1999). Many of the more recent beach nourishment reports performed non-metric multi-dimensional scaling (MDS) which is a non-parametric multivariate procedure. Peterson and Bishop (2005) hail this analysis as one of the best ways to detect ecological patterns and state that there are additional analyses in Primer statistical software that can detect how well physical variables explain biological variables.

No reports stated the power of performed tests when no significant difference was found. Power indicates the probability that a test will correctly reject a null hypothesis when it is false. Without reporting the power of the test, there is no way to tell if there truly was no impact or if the experimental design wasn't strong enough to detect an impact. It is generally accepted that results should be viewed with caution when the power is less than 80%. Therefore, a recommendation is that all reports state the power of performed parametric tests when no differences are found so that conclusions can be drawn based on all of the information and that improvements can be made to future monitoring designs.

Interpretation

Of the reports that did statistical analyses, most interpreted statistical results correctly. However, as discussed previously, it was impossible to determine if the experimental design supported tests powerful enough to detect impact. When differences or impacts such as increased sediment were found, inability to attribute those differences directly to the project was often declared, and other potential explanations included storms, natural variability, inter-observer bias, or inaccurate placement of permanent transect lines between survey periods. Most of these factors could have been ruled out by better experimental design.

A large number of reports (72%) lacked an adequate synthesis of literature and discussion of the results in a larger context. Although this was generally not a permit requirement, references to results of previous studies to support drawn conclusions would strengthen the credibility of monitoring reports. Placing the meaning of the results into a broader context and synthesizing what was learned from the monitoring project could also help agencies to develop a more regional approach to management instead of the current project by project approach.

4.2 Interviews

Some of the agencies expressed concern over conflict of interest when the same company was responsible for both project construction and project monitoring. Most consultants interviewed did not feel that reporting impact would affect their future marketability though some indicated it was client dependent. Most felt that if they didn't report impacts, they would be less marketable in the future because they would be perceived as not good at their job. Everyone indicated that ethics were essential, and one of the agencies suggested establishment of a code of ethics. Another potential solution is to avoid all semblance of impropriety and have separate companies for construction and for monitoring to provide independent oversight.

A surprising problem was the lack of follow-up and examination of post-construction reports by many agencies. The reason seems to be time constraints, agency mandates, and number of qualified staff. Many of the beach nourishment permits stipulate that monitoring reports are due 90 days after completion of field work which mostly occurs during the summer, so often multiple project reports are submitted at the same time. Only one FDEP BBCS staff member is assigned to review monitoring reports, and during the end of the year when most reports are submitted, timely review of multiple, long reports is challenging. Funding is urgently needed to support contract employees or consultants who can help during this period to ensure that post-construction reports are reviewed in a timely manner and that results are used to improve future monitoring.

One of the needs expressed during multiple interviews was a way to share experiences, methods, knowledge, lessons learned, and recommendations for future monitoring between those responsible for monitoring and those requiring monitoring. Some participants indicated a section at the end of each monitoring report should be dedicated to this. Report summary sections would provide a permanent record that could be accessed later. Given the lack of follow-up on post-construction surveys by many agencies, an additional avenue such as a regularly scheduled conference, meeting, or workshop would be beneficial as a forum for presentations and discussions. Another suggestion was a state sponsored regional database to collect this information. The problem with databases is the need for continual updating, and with limited funding and staff time, this is a difficult endeavor. If a contract position was available to help review monitoring reports as mentioned above, this person could potentially assist with database updating and maintenance.

Most people interviewed had at least a master's degree in a field that included statistics as required coursework but did not have formal statistical training within their organization. However, most resource trustee agencies and consultants indicated that this training would be useful and that they would be allowed to participate if training opportunities were local and low cost. Regulatory agencies did not view this training as necessary because they do not view statistical analysis as a necessity for providing "reasonable assurance" against project impact. However, reasonable assurance must be balanced with a level of certainty, and it is recommended that local training opportunities be available on a regularly scheduled interval (3-5 years) to all those reviewing or requiring monitoring of coastal construction projects. Ideally, a course would provide opportunities to examine issues faced on the job. For instance, a real example of a suggested monitoring design with preliminary data could be analyzed as an exercise to determine the ability to detect project effects. It is suggested that training opportunities be organized through the FDEP Coral Reef Conservation Program (CRCP) or the Southeast Florida Coral Reef Initiative (SEFCRI) similar to the fish, invertebrate, and coral identification courses that are currently offered by CRCP.

Project monitoring should have two goals: 1) answer questions about environmental impacts, and 2) quantify injury to determine the need or amount of compensatory mitigation (Peterson and Bishop, 2005). Some of the agencies felt that monitoring surveys were developed more toward providing information for the Uniform Mitigation Assessment Method (UMAM) to calculate mitigation area than for rigorous assessment of environmental impact and that monitoring was just a checklist for compliance with permit conditions. They also felt there was a difference in agency opinion between the definition and purpose of monitoring. The local sponsors felt that agencies often wanted them to do "research" versus monitoring and that they were not responsible for this type of information or able to do it under the confines of their jobs.

General decline of coral reef communities has not been attributable to any dominant particular cause. Construction projects likely act in concert or synergistically with other stressors, and it is very difficult to differentiate project effects from other causes of decline. Many resource trustee agencies would like to look at sub-lethal and cumulative effects that degrade communities over time, but many of the project sponsors consider this research and not monitoring. Monitoring has generally been restricted to detecting changes in community structure which can take a longer time to react to stressors and are not as easily detected because of low power of tests (Osenberg, et al., 1996). Individual organism-based parameters and demographics provide the mechanisms that underlie changes at the community level and would be an alternative indicator of impact, but they are more difficult to mitigate for since current mitigation assessments are based on an amount of area needed (e.g., within which to deploy artificial reef structures) to provide functional gain to offset the area of functional loss.

There was a desire from some interview participants to consider alternative mitigation for project impacts. Currently, an in-kind approach is taken where mitigation limestone boulders are deployed near impacted habitats, but this has posed a problem for shallow nearshore environments when the draft of vessels that deploy boulders is too deep (Continental Shelf Associates Inc., 2006). This limitation has led to deployment in deeper sites where replacement value is questionable due to differing habitat types. Mitigation artificial reefs were generally monitored for 5 years or less, and benthic community development on these structures was different from reference sites, even after 12 years of deployment (Thanner et al., 2006). Differences in topographic complexity between artificial boulder and natural reefs is one of the factors contributing to this difference and has led to questioning of whether these boulders are providing equivalent replacement services for those lost. Because the value of current mitigation boulders is in debate, alternative mitigation options are desired by some of those interviewed. A potential option mentioned was to pay into a fund that would be used for research to answer fundamental questions needed to evaluate project impacts or fund general monitoring not tied to a specific project. As mentioned previously, the current use of UMAM precludes determination of appropriate mitigation not tied to functional gain to offset functional loss, so alternative mitigation, while justified and perhaps more valuable if applied well, would require a considerable amount of work to approve and implement.

If only one recommendation from this report can be adopted, it is to define impacts, effect sizes (limit of acceptable change due to impact), and limits of probability of committing a Type I (rejecting a true null hypothesis) or Type II (accepting a false null hypothesis) error. These need to be defined before a project begins in order to clarify the objectives of monitoring, determine the optimal experimental design, and have agreement among all parties as to what will be considered an impact. Ideally, these discussions would include all groups involved with project monitoring (local sponsors, consultants, and agencies) so that general consensus could be reached, but ultimately, this is the responsibility of the regulatory agencies. Many of the decisions are ecological in nature and not statistical, though a good understanding of statistics is needed and may require input from outside people who are well versed in statistics and experimental design. The state regulatory agency and many local sponsors acknowledge that under-sampling is a problem but say that they are restricted by funding. However, if monitoring is worth doing, it is worth doing well, and it seems counterproductive to require monitoring that is not able to detect even large impacts.

General guidance for minimum effect size was provided by Peterson and Bishop (2005) as a 50% decrease or a 100% increase of a population. The probability of a Type I error (rejecting a true null hypothesis) is traditionally set at 5% (α=0.05), but because α and β (probability of committing a Type II error) are inversely related for a given number of samples, this leads to a bias of greater probability of accepting a false null hypothesis of no project effects. This, in turn, leads to a prioritization of development over environment because large impacts can often be missed (Mapstone, 1996). An environmentally conservative approach is to stipulate a low rate of a Type II error (Mapstone, 1996).

Defining impacts and the justification behind required monitoring methods would help clarify what information is sought. A good example is in the permit conditions for data gathered for sea turtle nesting. Each required monitoring parameter is justified as to why the information is important and how it will be used. Of course, the difference with sea turtle monitoring is that the data are analyzed "in house," and analysis is more standardized when just looking at one group of species rather than a whole community. Even though benthic community monitoring is less tractable, explaining the reasoning and justification of what information is needed and how it will be used to assess impact would help consultants focus on what information the agencies need. This would ultimately reduce costs and time spent collecting, analyzing, and discussing data that are not important for determination of impact. For instance, is cover of barnacles or bryozoans important information for detecting impact to coral reef communities? Is this level of detail needed, or would incorporation into a broader group be acceptable? If they are important, what amount of change is ecologically relevant? These are decisions that agencies need to make.

Defining impacts is difficult and is an environmental question of how much change is acceptable (e.g., 50% reduction in cover, 5% change in species presence, 25% dissimilarity in community composition, 20% increase in sand cover, etc). Currently, the definition of impacts is subjective, and there can be disagreement among parties involved about what constitutes an impact. The FDEP BBCS indicated that impact for beach nourishment projects is determined by a difference in cover of functional groups correlated with increases in sand cover amounts or duration. Pre-defining what constitutes impact and acceptable levels of change due to impact might depoliticize monitoring to some extent by requiring sample designs sufficient to detect these impacts rather than basing decisions on more subjective factors. This might actually reduce the monitoring required if efficient designs can be adopted and functional groups with low abundance or perceived value can be eliminated from monitoring.

4.3 Standardized Monitoring Protocols

One of the tasks of this project was to recommend standardized monitoring protocols that would allow for regional comparisons which, in turn, would aid in resource management. This is not an easy or straightforward endeavor because each construction project is different, and there will be differing target communities depending on location and habitat type. Additionally, as technology improves and new methods are developed, monitoring methods will likely follow suit. These suggestions are not intended to be restrictive or to imply that only this information is needed, but rather to provide a cornerstone from which to build upon depending on project and location specific needs. Some of these protocols have already been mentioned in the previous discussion, and many are currently already being followed. Protocols are discussed below and are listed in Table 3.

Benthic community structure assessments should include size and density estimates of corals, gorgonians, and sponges. Additionally, some quantitative or semi-quantitative measure of colony condition should be taken for these groups. Some examples include bleaching (normal, pale, partially bleached, fully bleached), occurrence of disease or tissue necrosis, and partial mortality measurements.

Percent cover estimates can be useful for colonial encrusting organisms and macroalgae for which differentiation of individuals is difficult. Percent cover estimates using *in situ* methods are preferred due to greater accuracy in low biological cover environments. However, it is recognized that point counts from video and still images may be warranted in certain circumstances such as deep depths that limit bottom time or strong currents which make *in situ* surveys difficult. Video surveys are recommended for qualitative records of before and after construction conditions.

Fish surveys should include species, abundance, sizes, and life history stage (e.g., juvenile or adult). Common survey methods such as roving diver (timed swims), stationary diver (timed surveys within a defined area around a central point), and transect surveys each have their own advantages and disadvantages. Ideally, at least two of these methods should be used when monitoring sites so that both cryptic and pelagic species have a better chance of being observed.

Physical monitoring for beach nourishment and dredging projects (e.g., navigation channels, offshore sand sources for fill, etc.) should include sediment traps at each biological monitoring transect (ideally at least one trap at each end) during pre- and post-construction to get estimates of sedimentation rates and sand characteristics. These characteristics can then be analyzed to link physical data to biological response. Hardbottom edge mapping using a GPS unit towed by a scuba diver was also indicated by several of the consultants interviewed to be a very useful, low-cost method for determining sand movement from the beach to hardbottom habitat.

Cable projects should include estimates of impact to corals, gorgonians, and sponges. Currently five impact categories are identified for each organism: 1) cable touching organism, 2) cable shading organism, 3) cable abrading organism, 4) cable formerly abraded organism but no longer abrading, and 5) cable dislocated organism. It is recommended that these categories continue to be monitored unless it is determined that they are no longer needed due to absence of negative impact (e.g., shading does not cause mortality, organism can continue to grow around or over cable, etc.).

Table 3. Standardized monitoring protocols.

Survey Target or Project Type	Measurements	Method
Benthic Invertebrates	Colony size, density, and condition of corals, gorgonians, and non-encrusting sponges and identification to species level if possible *Colony condition includes*: 1) bleaching (pale, partial, total) 2) disease/tissue necrosis 3) partial mortality measurements *Colony size includes:* 1) maximum diameter for scleractinian corals 2) height for gorgonians 3) height and width of sponges	*In situ* belt transects and/or quadrats
Benthic Organisms	Percent cover of functional groups (sponges, algae, corals, gorgonians, etc.)	*In situ* belt transects and/or quadrats preferred, but point counts from video or still images if conditions warrant
Fish	Species, abundance, size, life history stage	*Choose 2 of following:* 1) stationary diver 2) roving diver 3) transects
Beach Nourishment and Dredging	Sedimentation and sand characteristics	1) sediment traps along each transect used for biological monitoring pre- and post nourishment 2) grain size analysis
Beach Nourishment	Hardbottom edge mapping	Diver towed GPS
Cable Projects	Impacts to corals, gorgonians, and sponges *Impact categories:* 1) cable touching 2) cable abrading 3) cable shading 4) dislocated/unattached 5) cable formerly abraded but not currently	*In situ* belt transects

5. RECOMMENDATIONS

The author suggests the following list of recommendations to improve future monitoring based on the literature review, examination of past monitoring reports, and interviews. Reasoning for these recommendations was discussed in detail in the discussion section above. Selected references to the literature and interviews are included below the recommendation for brief support and to provide an easy reference. The recommendations are categorized by project type, or if they apply to more than one project type, they are listed under general recommendations.

Mitigation

1. Define minimum performance criteria (e.g., how much similarity between reference and mitigation sites) to evaluate the effectiveness of mitigation reefs to replace lost ecological services or relate services gained from the mitigation to those lost due to project impact.

    - Differences in complexity between mitigation artificial reefs and natural reefs will likely result in a difference in community structure (Thanner et al., 2006). Mitigation reefs constructed to compensate for impacts to nearshore hardbottom that are not placed in the same habitat (deeper depths) differ from natural reefs in community structure (Continental Shelf Associates Inc., 2006). Conclusions are rarely drawn about the effectiveness of artificial reefs relative to objectives of the project (Seaman & Jensen, 2000).
    - In interviews, some people questioned the ability of mitigation to replace lost habitat, particularly nearshore habitat where mitigation was placed further offshore due to logistical reasons.

Cable

2. Require longer-term monitoring for cable projects due to permanent placement and potential movement. Monitoring should be performed until it can be shown that the cable has been "cemented" down from overgrowth and is not in danger of causing future impact. Alternatively, monitoring time periods could be kept at the current level if no anchoring zones could be implemented along existing cable corridors to reduce the potential for impact.

3. Include gorgonians and sponges in addition to stony corals in monitoring of potential cable impacts.

    - Impacts to sponges and gorgonians from cable placement were found to be more numerous than to corals (Sultzman, et al., 2002).

Beach Nourishment and Dredging

4. Examine ways to incorporate a more regional management approach for large projects such as beach nourishment. This could be accomplished through a GIS database of impact and reference survey sites, thereby preventing the occurrence of reference sites within areas of potential impact from other projects. In addition, a regional monitoring program that is not tied to a specific project, but provides standardized pre-nourishment data across the four county region, would allow for regional comparisons and aid in management.

    - The independence of treatment (impact) and control (reference) sites is an important assumption of statistical analysis (Zar, 1999). Peterson and Bishop (2005) found that there was a problem of sites formerly filled being used as controls for subsequent fills in the beach nourishment monitoring projects they examined and recommended that a gradient of control sites at varying distances away from the fill site would help deal with the problem. Modeling at broad spatial and temporal scales using regional data can be used to couple physical and biological processes to help understand and predict impacts (Peterson & Bishop, 2005).
    - In interviews, some people were concerned about the effect of cumulative impacts from repeated projects within the same area. Additionally, many wanted to learn from the experiences of past projects so that future projects could be improved and felt that the availability of a regional database would aid in this endeavor.

5. Include better monitoring methods for tracking sand movement from nourished beaches to the marine environment and perform better analysis (e.g., regression) for coupling physical and biological data. Some suggested ways to accomplish better tracking and coupling include use of sediment traps and sediment core samples at hardbottom sites used for biological monitoring pre- and post-construction to determine if changes in sediment quality have occurred due to nourishment or dredging.

    - Coupling of physical and biological data is important for determining impact due to construction, and monitoring designs and analyses must be able to detect the relationship between impact related change in the biological variables and environmental variables (Green 1979). Peterson and Bishop (2005) found a lack of habitat characterization (physical parameters) in assessment of impacts to biological communities in the beach nourishment monitoring they examined. Most sand used in beach nourishment projects in southeast Florida is dissimilar in grain size, durability, and hydrodynamic behavior to that found on natural beaches

(Wanless & Maier, 2007). Other physical parameters that could be measured include measurement of sediment transport, erosion of fine particles off the beach, turbidity plume dynamics, and concentration of large shells (Peterson & Bishop, 2005). Measurements must be made on all relevant biological and environmental variables in association with the individual samples, and measurements for an area covering a number of samples are useless for hypothesis testing (Green, 1979).
- FDEP BBCS indicated that impact was determined from a change in percent cover of benthic organisms in association with presumed sediment migration from the project.

6. Incorporate more pre-construction surveys into monitoring programs of beach nourishment and dredging projects to better detect natural seasonal and inter-annual variation. The duration of the pre-construction monitoring period should be at least as long as the duration of the post-construction monitoring period.

   - Before impact baseline data are needed to provide temporal control for after impact comparison (Green, 1979). Nelson (1993) recommends sampling monthly for at least three months before impact, bi-weekly for two months after impact, and monthly thereafter for 9-12 months. There is a need for adequate baseline data to document natural spatial and seasonal variability in numbers, species composition, and diversity of organisms (National Research Council, 1995).
   - Many people interviewed acknowledged the need for more pre-construction surveys but worry about funding such surveys since cost-sharing is limited.

<u>General</u>

7. Define hypotheses to be tested and used to detect environmental impact or determine ability of mitigation reefs to replace services in monitoring plans and monitoring reports.

   - Experimental designs must be able to test the null hypothesis that any change in the biological community of the impact area over the time period which includes the impact does not differ from the reference area (Green, 1979).
   - Several consultants indicated that they did not know exactly what information the agencies wanted for determining impact.

8. Collect video data as a record of conditions but use *in situ* data of percent cover, density, and size class for analysis of community structure. It is recognized that there are circumstances, such as extreme depths that limit bottom time, where video may need to be used to collect data; however, there should be standards such as distance from substrate, resolution, and tow or swim speeds to ensure useful video footage.

   - Density and size estimates can be used in predictive models of change such as population matrices (Leslie, 1945) and agent based models (Osenberg et al., 1996).
   - Several consultants indicated that *in situ* data for percent cover was more accurate than point counts from video when both methods were used but that video was good to have for qualitative record of conditions and could always be quantitatively analyzed later if deemed necessary.

9. Include more individual based measurements of biological condition (growth, fecundity, gene expression, physiological changes, tissue structure as it relates to organism function, etc.) in monitoring designs.

   - Changes in individuals are often more easily detected and can give a more sensitive indication of the environmental impacts of coastal construction projects (Osenberg et al., 1996). Constraints in the number of before impact temporal replicates are most likely to hamper detection of impacts on population density and physical-chemical characteristics and least likely to affect detection of effects on individual performance (Osenberg et al., 1992, 1996). Individual-based parameters (and demographics) provide the mechanisms that underlie changes at the population and community level (Osenberg et al., 1996).

10. Incorporate *a priori* power analyses into monitoring plans to ensure that adequate sample sizes are collected to detect change.

   - Green (1979) advocates preliminary sampling to evaluate sampling design and statistical analysis options. If species composition is of interest, more diverse and heterogeneous communities or smaller sampling units (e.g., quadrats) will require a larger number of replicates (which relates to a larger area of substrate surveyed) (Miller & Falace, 2000). Similar to species area curves, evaluation of the number of transects needed to adequately assess percent cover can be graphed with the variance or standard deviation on the y-axis versus number of transects surveyed on the x-axis, and sufficient replication is determined by the a leveling off of the curve (asymptote) before the last replicate is added (Miller & Falace, 2000).

11. Aim for equal numbers of reference and treatment sites, and locate reference sites both north and south of potential impact areas.

    - When interspersion of treatment and control sites is not possible, locating control sites on both sides of the treatment site is the next best option (Green, 1979; Nelson, 1993). An equal number of randomly allocated replicate samples for each combination of controlled variables leads to balanced designs which provide more powerful statistical tests (Green, 1979).

12. Take replicate samples of each variable (time, site, depth, distance from shore, etc.) so that statistical testing can be used to test hypotheses of similarities and differences.

    - Nelson (1993) and Green (1979) advocate replication of sites within each combination of time and location and state that a factorial 2 way ANOVA (area and time) or 3 way (area, time, and beach zone) allows for area and time differences to be evaluated simultaneously where a significant area and time interaction indicates evidence of an impact. A BACI paired series standard analytical approach is to calculate the difference between control and impact values on each date (delta) and test whether the mean difference changes from before to after construction (sampling dates are replicates, and within survey replicates can be collected to reduce sampling error) (Osenberg et al., 1996). Differences among can only be demonstrated by comparison to differences within (Green, 1979).

13. Perform non-metric multidimensional scaling (MDS) procedures over diversity indices to test for similarities and differences in community structure.

    - Peterson and Bishop (2005) conclude that MDS analyses are more easily able to detect ecological patterns than univariate procedures such as similarity indices.

14. Incorporate stratified random sampling and nesting into monitoring design to factor out more natural variability that can obscure project effects.

    - Nested ANOVA is an appropriate design to allow for analysis of several layers of variation inherent in systems (e.g., replicate samples nested within replicate transects nested within treatment) (Nelson, 1993). A combination of factorial and nested ANOVA could be performed where several locations (Factor A) at several times (Factor B) are sampled, and at each site, the area to be sampled is randomly divided into plots from which a random sample is taken. Plots are nested in Factor A, and this design evaluates variation within a site (Nelson, 1993). Green (1979) advocates stratified random sampling when habitat patchiness or a large scale environmental pattern is present.

15. Report the power of performed parametric tests when accepting the null hypothesis.

    - Because α (probability of a Type I error, rejecting a true null hypothesis) is fixed, this leads to a bias of greater concern of a Type I than Type II error and a tacit prioritizing of development over environment since large impacts can often be missed (Mapstone, 1996).

16. Consider alternative mitigation options to artificial reef deployment.

    - Peterson and Bishop (2005) conclude that a project by project approach should be replaced with a centralized program, analogous to a wetland mitigation bank, where appropriate levels of monitoring and mitigation charges are assessed to each project and paid into a single fund that could be used to fund research proposals addressing the impacts of coastal construction. Funded projects should include modeling at appropriately broad spatial and temporal scales to address cumulative impacts and couple physical and biological processes to help understand, model, and predict impacts.
    - Some people interviewed questioned the ability of mitigation artificial reefs to adequately replace lost ecological services and felt that funds might be better spent trying to address some of the broader issues facing coral reefs such as poor water quality or funding regional monitoring programs or research to answer some of the questions needed for better management.

17. Before the project begins, clearly define what qualifies as impacts, effect size (the level of acceptable change due to impact), and the acceptable probability of committing a Type I (rejecting a true null hypothesis) or Type II (accepting a false null hypothesis) error.

    - Effect size in environmental impact monitoring is defined by the magnitude and form of maximum environmental impact tolerable in a particular case (limit of acceptable change due to impact) (Mapstone, 1996). Form could include changes in means or variances at control versus impact sites, scales at which impacts might occur, or specifying which means or group of means differ from which others. Magnitude is a measure of the amount by which means or variances change. An environmentally conservative approach is to stipulate a low rate of a Type II error (Mapstone 1996). Peterson and Bishop (2005) recommend a 50% decline or 100% increase of a population to be the minimal level of effect size.

- Most people interviewed would like clearer definitions of what constitutes impact and how impact is determined.

18. Include adequate synthesis of the literature and discuss the results of the monitoring project in a larger context.

- Some resource trustee agencies wanted more discussion of the results, but the regulatory agencies did not indicate this was important to them since they draw their own conclusions. Many of the resource trustee agencies indicated discussion in a broader context would be beneficial for management decisions.

19. Provide more formal training opportunities and refresher courses on experimental design and statistics that include examples and exercises relevant to coastal construction project monitoring. These courses could be organized by FDEP CRCP or SEFCRI similar to the existing fish, coral, and invertebrate identification classes.

- Most people interviewed indicated that more training would be useful but that they would only be able to participate if they were local and low cost.

20. Implement an avenue to share experiences, methods, knowledge, lessons learned, and recommendations for future monitoring between those responsible for monitoring and those requiring monitoring. Possibilities include summary sections in monitoring reports, a regional database, and regularly scheduled meetings or conferences.

- Many people interviewed indicated that they would like some way to learn from the past experience of others, but ideas of how to best accomplish this were varied.

21. Provide additional funding for a contract or consultant position at FDEP BBCS during the end of the year when most reports are submitted to help review post-construction monitoring reports and ensure that results are used to improve future monitoring.

- Post-construction follow-up of monitoring reports is lacking due to limited staff numbers and the fact that most reports are submitted at the same time.

22. Determine a mechanism to ensure that companies conducting resource monitoring are separate from those performing project construction and design. This would allow for independent oversight and avoid any semblance of impropriety.

    - Although consultants indicated that they did not feel like reporting of impact would affect their marketability for future projects, there was concern from some agencies that there was no independent oversight of project construction and project monitoring.

LITERATURE CITED

Arthur V. Strock & Associates Inc. (1983). Five Year Environmental Follow-Up Reef Survey for the 1978 Delray Beach Maintenance Nourishment Project. Delray Beach. Arthur V. Strock & Associates Inc.

Bence, J.R., Stewart-Oaten, A., Schroeter, S.C. (1996). Estimating the size of an effect from a before-after-control-impact paired series design. In: Schmitt, R., & Osenberg, C. (ed). *Detecting ecological impacts: concepts and applications in coastal habitats*: Academic Press. San Diego. pp. 133-149.

Baron, R., Hague, E., & Kruempel, C.J. (2007). City of Boca Raton - South Boca Raton, FL Beach Nourisment Project - Post-Construction Monitoring: Three-Year Artifical Reef and Four-Year Natural Hardbottom Biological Monitoring Results. Boca Raton. Coastal Planning & Engineering, Inc.

Bohnsack, J.A. (1989). Are high densities of fishes at artificial reefs the result of habitat limitation or behavioral preference? *Bulletin of Marine Science, 44*(2), 631-645.

Bohnsack, J.A., & Sutherland, D.L. (1985). Artificial reef research: a review with recommendations for future priorities. *Bulletin of Marine Science, 37*, 11-39.

Coastal Planning & Engineering Inc. (2009). Segment III Broward County Shore Protection Project: 36-Month Post-Construction Nearshore Environmental Monitoring Report. Boca Raton. Coastal Planning & Engineering, Inc.

Coastal Planning & Engineering Inc. (1988). Boca Raton Inlet and Adjacent Beaches Management Program: Status report No. 7. Boca Raton. Coastal Planning & Engineering, Inc.

Coastal Planning & Engineering Inc. (1992). Boca Raton Beach Restoration Project 3 Year Post-Construction - Volume 1: Environmental Monitoring Report. Boca Raton. Coastal Planning & Engineering, Inc.

Coastal Planning & Engineering Inc. (1997). City of Delray Beach Third Periodic Beach Renourishment Project - 4 Year Post-Construction Phase: Hardbottom Environmental Monitoring with Borrow Area and Fill Site Infauna Assessment Report. Boca Raton. Coastal Planning & Engineering, Inc.

Coastal Planning & Engineering Inc. (2000). Boca Raton Beach Renourishment Project (Palm Beach County, Florida): One-Year Post-Construction Environmental Monitoring Report: Hardbottom Habitat, Sedimentation Rate, and Construciton Water Qualilty Results. Boca Raton. Coastal Planning & Engineering, Inc.

Coastal Planning & Engineering Inc. (2004). City of Boca Raton- Central Boca Beach Nourishment Project: Pre-, Mid and Post Construction Biological Monitioring. Boca Raton, Coastal Planning & Engineering, Inc.

Coastal Systems International Inc. (1999). 1-Year Post-Construction Hardbottom Monitoring Report for the Hillsboro Beach/Deerfield Beach Nourishment Project. Coral Gables. Coastal Systems International, Inc.

Continental Shelf Associates Inc. (1981). Environmental Monitoring Associated with the Port Everglades Harbor Deepening Project of 1980 - Final Report. Tequesta. Continental Shelf Associates, Inc.

Continental Shelf Associates Inc. (2006). Nearshore Artificial Reef Monitoring Report: Final Report. Jupiter. Continental Shelf Associates, Inc. Prepared for Palm Beach County Department of Environmental Resources Management.

Courtenay, W.R., Jr., Hartig, B.C., & Loisel, G.R. (1980). Ecological Evaluation of a Beach Nourishment Project at Hallandale (Broward County), Florida. Volume I. Evaluation of Fish Populations Adjacent to Borrow Areas of Beach Nourishment Project, Hallandale (Broward County), Florida. Boca Raton. Florida Atlantic University, Department of Biological Sciences.

CSA International Inc. (2007). Texas Reef Monitoring Program: Year 3 Survey. Jupiter. CSA International, Inc.

CSA International Inc. (2008). Pre-construction Monitoring Survey of Nearshore Hard Bottom Habitats at Bathtub Reef Beach, Martin County, Florida. Stuart. CSA International Inc.

Cummings, S.L. (date unknown). The Boca Raton Mitigative Artificial Reef- 5 1/2 Years Later. Boca Raton. Coastal Planning & Engineering, Inc.

Dodge, R.E., Hess, S., & Messing, C. (1991). Final Report: Biological Monitoring of the John U. Lloyd Beach Renourishment: 1989. Dania. Nova University Oceanographic Center.

Fisher, L., Banks, K., Gilliam, D., Dodge, R.E., Stout, D., Vargas-Angel, B., & Walker, B.K. (2008). Real-time coral stress observations before, during, and after beach nourishment dredging offshore southeast Florida, USA. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida.

Florida Oceanographic Society Palm Beach County Reef Research Dive Team. (2002). Florida Fish and Wildlife Conservation Commission Grant No. 00122 Summary Report for October 2002 to September 2002 Grant Period.

Florida Oceanographic Society Palm Beach County Reef Research Team. (2006). Florida Fish and Wildlife Conservation Commisssion Grant No. 04030 Annual Report for December 2004 to November 2006 Grant Period.

Florida Oceanographic Society Palm Beach County Reef Research Team. (2008). Florida Fish and Wildlife Conservation Commission Grant No. 06122 Final Report for February 12, 2006 to December 1, 2008 Grant Period.

G.M. Selby & Associates Inc. (1995). Sunny Isles Artificial Reef Monitoring Project Twelfth Quarterly Report - December, 1994. Melbourne. G. M. Selby & Associates, Inc.

Green, R. (1979). *Sampling design and statistical methods for environmental biologists*. New York: John Wiley & Sons Inc.

Hague, E., Barrett, C.A., Baron, R., & Bardes, P. (2007). City of Boca Raton - 2006 Central Boca Raton Beach Nourishment Project: 18 Month Post-Construction Biological Monitoring Report. Boca Raton. Coastal Planning & Engineering, Inc.

Hague, E., Barrett, C.A., Prekel, S.E., & Kruempel, C.J. (2006). Globenet (Formerly Atlantica U.S.A., L.L.C.) Fiberoptic Cable Installation Boca Raton (Palm Beach County), Florida - GLOBENET (Formerly ATLANTICA-I SYSTEM) Cables 1 and 2 Stony Coral Impact and Artificial Reef Colonization Five-Year Post-Construction Monitoring Report. Boca Raton. Coastal Planning & Engineering, Inc.

Hague, E., Miller, C., Baron, R., Delaney, A., & Massa, J. (2009). U.S. Army Corps of Engineers Palm Beach Harbor Maintenance Dredging Program/Town of Palm Beach Mitigative Artificial Reef, 2-Year Post-Mitigation Biological Monitoring Report. Boynton Beach. Tetra Tech EC, Inc. and Coastal Eco-Group, Inc.

Hague, E., Miller, C., Baron, R., Delaney, A., & Massa, J. (2010). Town of Palm Beach Reach 7, Phipps Ocean Park Beach Restoration Project 41-Month Post-Nourishment and FDEP Hurricane Recovery Dune Restoration Project Biological Monitoring Report. Boynton Beach. Tetra Tech EC, Inc. and Coastal Eco-Group, Inc.

Harris, L.E., Dillion, K.L., & Herren, L. (2008). Martin County's Nearshore Mitigation Reefs Year-7 Monitoring Report.

Harris, L. E., & Dillon, K.L. (2004). 2003 Monitoring of Martin County's Artificial Reefs. Stuart. Martin County Engineering Department.

Harris, L.E., & Dillon, K.L. (2006). 2005 Monitoring Report Martin County's Artificial Reefs Deployed 2000 to 2005.

Hart, A.D., Snyder, D.B., Spring, K.D., & Hammer, R.M. (2005). Application of scientific experimentatal design in monitoring hard bottom habitats associated with areas of beach nourishment. Jupiter: Continental Shelf Associates, Inc.

Jordan, L.K.B., Banks, K.W., Fisher, L.E., Walker, B.K., & Gilliam, D.S. (2010). Elevated sedimentation on coral reefs adjacent to a beach nourishment project. *Marine Pollution Bulletin, 60*, 261-271.

Kruempel, C.J., Hague, E., Lybolt, M., & Baron, R. (2006). Telefonica International Wholesale Services, Inc. (Formerly Emergia) Fiberoptic Cable Installation Boca Raton (Palm Beach County), Florida: Telefonica SAm-1 Cables H and I Stony Coral Impact and Artificial Reef Colonization Five-Year Post-Construction Monitoring Report. Boca Raton. Coastal Planning & Engineering, Inc.

Leslie, P.H. (1945). On the use of matrices in certain population mathematics. *Biometrika, 33*, 183-212.

Light, P.R., Vose, F.E., & Snyder, D.B. (2003). *Comparison of Fish Assemblages on Artificial and Natural Reefs off Southeast Florida*: Florida Fish and Wildlife Conservation Commission.

Lindberg, W.J. and W. Seaman (editors). 2011. Guidelines and Management Practices for Artificial Reef Siting, Use, Construction and Anchoring in Southeast Florida. Florida Department of Environmental Protection. Miami, FL. xi and 148 pages.

Makowski, C., Prekel, S.E., Lybolt, M.J., & Baron, R.M. (2009). The Benthic Ecological Assessment for Marginal Reefs (BEAMR) Method. *Journal of Coastal Research 25*(2), 515-522.

Mapstone, B.D. (1996). Scalable decision criteria for environmental impact assessment. In: Schmitt, R., & Osenberg, C. (ed). *Detecting ecological impacts: concepts and applications in coastal habitats*: Academic Press. San Diego. pp. 67-80.

Marsh, A.G., Bowen, P.R., Deis, D.R., Tubeville, D.B., & Courtenay, W.R., Jr. (1980). Ecological Evaluation of a Beach Nourishment Project at Hallandale (Broward County), Florida: Volume II. Evaluation of Benthic Communities Adjacent to a Restored Beach, Hallandale (Broward County), Florida. Boca Raton. Florida Atlantic University Department of Biological Services.

McGlynn, K. (2002). DEP permitting for the Diplomat Beach Renourishment Project, City of Hollywood, Broward County, Fl- DEP file No. 0174142-001-JC. Coral Gables. Coastal Systems International, Inc.

Miami-Dade County Department of Environmental Resources Management (2009a). Annual Monitoring Report for the Golden Beach Artificial Reef Site. Miami-Dade County Department of Environmental Resources Management.

Miami-Dade County Department of Environmental Resources Management (2009b). Annual Monitoring Report for the Key Biscayne Special Management Zone Artificial Reef Site. Miami-Dade County Department of Environmental Resources Management, .

Miller, M.W., & Falace, A. (2000). Evaluation methods for trophic resource factors-nutrients, primary production, and associated assemblages. In W. Seaman Jr. (Ed.), *Artificial Reef Evaluation with Application to Natural Marine Habitats* (pp. 95-126). Boca Raton: CRC Press.

National Research Council (1995). *Beach Nourishment and Protection*. Washington, DC: National Academy Press.

Nelson, W. (1993). Beach restoration in the southeastern US: environmental effects and biological monitoring. *Ocean & coastal management, 19*(2), 157-182.

Osenberg, C.W., Holbrook, S.J., & Schmitt, R.J. (1992). Implications for the design of environmental assessment studies. In P.M. Grifman & S.E. Yoder (Eds.), *Perspectives on the Marine Environment, Proceedings from a Symposium on the Marine Environment of Southern California* (pp. 75-89). Los Angeles, CA: USC Sea Grant Program.

Osenberg, C.W., Schmit, R.J., Holbrook, S.J., Abu-Saba, K.E., & Flegal, A.R. (1996). Detection of Environmental impacts: natural variability, effect size, and power analysis. In R.J. Schmitt & C.W. Osenberg (Eds.), *Detecting ecological impacts: concepts and applications in coastal habitats* (pp. 83-108). San Diego: Academic Press.

Palm Beach County Department of Environmental Resources Management. (2000). Evaluation of Mitigation Reef Constructed to Offset Impacts of the 1995 Jupiter/Carlin Shore Protection Project: Interim Report. Palm Beach Department of Environmental Resources Management.

Palm Beach Reef Research Team. (2004). Executive Summary: A Summary of the Monitoring Data Collected from 11/02 to 12/04 by the Palm Beach County Reef Research Team.

PBS&J. (2004). Year Five Monitoring Report.

PBS&J. (2009). CFX-1 Cable Installation Year -One Monitoring Report.

Pennell, J. (2007). Jupiter Island Beach Restoration Biological and Sedimentation Survey Post-Dredge Report. Jupiter. Environmental Services, Inc.

Pennell, J. (2008). St. Lucie Inlet Federal Navigation Channel Maintenance Dredging Project - Nearshore Hardbottom Biological Monitoring Post-Dredge Report. Jupiter. Environmental Services, Inc.

Peterson, C., & Bishop, M. (2005). Assessing the environmental impacts of beach nourishment. *BioScience, 55*(10), 887-896.

Prekel, S., Ward, G., & Snyder, D. (2009a). Town of Palm Beach Reach 7, Phipps Ocean Park Beach Mitigative Artificial Reef, 48-Month Post-Mitigation and FDEP Hurricane Recovery Dune Restoration Project Biological Monitoring Report. Boca Raton. Coastal Planning and Engineering, Inc.

Prekel, S.E. (2009). Ocean Ridge Shore Protection Project Third Annual and Final Post-Construction Biological Monitoring Report. Boca Raton. Coastal Planning and Engineering, Inc.

Prekel, S.E., Hannes, A.R., Ward, G.A., Spieler, R.E., & Freeman, J. (2009b). Fifth Annual Environmental Monitoring Report of the Mitigative Artificial Reef, 60 Months Post-Mitigation. Boca Raton. Coastal Planning and Engineering, Inc.

Raymond, B., & Antonius, A. (1977). Final Report: Biological Monitoring Project of the John U. Lloyd Beach Restoration Project. Fort Lauderdale. D. E. Britt Associates, Inc.

Sathe, M.P., Thanner, S.E., & Blair, S.M. (2007). Bal Harbor Mitigation - Artificial Reef Monitoring Program: Year 8 and 9 Progress Report and Summary. Miami. Miami- Dade County Department of Environmental Resources Management.

Schmitt, R., & Osenberg, C. (1996). *Detecting ecological impacts: concepts and applications in coastal habitats*. San Diego: Academic Press.

Seaman, W.J., & Jensen, A.C. (2000). Purposes and practices of artificial reef evaluation. In W. Seaman Jr. (Ed.), *Artificial Reef Evaluation with Application to Natural Marine Habitats,* (pp. 1-19). Boca Raton: CRC Press.

Smith, E.P. (Ed.) (2002). Encyclopedia of Environmetrics (Vols. 1). Chichester: John Wiley & Sons, Ltd.

Spieler, R. (1994). Evaluation of a Novel Material for Recycling Tires into Artificial Reefs: Second Year Annual Report. Dania, FL: Nova University, Oceanographic Center.

Spieler, R. (1995). A Preliminary Study of Fish Recruitment to "Reefball" Artificial Reefs in Shallow and Deep Water. Dania, FL: Nova Southeastern University Oceanographic Center.

Spieler, R. (2000). Artificial Reef Research in Broward County 1993-2000: A Summary Report. Dania, FL: Nova Southeastern University Oceanographic Center.

Spieler, R.E. (2003). Fish Census of Selected Artificial Reefs in Broward County.

Stewart-Oaten, A., Murdoch, W., & Parker, K. (1986). Environmental Impact Assessment:" Pseudoreplication" in Time? *Ecology, 67*(4), 929-940.

Sultzman, C., Halter, H.A., Craig, R.K., Meyer, D., Ruggieri, J.A., & Spurgeon, J. (2002). A Professional Jury Report on the Biological Impacts of Submarine Fiber Optic Cables on Shallow Reefs off Hollywood Florida. Vero Beach. PEER Coral Reef/Fiber Optic Cable Jury.

Thanner, S.E., McIntosh, T.L., & Blair, S.M. (2006). Development of benthic and fish assemblages on artificial reef materials compared to adjacent natural reef assemblages in Miami-Dade County, Florida. *Bulletin of Marine Science, 78*, 57-70.

Wanless, H.R., & Maier, K.L. (2007). An evaluation of beach renourishment sands adjacent to reefal settings, southeast Florida. *Southeastern Geology, 45*(1), 25-42.

Ward, G.A., Craft, J., & Snyder, D. (2008). Mid-Town Beach Renourishment and Expansion Project: Year Three Post-Contruction Environmental Monitoring Report. Boca Raton. Coastal Planning and Engineering, Inc.

Zar, J.H. (1999). *Biostatisical Analysis* (Fourth ed.). Upper Saddle River, New Jersey: Prentice Hall.

Appendix 1. Database, keyword, and internet searches for relevant literature

Database: Aquatic Sciences and Fisheries Abstracts (ASFA)

Key Words:
Beach Nourishment
Beach Nourishment & Benthic Communities
Beach Nourishment & Coral Reef
Beach Renourishment
Beach Renourishment & Coral Reef
Beach Renourishment & Monitoring
Benthic Communities
Benthic Communities & Beach Nourishment
Benthic Communities & Coral Reef
Benthic Communities & Fish
Benthic Communities & Monitoring
Benthic Communities & Water Quality
Coral & Dredging
Coral & Monitoring
Coral Reef & Beach Renourishment
Coral Reef & Benthic Communities
Coral Reef & Mitigation
Coral Reef & Monitoring
Coral Reef & Survey
Dredging & Coral
Fish & Benthic Communities
Mitigation & Coral Reef
Monitoring & Beach Nourishment
Monitoring & Benthic Communities
Monitoring & Coral
Monitoring & Coral Reef
Monitoring & Reef Fish
Reef Fish & Monitoring
Reef Fish & Survey
Water Quality & Benthic Communities

Internet Searches:

- The Nature Conservancy
    - Florida Reef Resilience Program(FRRP)Surveys
- The Florida Department of Environmental Protection
    - http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#SBMP Publications

- Miami-Dade Department of Environmental Resource Management
    - http://www.miamidade.gov/derm/reports2.asp
    - http://www.miamidade.gov/derm/beach_erosion.asp
- Palm Beach Department of Environmental Resource Management
    - http://www.co.palm-beach.fl.us/erm/coastal/shoreline/beach/reports.htm
- Martin County Growth Management Department ,Environmental Division
    - http://www.martin.fl.us/portal/page?_pageid=73,72043&_dad=portal&_schema=PORTAL
- Florida Fish and Wildlife Conservation Commission
    - Coral Reef Evaluation and Monitoring Project (CREMP)

Other databases:

- EndNote database of artificial reef literature maintained by Keith Mille of FWC's Artificial Reef Program

Appendix 2. Evaluation criteria for monitoring reports

Project Name:____
Document Description:____
Report Title:____
____
Permit number:____
Date of report:______________________ Date of evaluation:_______

<u>Experimental design</u>

1. Stated hypothesis?
Score:______
0 - no hypothesis, questions, or objectives
1 - objectives stated
2 - questions posed
3 - hypothesis stated
Comments:

2. Sampling/surveying methods employed?
Score:______
0 - inappropriate methods to measure response
1 - methods highly limited in ability to measure response
2 - methods able to measure moderate level of response
3 – methods able to measure high level of response
Comments:

3. BACI (before-after, control-impact) sampling design?
Score:______
0 – no BACI
1 – either B/A or C/I
2 – BACI design
Comments:

4. Nested sampling in time and space?
Score:______
0 – no nested sampling
1 – nested in time or space
2 – nested in both time and space
Comments:

5. Sampling frequency pre-construction?
Score:_______
0 – no pre-construction sampling
1 – one pre-construction sampling event
2 – two to three pre-construction sampling events
3 – more than three pre-construction sampling events
Comments:

6. Post construction sampling frequency?
Score:_______
0 – no post-construction sampling
1 – yearly
2 – two to three times per year
3 – more than three times per year
Comments:

7. Duration of pre-construction sampling
Score:_______
0 –one month or less
1- between two and four months
2 – between five and nine months
3 – between ten and 12 months
4 – greater than 12 months
Comments:

8. Duration of post-construction sampling?
Score:_______
0 – one year or less
1 – between two and three years
2 – between four and five years
3 – greater than five years
Comments:

9. *A priori* power analysis performed to determine samples size sufficient to detect change?
Score:_______
0 - no *a priori* power analysis
1 - no *a priori* power analysis but reference to previous studies that have determined appropriate sample size
2 - *a priori* power analysis
Comments:

10. Sufficient replication (# of reference sites/samples similar to # impact sites/samples?

Score:_______

0 - no reference sites/samples
1 - # reference sites/samples much smaller than # treatment sites/samples
2 - # reference sites/samples smaller but similar to # treatment sites/samples
3 - # reference sites/samples equal to # treatment sites/samples
Comments:

11. Random sampling design?

Score:_______

0 - arbitrarily chosen sample sites
1 – haphazardly chosen sample sites
2 – randomly chosen sample sites
3 – stratified random samples (space or time)
4 – stratified random samples in space and time
Comments:

12. Controls appropriate (similar habitat, independent of each other and treatments, spatially distributed around all sides of treatment)?

Score:_______

0 - no controls
1- dissimilar habitat
2 - similar habitat, not independent, not located appropriately
3 - similar habitat, not independent, located appropriately
4 - similar habitat, independent, not located appropriately
5 – similar habitat, independent, located appropriately
Comments:

General comments experimental design:

Statistical analysis

13. Statistical analysis performed?

Score:_______

0 - no statistical analysis
1 – inappropriate tests
2 – more appropriate tests could have been used (e.g., factor out more variation)
3 – Most appropriate tests used
Comments:

14. *Post hoc* power analysis?
Score:_______
0 - no *post hoc* power analysis
1 - *post hoc* power analysis performed
Comments:

15. BACI (before-after, control-impact) **analysis?**
Score:_______
0 – no BACI analysis
1 - before/after OR control/impact analysis performed
2 – before/after AND control/impact analysis performed
Comments:

16. Link physical habitat and biological response?
Score:_______
0 – no testing for linkage between physical habitat and biological response
1 – testing for linkage between physical habitat and biological response
Comments:

17. Test to discriminate between a short and long term effect?
Score:_______
0 – no testing of short or long term effect
1 – test short term but not long term
2- test long term
Comments:

General comments statistical analysis:

<u>Interpretation</u>

18. Statistical results interpreted correctly?
Score:_______
0-no interpretation of statistical results or no statistics preformed
1- incorrect interpretation of statistical results
2 - correct interpretation of statistical results
Comments:

19. Conclusions properly supported?
Score:_______
0 – no conclusions
1 – conclusions not properly supported by observations and statistical results
2 – conclusions properly supported by observations and statistical results

Comments:

20. Credible explanation of biological response?
Score:_______
0 – no explanation of biological response
1 – explanation not credible
2 – explanation credible
Comments:

21. Citations and synthesis of literature?
Score:_______
0 – no citations
1 – citations/synthesis insufficient (sparse number, only gray literature, poor synthesis)
2 – citations/synthesis sufficient (adequate number, include published literature, good synthesis)
Comments:

General comments interpretation:

General overall comments:

Appendix 3. Interview questionnaire for project sponsors.

MONITORING DESIGN

1. Do you as a local sponsor develop monitoring plans and review monitoring reports for submittal for agency approval or do you contract this work to consultants?

2. If you are involved with monitoring plan design, to what specific aspects (e.g. number and location of compliance and control sites, monitoring methods, communities evaluated, when and how often monitored, etc.) does your agency typically contribute input?

3. If you are involved with monitoring, what are your QA/QC procedures for data collection, entry, and analysis?

4. Are you as a local sponsor trained in experimental design and statistical analysis either by job qualifications or through on the job training?
    a. If not, do you feel this would be useful?
    b. Do you have an active training program within your agency that allows employees to become more experienced in statistical methods?

5. How is the involvement/opinion of the general public integrated into the program when developing a monitoring program? For instance, do you incorporate specific sites or methods requested by non-agency stakeholders?
    a. Is there a mechanism to receive and incorporate public comments into monitoring plans?
    b. Should stakeholders have a greater or lesser influence in program design?

6. To what extent is the development of monitoring plans adapted to fulfill regulatory requirements versus to perform ecological assessments?

7. Do you think there should be a difference in methods or protocols between monitoring of habitats such as nearshore hardbottom communities, offshore reef communities, and artificial reefs?
    a. If so, please describe how protocols should differ.

8. What are the major challenges in project monitoring (e.g. agency approval, time, design, cost, implementation) and why?
    a. What ideas do you have to address these challenges?

9. Is there any cost-benefit analysis conducted in association with monitoring program design?
    a. If not, should there be?
    b. Should there be a cap on the total cost of ecological monitoring?
    c. Are you concerned about the ecological effects if there are caps imposed?

10. Would it be helpful to specify the statistical analysis that will be required in the permit or monitoring plan?

11. As a local sponsor, which aspects of ecological monitoring do you feel are appropriate to evaluate project effects?

12. Are there elements of habitat characterization, condition documentation, and monitoring that are currently not required during the permitting process but in your opinion should be added (regardless of cost or other potentially limiting constraints)?

13. Are there elements of monitoring that can/should be removed or revised?

<u>ECOLOGICAL IMPACTS</u>

14. Would it be helpful to define the biological difference that will be determined to be an "impact" in the permit or monitoring plan?

15. Do you work in conjunction with other disciplines (e.g., biologists, surveyors, geologists, coastal engineers) in the evaluation of project-related impacts?
    a. Are biological monitoring results examined in conjunction with the physical monitoring results in the determination of project effects for the projects you sponsor?

16. If ecological impact is detected through monitoring, as a local sponsor what is your response?
    a. Is response dictated by the project permits and agency requirements, or do you have established internal policies?

<u>MONITORING REPORTS</u>

17. Is there a current system in place for tracking and housing monitoring reports?
    a. If so, how is this accomplished?

   b. If you think there is room for improvement, do you have any recommendations?

18. Would monitoring report standardization be helpful, and if so, what info would you like included?

19. If your monitoring reports are prepared by outside consultants, how often do you interface with their professionals during monitoring and report preparation?

20. How do you use/apply the monitoring results?
    a. Is there a feedback loop for application in future projects?

21. Do you review monitoring reports for content or compliance with approved monitoring plans and permits before they are submitted to the agencies?

22. In general, do you feel like monitoring reports provide you with the information you need to make decisions about the ecological impacts of coastal construction projects and the ability of mitigation to replace lost ecological services?
    a. If not, in the ideal world, what information do you need that is currently lacking?
    b. What are the obstacles to getting this information?

23. If you do not agree with the conclusions of the monitoring reports or think there is something incorrect with the analysis, is there any recourse available to you?

GENERAL QUESTIONS

24. What do you think is effective with the current system?

25. What about the system needs improvement?

26. What are the major obstacles to improving the system and any thoughts on how this can be accomplished?

27. Is there anything else I did not ask that you feel is important for improving the ability of future coastal construction project monitoring to detect environmental impact and to mitigate for those impacts?

Appendix 4. Interview questionnaire for consultant companies and universities.

MONITORING DESIGN

1. Are monitoring staff trained in experimental design and statistical analysis either through job qualifications or on the job training?
    a. What is the minimum training required for staff working on each of the following aspects of a monitoring project: project design, data collection, analysis of results?
    b. Do you have an active training program within your company that allows employees to become more experienced in statistical methods?

2. How are sampling designs formulated (decisions on number and location of control and compliance sites, when and how many times sites surveyed, methods used, number of quadrats, transect lengths, etc)?

3. How do monitoring methods/protocols differ based on specific types of projects (dredge, fill, artificial reefs, cable laying, etc)?

4. Does your company use differing monitoring protocols for different habitats (i.e. nearshore hardbottom communities, offshore reef communities, and artificial reefs)?

5. What are the major challenges in project monitoring (e.g. agency approval, time, design, cost, implementation) and why?
    a. What ideas do you have to address these challenges?

6. To what extent are monitoring plans developed to fulfill regulatory requirements versus to perform ecological assessments?

7. Is *a priori* testing of sample size conducted to determine if statistical tests will be powerful enough to detect changes/differences? If not, why?

8. When no differences are found from statistical testing, are power analysis tests performed? If not, why?

9. Are lessons learned from past projects applied in designing future projects? If so, please describe an example.

10. Are there elements of habitat characterization, condition documentation, and monitoring that are currently not required during the permitting

process but in your opinion should be added (regardless of cost or other potentially limiting constraints)?

11. Are there elements of monitoring that in your opinion can be removed or revised?

<u>ECOLOGOCAL IMACTS</u>

12. Do you work in conjunction with other disciplines (e.g. biologists, surveyors, geologists, coastal engineers) in the evaluation of project-related impacts?
    a. Are biological monitoring results examined in conjunction with the physical monitoring results in the determination of project effects for the projects you work on?

13. How does your firm report unanticipated or unauthorized impacts?

14. Do you have concerns about conflict of interest with monitoring contracts? For example if your firm reports a violation, do you feel the firm may be less marketable on future projects?

<u>MONITORING REPORTS</u>

15. Is there a current system in place for tracking and housing monitoring reports?
    a. If so, how is this accomplished?
    b. If you think there is room for improvement, do you have any recommendations?

16. What are your thoughts on monitoring report standardization?
    a. If you think this would be helpful, what info would you like included?

17. What are your QA/QC procedures for data collection, entry, and analysis?

18. Are statistics routinely used in evaluating impacts of construction activities?
    a. If so, are the hypotheses to be tested formulated prior to designing the monitoring plan?
    b. What statistical tests are typically used by your agency? If statistics are not used, why not?

GENERAL QUESTIONS

19. What do you think is effective with the current system?

20. What about the system needs improvement?

21. What are the major obstacles to improving the system and any thoughts on how this can be accomplished?

22. Is there anything else I did not ask that you feel is important for improving the ability of future coastal construction project monitoring to detect ecological impact and to mitigate for those impacts?

Appendix 5. Interview questionnaire for state and federal regulatory and resource trustee agencies.

CAPACITY AND JURISDICTION

1. Which of the following counties are in your jurisdiction for permit review: Martin, Palm Beach, Broward, Miami-Dade?

2. Which of the following stages of the monitoring process does your program review: baseline, pre-, during-, post-construction?

3. How many staff within your agency are assigned to approve monitoring plans and review monitoring reports of coastal construction activities in the region of Miami-Dade, Broward, Palm Beach, and Martin Counties?
    a. Do you feel this is enough? If not how many additional staff would be needed?

MONITORING DESIGN

4. How much training either by job qualifications or through on the job training do the reviewers within your agency have in experimental design and statistical analysis?
    a. If none or little and you feel this training would be useful, how much or what type of training do you feel is needed?
    b. Do you have an active training program within your agency that allows reviewers to become more experienced in statistical methods?

5. What specific aspects of the experimental design (e.g. number and location of compliance and control sites, monitoring methods, communities evaluated, when and how often monitored, etc.) of biological monitoring does your agency require, or is the design left to the expertise of those doing the monitoring?

6. Does your agency work with the project sponsor and/or other agencies to develop a monitoring plan that addresses your concerns and needs as a regulator?
    a. If not, would it be helpful if you were involved in the monitoring plan development phase of the regulatory process?

7. What other agencies, besides your own, are involved with permit/project review and under what circumstances?

   a. Describe how they have opportunities to provide input into planning of monitoring designs.
   b. Is this input always captured before a permit decision is made? Why or why not?

8. How is the involvement/opinion of the general public integrated into the program when developing a monitoring program? For instance, do agencies incorporate specific sites or methods requested by non-agency stakeholders?
   a. Is there a mechanism to incorporate public comments into permits or monitoring plans?
   b. Should stakeholders have a greater or lesser influence in program design?

9. Does your agency have standard monitoring protocols/methods that are required for specific types of permits (dredge, fill, artificial reefs, cable laying, etc)? If so what are they?

10. Are there differing monitoring protocols for different habitats (i.e. nearshore hardbottom communities, offshore reef communities, and artificial reefs)?

11. To what extent is the development of monitoring plans adapted to fulfill regulatory requirements versus to perform ecological assessments?

12. What type and level of statistical analysis is required for your agency to adequately evaluate the monitoring program results, and do you feel it is adequate?
    a. Would it be helpful to specify the statistical analyses that will be required in the permit or monitoring plan?

13. For required monitoring plans, is *a priori* testing of sample size conducted to determine if statistical tests will be powerful enough to detect changes/differences? If not, why?

14. What elements of habitat characterization, condition documentation, and monitoring design are currently not required during the permitting process but your agency thinks should be added (regardless of cost or other potentially limiting constraints)?

15. What elements of monitoring can/should be removed or revised?

ECOLOGICAL IMPACTS

16. Before the monitoring begins, do you define the biological difference that will be determined to be an "impact"?
    a. How do you make sure monitoring plans are designed to detect a biological difference that is big enough to be detected (i.e., the signal is louder than the noise)?
    b. Before the monitoring begins, do you lay out all possible outcomes and how they will be interpreted (i.e., as an impact or not as an impact)?

17. Based on your agency's guidelines, define short-term and long-term ecological impacts.
    a. If short-term or long-term ecological impact is detected through monitoring, what happens?
    b. Is there a difference in the outcome if it is a short term versus a long term effect?

18. Based on your agency's guidelines, define cumulative impacts.
    a. How do monitoring plans attempt to evaluate cumulative effects of repeated projects within the same project area?

19. What other disciplines (e.g. geologists, coastal engineers, biologists, surveyors, GIS, etc.) do you work with in the evaluation of project-related impacts?
    a. How are biological monitoring results examined in conjunction with the physical monitoring results in the determination of project effects?

MONITORING REPORTS

20. Is there a current system in place for tracking and housing monitoring reports?
    a. If so, how is this accomplished?
    b. If you think there is room for improvement, do you have any recommendations?

21. What are your thoughts on monitoring report standardization?
    a. If you think this would be helpful, what info would you like included?

22. How are monitoring reports reviewed for content or compliance with approved monitoring plans and project permits?

   a. How long after they are submitted is this compliance determination made?

23. How does your agency use/apply the monitoring results?
    a. Is there a feedback loop for application of historic results in the evaluation of future project proposals?

24. If you do not agree with the conclusions of the monitoring reports or think there is something incorrect with the analysis, what recourse is available to your agency?

25. What is your recourse for non-compliance of monitoring to approved monitoring plans?

26. In general, do you feel that monitoring reports provide your agency with the information needed to make decisions about the ecological impacts of coastal construction projects and the ability of mitigation to replace lost ecological services?
    a. If not, in the ideal world, what information do you need that is currently lacking?
    b. What are the obstacles to getting this information?

GENERAL QUESTIONS

27. What do you think is effective about the current system?

28. What about the system needs improvement?

29. What are the major obstacles to improving the system?
    a. How this can be accomplished?

30. Is there anything else I didn't ask that you feel is important for improving the ability of future coastal construction project monitoring to detect environmental impact and to mitigate for those impacts?

Appendix 6. List of people who participated in the interviews or filled out the questionnaires.

1. Federal Agencies
   - Jocelyn Karazsia (NOAA NMFS)
   - Jeff Howe (USFWS)
   - Chuck Kelso (USFWS)
   - Terri Jordan-Sellers (USACE)
   - Melody White (USACE)
   - Linda Knoeck (USACE)
   - Jose Rivera (USACE)

2. State Agencies
   - A. Florida Department of Environmental Protection (FDEP)
     - Vladimir Kosmynin (BBCS)
     - Martin Seeling (BBCS)
     - Lainie Edwards (BBCS)
     - Steve MacLeod (BBCS)
     - Jackie Larson (BBCS)
     - Benny Luedike (SED)
     - Jason Andreotta (SED)
     - Jennifer Smith (SED)
   - B. Florida Fish and Wildlife Conservation Commission (FWC)
     - Lisa Gregg
     - Keith Mille
     - Robbin Trindell
     - Erin McDevitt
     - Jeff Beal

4. Local Counties
   - Leanne Welch (Palm Beach County)
   - Paul Davis (Palm Beach County)
   - Carman Vare-Vernachi (Palm Beach County)
   - Kathy Fitzpatrick (Martin County)
   - Baret Barry (Martin County)
   - Ken Banks (Broward County)
   - Lou Fisher (Broward County)
   - Dave Stout (Broward County)
   - Pat Quinn (Broward County)
   - Eric Myers (Broward County)
   - Marissa Magrino (Broward County)
   - Brian Flynn (Miami-Dade County)

Chrissy Hopps (Miami-Dade County)
Sara Thanner (Miami-Dade County)

5. Consultants and Universities
Erin Hodel (CSA International)
Don Deis (PBS&J)
Martha Robbart (Dial Cordy)
Richard Spieler (Nova Southeastern University)
David Gilliam (Nova Southeastern University)
Jessica Craft (Coastal Planning & Engineering)
Stacey Prekel (Coastal Planning & Engineering)
Craig Kruempel (TetraTech)
Erin Hague (TetraTech)
Rob Baron (Coastal Ecogroup)
Angela Delaney (Coastal Ecogroup)
Christie Barrett (Coastal Systems International)
Penny Cutt (Coastal Systems International)
Dan Moretz (Coastal Systems International)

Appendix 7. Summary of answers to the interview questions.

CAPACITY AND JURISDICTION

Which of the following counties are in your jurisdiction for permit review: Martin, Palm Beach, Broward, Miami-Dade?

- USACE- Palm Beach Gardens Regulatory office reviews all but Miami-Dade County. Miami Regulatory office reviews Miami-Dade and Monroe counties.
- FDEP Bureau of Beaches and Coastal Systems (BBCS)- areas of regulatory purview are beaches, deep-water ports, and inlet dredging within all four counties.
- FDEP SE District (SED), FWC, USFWS and NMFS- all four counties.

Which of the following stages of the monitoring process does your program review: baseline, pre-, during-, post-construction?

Regulatory Agencies:

- USACE Permitting Section reviews baseline and pre-construction. USACE Enforcement Section reviews post-construction.
- FDEP BBCS- All stages are reviewed. Review scope of work for baseline survey to approve methods.
- FDEP SED- Permit processors review pre-construction baseline during the application phase. During construction and post-construction activities are reviewed by the Compliance Section.

Resource Trustee Agencies:

- FWC reviews pre-construction and/or baseline surveys for avoidance/minimization during project development. Imperiled species section reviews all monitoring reports.
- NMFS reviews pre-construction/baseline surveys during application review for avoidance/minimization. If high-profile project, then may review post-construction reports if alerted to potential impacts by other agencies.
- USFWS reviews pre-construction/baseline reports. Similar to NFMS, detailed review of during and post-construction monitoring performed during review of future permit applications.

How many staff within your agency are assigned to approve monitoring plans and review monitoring reports of coastal construction activities in the region of Miami-Dade, Broward, Palm Beach, and Martin counties? Is this enough? If not how many additional staff would be needed?

Regulatory Agencies:

- Sufficient staff to meet the USACE performance measure which is a 5% compliance of all reports. Palm Beach Gardens: Permitting (9), Enforcement: (1); Miami Enforcement (1).
- FDEPBBCS – one main reviewer; not sufficient. A second expert/reviewer is needed to review plans and reports. BBCS relies on experts from outside resource trustee agencies and independent consultants may be required for additional QA/QC review of some projects.
- FDEP SED – Sufficient staff to meet workload, 4 ERP and 2 in Water section.

Resource Trustee Agencies:

- Federal agencies generally do not have enough staff but collaborate and work with other agencies. NMFS: ½ Full Time Employee (FTE), need at least 2 FTEs; FWS: 1 FTE.
- FWC: 3 in Imperiled Species, 1 in Artificial Reefs, 4 in Fisheries; FWC has sufficient staff due to utilization of outside experts.

MONITORING DESIGN

Do local sponsors develop monitoring plans and review monitoring reports for submittal for agency approval or contract this work to consultants?

Sponsors:

- Some local sponsors develop their own monitoring plans and reports (e.g. Miami-Dade, Palm Beach); other local sponsors use consultants for all or some this work (e.g., Martin and Broward). All local sponsors review monitoring reports prior to submittal to regulatory agencies if prepared by outside consultants.

Is there any cost-benefit analysis conducted in association with monitoring program design? If not, should there be? Should there be a cap on the total cost of ecological monitoring? Are you concerned about the ecological effects if there are caps imposed?

Sponsors:

- Cost-benefit analysis for monitoring program design is not typically conducted. General agreement that cost-benefit analyses should be performed, but there is no appropriate method to conduct analysis. In an ideal world, no cap should be imposed, but in reality, monitoring is cost driven. Need to balance the costs of monitoring with goals of monitoring. At the federal level, cost-benefit analysis for storm protection benefits is performed, but not for monitoring program design. The Florida State Beach Management Working Group has suggested 10% of total project cost as reasonable percentage for monitoring. Sponsors generally agree that caps should not be imposed due to project-specific differences in scope/potential impacts/habitats.

Staff qualifications/ job training in experimental design/statistical analysis:

Sponsors:

- Masters of Science (MS) degree generally preferred but not required for new hires. Typically, those developing monitoring plans have MS degrees with academic training in statistics. Sponsors generally do not have in-house or on the job training. Statistics and GIS training for statistical design are needed; however, budget and funding control outside training opportunities.

Consultants:

- Academic training via MS degree is typically required. Workshops and external conferences (i.e., PRIMER), and on-job training with in-house monitoring methods is company dependent. In-house training is usually available for new hires, but dependent upon firm and job specific. Many firms do not have resources for active in-house training programs on statistical methods, but would implement them if economy improves.

Regulatory Agencies:

- New hire qualifications typically include a preference for a master's degree. In general, regulatory staff have had basic academic coursework in statistics. Active in-house statistical training programs may be available. Heavy statistical tools are not needed, and monitoring at the state level is for reasonable assurance. State employees have access to a tuition waiver program. Statistical software package/licenses are not readily available. Additional training must be cost effective and justified. In-house training by internal staff is an option if qualified staff available. At the federal level, no regulations are in place to specify sample size; burden is on applicant to provide the required information.

Resource Trustee Agencies:

- Some positions require a master's degree. Reviewers have a basic understanding of statistics, can access internal resources or get verification from independent sources or outside agency experts (e.g., Florida Fish and Wildlife Research Institute). In-house training generally not provided, but opportunities for training appear to be more available at the federal level in comparison to state. General agreement that more statistical training would be beneficial.

Sampling design &monitoring methodology development:

Sponsors:

- Local sponsors, FDEP, and consultants work together to contribute to monitoring plan design. Some sponsors design and implement their own plans. There are varying degrees of conflicts among sponsors in monitoring plan development when working with regulatory agencies with some perception of personal opinion/research interests by regulatory staff injected into decision-making.

Consultants:

- Sampling design and methodology are generally suggested by Principal Investigator/Project Manager and formulated in coordination with state and federal agencies. Design protocols may also be established during scope of work and/or baseline characterization when sample size is determined. *A priori* design of sample sizes and power analyses are performed by some consultants, particularly for recent projects, but general opinion is that statistical analyses are typically not adequate or understood by all parties. Type of project determines sampling design which often includes Before After Control Impact (BACI) protocol to detect change/impact and stratified random design.

Regulatory Agencies:

- USACE requires NMFS survey protocols for *Acropora* and *Halophila johnsonii*. Defers to NMFS for experimental design, and burden is on applicant to provide the required information for decision document.
- FDEP BBCS reviews draft monitoring plans and dictates timing and frequency of monitoring, and ultimately approves the plan. Stated that BACI is not applicable to beach nourishment projects in southeast Florida because there are no appropriate controls.

Resource Trustee Agencies:

- FWC Imperiled Species staff provide very specific guidance on sea turtle monitoring protocols, sample size, interspersion and randomization and conduct *post hoc* analyses. Work with sponsor and other regulatory agencies in monitoring plan development.

- FWC Fisheries dictate number and location of sites after applicant proposes draft plan. Work with project sponsors and consultants in plan development/revisions.
- FWC Artificial Reef (AR) program only requires physical surveys to verify stability. AR does not have to offset an impact, and no burden is placed on permittee to answer biological questions.
- NMFS & USFWS do not develop monitoring plans; review draft plans in concert with other state and federal agencies.

Any other agencies, besides your own, involved with permit/project review and under what circumstances do they have opportunities to provide input into planning:

Regulatory Agencies:

- USACE coordinates with NOAA NMFS, USFWS, and EPA. Public notice period is the opportunity for all agencies and general public to provide comments. USACE must have resource agency comments for decision document.
- FDEP circulates application and Requests for Additional Information (RAIs) to resource trustee agencies and consults with federal agencies for Biological Opinions on water dependent species. Coordinates with State Historic Preservation Office for historical resources and FWC for Endangered Species Act and consistency with the Coastal Zone Management Act. Consults with the U.S. Coast Guard (USCG) and NOAA for charting issues for artificial/mitigation reefs.

Resource Trustee Agencies:

- NMFS works with all regulatory and resource agencies, state and federal.
- USFWS consults with FWC and NOAA.
- FWC has website portal where agency lead and experts are assigned for project review. If consulted during application phase, FWC reviews project. After application is complete, FWC provides permit conditions to FDEP.

Level of stakeholder involvement in development of monitoring plan /permit:

Sponsors:

- All permits are advertised and public comments are received during noticing period. Typically, sites of public concern are considered and may be incorporated into monitoring plan. Sponsors generally only coordinate with agencies in monitoring program development. Level of stakeholder involvement is appropriate.

Regulatory Agencies:

- Level of stakeholder involvement is appropriate. Public interest is important, and comments must be included in decision document but not in monitoring plan.
- State advertises notice of permit application and intent to issue permit. There is no notice of monitoring proposal, and FDEP does not typically incorporate methods suggested by stakeholders. If a location is provided by public comments as an avoidance measure, it will be considered for potential impacts.

Resource Trustee Agencies:

- Stakeholder, local expert, and academic comments are welcomed. All agree that stakeholder influence is appropriate.

Are monitoring requirements/methodology specific to permit/project/habitat:

Sponsors:

- Habitats are different; methods cannot be universally applied. Physical habitat conditions limit standard application of methods.

Consultants:

- It depends on the type of project, goals, location, and agency concerns. Different monitoring protocols are used for different habitats/physical conditions (e.g., Benthic Ecological Assessment for Marginal Reefs (BEAMR) for less-developed nearshore hardbottom communities and artificial reefs and Atlantic and Gulf Rapid Reef Assessment (AGRRA) for more complex offshore reef communities). Written documentation from agencies is required to approve any change in methods in monitoring plans.

Regulatory Agencies:

- USACE – only standard monitoring protocol is frac-out plan (i.e., rupture of drilling mud) for fiber-optic cable installation projects using horizontal directional drilling. USACE relies on NMFS for monitoring protocols.
- FDEP attempts to have standard monitoring protocols, but project needs are often specific. FDEPBBCS is currently developing biological monitoring guidelines for beach nourishment projects. FDEP has standard monitoring conditions/Best Management Practices (BMPs) for fiber-optic cable installation projects.

Resource Trustee Agencies:

- FWC uses standard deep water coral and coral transplantation protocols. Currently developing standard methods for marine surveys. Outer Continental Shelf Program is used for offshore survey methods. Ultimately, burden is on applicant to provide required information to determine effects on fish and wildlife resources.
- USFWS has standard monitoring protocols available on website.
- NMFS has standard seagrass survey protocols. Uses FWC deep water coral protocols and FDEP BMPs for frac-out monitoring for fiber-optic cable projects.

Major challenges/suggestions in project monitoring:

Sponsors:

- Funding and insufficient staff are limiting factors. Monitoring is required by permits but no funding to pay for it. In-house monitoring may help control costs.
- Monitoring needs to become more cost effective. Adjacent counties should work together and conduct workshops to discuss findings.
- There should be recommendations for future monitoring in reports. Lessons learned from project monitoring should be applied during future projects. Monitoring results are not being used in future projects.
- State agencies appear to be micro-managing details of monitoring. Need to clearly identify the goals of monitoring and possible results during plan development.
- Need to agree on data interpretation and thresholds and define purpose of monitoring in permit conditions.
- Statistically valid analyses may not be necessary. More reasonable and standardized monitoring is needed.
- Increase pre-project monitoring events to identify natural variability/conditions. Need funding to establish nearshore hardbottom program with permanent sites to determine natural variability.

Consultants:

- Funding limits monitoring plan design. Lack of time and funding for multiple pre-construction monitoring events.
- Beach projects have extremely aggressive turn-around times for data analyses and reporting, often 60-90 days after completion of fieldwork. This deadline becomes very challenging, and compromises reporting products. Need to extend report deadlines in standard permit conditions.
- Lack of sampling design. Most monitoring is fairly meaningless without *a priori* knowledge of what you want to determine from the project (i.e.,

goals, hypotheses). It is critical to design monitoring around goals; otherwise, the results are useless.
- Agency approval is problematic as permit regulations limit project design. The ability of permit processors at regulatory agencies to review monitoring plans varies widely, and agency personnel are not in tune with the financial constraints of monitoring. We need to incorporate agency "wish lists" and create a balance between what the client is able to pay for versus reasonable monitoring parameters and what monitoring will provide.
- Monitoring results should make recommendations for future projects. A "Lessons Learned" document should be a requirement of every monitoring program. There should be more emphasis in getting the information in peer reviewed literature so that the science community can review and build upon it.

Are monitoring plans developed to fulfill regulatory requirements versus ecological assessments?

Sponsors:
- Monitoring plans fulfill regulatory requirements, but are balanced with ecological assessments as appropriate. Internal funding cannot be used for research. If program is funded externally, can pursue research for ecological assessment. Budget constraints limit ecological assessments.

Consultants:
- Both have entirely different goals. Assessments are completed prior to monitoring. Research is not part of the monitoring protocol.
- There should be no difference between the two; however, some monitoring only minimally fulfills regulatory requirements. Because scientists are not driving project design, monitoring and assessing ecological impacts are often secondary.

Regulatory Agencies:
- USACE- all monitoring plans must meet regulatory requirements (no net loss of habitat).
- Goal of monitoring is to provide reasonable assurance; is change attributed to the project? Monitoring is not research. Agencies are aware of inadequate sample size/frequency of monitoring. Plans are designed to meet regulatory requirements.

Resource Trustee Agencies:
- All recommended monitoring is to fulfill regulatory requirements for minimization of impacts to threatened and endangered wildlife. Both are

tied together, and if able, try to incorporate research into plan for future mitigation tools. Monitoring provides minimum amount of data needed to evaluate project related effects.

What type and level of statistical analysis is required to adequately evaluate the monitoring program results? Should it be specified in the permit or monitoring plan?

Sponsors:

- Differing views from sponsors- some sponsors believe that it would not be helpful to specify in permit as any change would require permit modification and increase paperwork. Need flexibility.
- Some sponsors think statistical methods should be specified in monitoring plan- need to decide how to analyze the data before they are collected.
- Data can be examined from different perspectives. Sponsors and agencies should accept responsibility for data if collected according to approved plan.

Regulatory Agencies:

- USACE defers to NMFS for detailed statistical analyses. USACE does not require statistical analyses to determine functional loss versus functional gain.
- FDEP- State standard is reasonable assurance, particular statistical analyses are not required but may be helpful to specify in the monitoring plan. Standard permit language is "appropriate statistical analyses shall be applied."

Resource Trustee Agencies:

- Statistical analyses are descriptive not rigorous; surveys are developed to provide information to feed into UMAM, which only uses qualitative information and targets areas to avoid/minimize based on habitat classification/high quality resource areas.
- A discussion of *a priori* and *post hoc* methods would be useful. Designation of appropriate controls and replicates is typically not possible; lack of replication, repeated measures, and pseudoreplication are typical. Serious lack of understanding of difference between parametric and nonparametric methods.
- Monitoring plans should define statistical analyses, target monitoring to get information for future projects, and feed results into predictive models. Purpose is to eliminate uncertainty but is subjective as how much uncertainty is acceptable for assurance. A level of rigor balanced against certainty is needed to demonstrate impact/no impact.

For required monitoring plans, is *a priori* testing of sample size conducted to determine if statistical tests will be powerful enough to detect changes/ differences? If not, why?

Consultants:

- It is project dependent. Results of previous projects can help pre-determine sample size.
- Agencies have not sought this level of statistical significance in previous monitoring plans. Agencies specify the length and number of transects which are not based on a statistically appropriate sample size.
- Often difficult to obtain sufficient sample size because cost driven. *Post hoc* power analysis becomes useful when variation is high.

Regulatory Agencies:

- Some recent projects consider sample size, transect locations, and thresholds which would be required to detect change. Overall concern that we are under sampling but restricted by cost/funding.

Resource Trustee Agencies:

- Some agencies require a minimum percentage of the project area to be sampled and place burden/cost on sponsor/applicant.
- Federal agencies are often challenged on what is compliance monitoring versus what is research. Usually cannot achieve National Environmental Policy Act (NEPA) compliance or afford to monitor/mitigate based on Council on Environmental Quality (CEQ) Guidance.
- Size of project, scale of impact, how much money, and political pressure often define sample size.

When no differences are found from statistical testing, are power analysis tests performed? If not, why?

Consultants:

- Some consultants answered affirmatively with caveat that whether it is understood or appreciated is questionable.
- Some consultants indicated that it was dependent upon whether a baseline characterization or pilot study was performed, and typically power analyses are not performed.

Are lessons learned from past projects applied in designing future projects? If so, please describe an example.

Consultants:

- Yes. If a monitoring parameter doesn't provide useful data, submit request to discontinue to agencies. Most frequently cited example was Point Count analysis of video transect data in nearshore- consensus that *in situ* data provide higher resolution.
- Increase frequency of sediment monitoring; sediment data have indicated need to extend cross-shore transect lengths.
- Lessons learned document should be a requirement of every monitoring program.

As a local sponsor, which aspects of ecological monitoring do you feel are appropriate to evaluate project effects?

Sponsors:

- Benthic community surveys are important. Need to evaluate cumulative effects on nearshore reefs. Fish surveys are not high priority.
- Sediment traps at borrow sites are not needed. Depth measurements and line intercept work better than traps.
- Some sponsors feel that diver visual assessments at borrow sites is best method for evaluating construction related impacts; quantitative protocols may not be necessary.
- Turbidity monitoring is required but Nephelometric Turbidity Units (NTUs) are not adequate to monitor turbidity; need additional water quality monitoring. Turbidity mixing zones should be resource based.
- Sea turtle nesting: we know that turtles avoid newly nourished beaches- is continued monitoring needed? May be better to redirect funds to turtle friendly design and monitor effects.
- Redirect funding to analyze and synthesize data that have been collected rather than continue monitoring same parameters.
- Database of all monitoring data in southeast Florida is needed.
- Increase physical environmental parameters- water quality, sedimentation, turbidity, temperature, and wave energy.

Elements of habitat characterization, condition documentation, and monitoring that are currently not required during the permitting process but in your opinion should be added (regardless of cost or other potentially limiting constraints)?

Sponsors:

- Increase survey area and pre-construction background data to capture natural variability in sedimentation rates.
- Physical habitat monitoring and nearshore reef mapping with Light Detection and Ranging (LIDAR) elevations.
- Water quality monitoring: install optical backscatter - need continuous record.
- Event response (e.g., storm event) monitoring is not frequent enough to capture natural variability versus impact.
- Ecosystem based monitoring should include sand as habitat.
- Increase the number of surveys for distribution of nearshore juvenile turtles in nearshore.

Consultants:

- Planning process should be expanded to increase knowledge and minimize impacts.
- Preconstruction baseline monitoring should address seasonality.
- Consistent method to sample sediment is needed for dredge and fill projects.
- Increase ecosystem based monitoring. Monitoring is based on current public interest including fisheries and reef builders, turtle food and macroalgae. Extensive research is necessary to determine additional indicator species.
- Large focus on benthic communities and corals even when they are not the dominant biota. Increase fish monitoring. Must be extra vigilant for all Endangered Species Act (ESA) listed species.

Regulatory Agencies:

- Extend frequency and duration of monitoring beyond 3 years to life of project. However, federal authorization only allows for 5 years of monitoring.
- Consider permanent monitoring sites versus project specific in some cases.
- Increase sample size and include additional parameters (e.g., juvenile fish) to evaluate secondary effects and/or physiological impacts.
- Look at species indicators by percent cover to investigate impact.
- No adequate control sites for beach nourishment projects in southeast Florida.

Resource Trustee Agencies:

- Need more quantitative data to characterize habitats.
- *A priori* decision making including minimum sample size and percentage of project area to be surveyed.
- Final summary of all projects with lessons learned, methods, techniques, success of mitigation.
- Pre-project monitoring for turtles.
- Include population connectivity analysis in condition documentation. Soft-bottom community connectivity to hardbottom community.

Monitoring elements that can be removed or revised?

Sponsors:

- Some sponsors indicated that they don't know which monitoring elements can be revised because data have not been synthesized.
- Numerical values/thresholds for sedimentation/coral stress during dredging: visual diver assessments are appropriate; quantitative assessments may not be needed.
- Sediment trays adjacent to borrow sites do not work; line intercept method is better.
- Essential Fish Habitat definition is over-evaluated; value of nearshore hardbottom is debatable.
- State turbidity standard of 29 NTU should be re-evaluated.
- Sacrifice community data for more frequent event response/sedimentation monitoring.
- Personal bias/research interests should be eliminated from decision-making.

Consultants:

- General opinion that point-counting of video transects for nearshore hardbottom habitats is not necessary: too time intensive, and level of detail is not high enough for impact analysis. *In situ* assessments yield more detail.
- Point Count can provide certain details that *in situ* cannot, but must have clear images and sufficient number of frames.
- Annual hardbottom edge mapping and sediment line-intercept monitoring must be done at the same time of year. Valid controls do not exist for nourishment projects; thus, increase frequency of pre-construction monitoring surveys to determine background conditions/variability.
- Inter-observer variability is a challenge.

Regulatory Agencies:

- Remove conditions that do not provide useful information necessary to make an assessment.

Resource Trustee Agencies:

- Funding should be focused on mitigation aspect with rigorous statistics on mitigation success.
- Remove personal opinion from monitoring reports. Applicants should provide conclusions and summary based on data and without bias.
- Uniform Mitigation Assessment Method (UMAM) qualitative/descriptive information is for mitigation assessments. Need more quantitative information for evaluation.
- Proper speeds and types of cameras should be specified for towed video surveys.
- Remove offshore monitoring of fish and snorkel as a method for fish species monitoring.
- Need scientific basis for buffer distances.
- Turbidity monitoring should include *in situ* meters and dissolved oxygen.
- Coral stress monitoring can't be applied directly; needs revision.

ECOLOGICAL IMPACTS

Before the monitoring begins, do you define the biological difference that will be determined to be an "impact"? How do you make sure monitoring plans are designed to detect a biological difference that is big enough to be detected (i.e. the signal is louder than the noise)? Before the monitoring begins, do you lay out all possible outcomes and how they will be interpreted (i.e. as an impact or not as an impact)? Would it be helpful to define the biological difference that will be determined to be an "impact" in the permit or monitoring plan?

Sponsors:

- Yes; general agreement that it would be helpful to define, but are concerned if it is possible. What percentage of decline is considered to be an impact, and can change be attributed to project versus natural variability? It is critical to choose parameters, thresholds, goals, and define primary impacts and permanent burial in relation to cross-shore fill adjustment and secondary impacts due to sand cover.

Regulatory Agencies:

- USACE often defines certain levels/thresholds in permit conditions for target species (e.g., corals).

- Impact should be defined before permit is issued, and monitoring plan should be able to detect it. Impacts are not laid out as hypotheses in permit conditions.
- Define impacts as difference in cover of main functional groups and correlate with increases in sand cover/duration of sand cover to determine community change and detect impact. If the number of pre-construction events is increased to document variability, then number of post-construction events must be increased. Thresholds for impact evaluation are not typically established in permit conditions.

Resource Trustee Agencies:

- Need more upfront consideration of interpretation of monitoring results, sample size, and *a priori* decision making.
- Usually project and species specific where criteria are based on detecting some sort of impact, especially during construction as this triggers agency notification.
- FWC Imperiled Species uses baseline information for sea turtle nesting from outside impact areas.

If short-term or long-term ecological impact is detected through monitoring, what happens? Based on your guidelines, define short-term and long-term ecological impacts. Is there a difference in the outcome if it is a short term versus a long-term effect?

Sponsors:

- Impacts dictated by permit conditions. Dredge will shut down if impact is recorded during construction. Unanticipated impacts from pipeline rupture require an impact evaluation for sand deposition on reef.
- During active dredging, dredge can be moved to avoid turbidity violations/impacts. Dredge corridors must be enforced and tracked by differential global position system (DGPS).
- Bi-weekly meetings held with contractor to discuss construction monitoring results.
- Depends on project. If long-term impact, may be able to adjust project design or sand specifications.
- Notification of violation is a standard condition in permit; however, regulators are often not notified directly about dredging impacts.

Regulatory Agencies:

- No difference between short-term versus long-term impacts. If impact is not permitted, then compliance and enforcement is initiated. Only difference is time lag.

- Current condition is shifting baseline, so no adequate characterization of pre-impact state, only long-term ecological impacts of beach projects in southeast Florida. If ephemeral community, then look at periodicity of exposure and cover by calcareous algae. If hardbottom is re-exposed without community mortality, then no permanent impact. If hardbottom is no longer exposed, then permanent impact.
- Not able to assess short-term (< 1 year) due to one year periodicity in monitoring. Mitigation requirements are reviewed differently for short-term temporary impacts. Short-term versus long-term impact requires different application in UMAM assessment to identify changes in community composition over time. Amount of additional mitigation from long-term impacts is different if permanent or net loss of habitats, but detecting long-term impacts is problematic.

Resource Trustee Agencies:

- Indirect impacts have a different temporal scale and do not imply severity of impact. Monitoring is not adequate to detect sublethal effects to corals and fishery resources; greater emphasis should be on assessing sublethal effects. Recommend offset of temporal loss through compensatory mitigation.
- Difficult to directly attribute long-term turbidity to project versus noise.
- FWC Imperiled Species- methods are recommended to minimize impacts, including working with project designers and engineers. Difference between short and long-term effects in turtle nesting is evaluated.
- FWC Fisheries do not review post-construction monitoring, therefore, not assessing impacts. Short-term impacts are within a 3 to 5 year timeframe.
- USFWS reviews direct and indirect impact under the ESA.
- FWC considers if mitigation was required and mitigation success. Contingency mitigation plans are required.

Based on your agency's guidelines, define cumulative impacts. How do monitoring plans attempt to evaluate cumulative effects of repeated projects within the same project area?

Regulatory Agencies:

- Cumulative effects are defined in the USACE regulations- review of past, present, and reasonably foreseeable effects.
- FDEP BBCS- any impact not offset by mitigation is cumulative. If mitigation is performed, then offsetting lost functions. State acknowledges that monitoring plans don't cover all parameters, act within framework of collected data; we are not able to compensate for all impacts.
- FDEP SED - definition of cumulative effects in basis of review; has denied projects based on cumulative effects.

Resource Trustee Agencies:

- NMFS uses CEQ guidelines for cumulative effects under NEPA.
- USFWS uses Code of Federal Regulations (CFR) definition of cumulative effects for Section 7 ESA.
- FWC uses cumulative impacts defined in Aquatic Preserve rule.
- FWC Imperiled Species review does not allow for assessment of cumulative impacts. Monitoring plans do not attempt to evaluate cumulative effects of repeated projects within the same project area.
- FDEP&FWC cannot use federal definition of cumulative impacts.

Do you work in conjunction with other disciplines (e.g., biologists, surveyors, geologists, coastal engineers) in the evaluation of project-related impacts? Are biological monitoring results examined in conjunction with the physical monitoring results in the determination of project effects for the projects you work on?

Sponsors:

- In general, multi-disciplinary approach is used but needs improvement. Turbidity monitoring is reviewed in context with biological and sedimentation data. Biological data are tied into physical monitoring around borrow site.
- In some cases, impacts are determined only by biologists.

Consultants:

- Biological and physical data are often examined together. Data can be analyzed both spatially and temporally in a well-maintained geospatial database.
- Example of collaborative analysis is nearshore hardbottom edge mapping. Biologists map the edge of hardbottom in the field, which is then compared to the physical monitoring results.

Regulatory Agencies:

- USACE contains all disciplines and tries to conduct a multidisciplinary and coordinated review. However, physical and biological reports are not reviewed together.
- FDEP biologists review the physical monitoring results in conjunction with biological community and evaluate cross-shore adjustment of beach fill; however, scale of physical data is too coarse.

Resource Trustee Agencies:

- All involved in project review. Coastal engineers help to assess fill spreading effects.

- FWS has in-house GIS capability but relies on outside experts/volunteers as there are no in-house hydrologists/engineers.
- FWC Fisheries reviews only biological data and consult outside and internal agency experts from other disciplines during project review.
- FWC Imperiled Species reviews project performance and equilibration and consults coastal engineers and GIS professionals.
- NMFS defers to FDEP BBCS coastal geologists for compatibility of fill material as they have no in house geologist. NMFS also uses experts at other agencies including the USACE engineering research group.

How does your firm report unanticipated or unauthorized impacts?

Consultants:

- Impacts are evaluated in the monitoring reports. The monitoring plan specifies the agency notification process for unauthorized impacts during project construction. A contingency mitigation plan is used if unauthorized impacts occur. Usually report impacts via email or letter report. Permitee/Client is notified first, then FDEP following the permit protocol. Transparency is crucial.

Do you have concerns about conflict of interest with monitoring contracts? If your firm reports a violation, do you feel the firm may be less marketable on future projects?

Consultants:

- Some consultants expressed no concern about conflict of interest/ marketability. Some indicated that it depends on client. A few suggested that it may affect marketability. All agreed that ethics must prevail.

MONITORING REPORTS

Is there a current system in place for tracking and housing monitoring reports?

Sponsors:

- Most responded affirmatively; however, historical information is virtually impossible to locate. Need statewide database/website which contains all monitoring reports and report summaries.

Consultants:

- Electronic format/databases appear to be the current standard.

Regulatory Agencies:

- USACE –database for report records; no compliance tracking database.

- FDEP-BBCS has a library for hard copies of biological and physical monitoring reports and has recently required submittal of reports in electronic format (PDF). There is no official library of electronic reports; reports are saved in project permit folders on internal server. Compliance officer checks reports into the Beaches and Coastal Management System (BCMS) compliance database.

Resource Trustee Agencies:
- Most agencies have an internal database for tracking reports; dedicated email addresses for monitoring report submittal.

What are your thoughts on monitoring report standardization and what would be helpful?

Sponsors:
- All projects are different, so standardization would prove difficult. Template of basic sections, background, and permit numbers would be appropriate.
- A summary report of permitted activity, what was constructed, and summary of monitoring, and mitigation required would be useful.
- Recommend a menu of monitoring protocol with minimum level of applicable monitoring methods. Standard format is not achievable.

Consultants:
- The general process can be standardized to some extent; however, there needs to be flexibility because projects are different. Reports are generally too long and need to be more concise and clearly address objectives; template and/or standard format would help. Regulatory agencies need to communicate report requirements, and more agency feedback is needed after reports are submitted. Federal and state agencies have different requirements, so standardization would be difficult.

Regulatory Agencies:
- Report format is already standardized. Standardization is not always appropriate since all projects are different. Reports should include a title page, recommended citation, keywords and standard terminology to improve tracking.

Resource Trustee Agencies:
- A minimum amount of information is required. A template that presents all minimum information, reporting protocols, and GPS references would be helpful.

If your monitoring reports are prepared by outside consultants, how often do you interface with their professionals during monitoring and report preparation?

Sponsors:

- High level of communication occurs during scope development. Daily reports are typically required during project construction. Monitoring reports are reviewed before submittal to the agencies. If problems occur, more frequent interface with consultants. Meetings with consultants to review monitoring data prior to draft report preparation would be beneficial (collaborative review of raw data). Sponsors have limited staff time to review reports in detail; only time to review one draft report in detail.

Are monitoring reports reviewed for content or compliance with approved monitoring plans and project permits before agency submittal? How long after they are submitted is this compliance determination made?

Sponsors:

- All sponsors answered affirmatively; report reviews ensure that all data have been provided to agencies according to monitoring plan and permit requirements.

Regulatory Agencies:

- USACE has a 5-year window to review projects, and they may only review the Year 5 report. If Year 5 is not compliant, it may trigger review of previous reports. Only 5% of monitoring reports are required to be reviewed for compliance with permit conditions. If a new application is received, previous projects may be reviewed for compliance. State compliance action may trigger compliance check.
- FDEP SED - submits report to compliance staff who may conduct inspection for confirmation; typically compliance and enforcement(C&E) is within 30 days but can go on for 3 to 5 years.
- FDEP BBCS - performs cursory review for compliance with permit after receipt. No time for immediate detailed review due to limited staff. Depends on project; review may not occur for 1 to 3 years or in conjunction with future permit requests.

Resource Trustee Agencies:

- NMFS does not have compliance or enforcement authority but shares information with regulatory agencies. Reviews only up-front portion of project during permitting. No review of post-construction reports unless project is high profile.

- USFWS does not have compliance officers and only reviews post-construction monitoring reports in conjunction with review of new permit application.
- FWC Imperiled Species varies from a month until next request for sand placement in a particular project area.
- FWC Fisheries does not typically review post-construction monitoring reports.

How are the monitoring results used/applied? Is there a feedback loop for application of historic results in the evaluation of future project proposals?

Sponsors:

- Some sponsors indicated that no feedback loop exists. Monitoring results are not used to improve effectiveness of monitoring, and effects of adjacent projects are not considered.
- Several sponsors suggested a forum/workshop where consultants and sponsors could meet and disseminate the results of their projects.
- Some sponsors indicated that the results of previous projects are used in the design/development of future projects for avoidance/minimization of potential impacts.
- Some sentiment that the regulatory agencies need to be held to commitments and monitoring results (e.g., if monitoring results indicate that buffer distance is appropriate to protect adjacent communities, results should be used in future projects).

Regulatory Agencies:

- USACE and FDEP- If new application is received, applicant must be in compliance with any previous permits. Any new action triggers a compliance check.
- FDEP BBCS –Uses database to enter the receipt of monitoring reports; however, no database exists for summary of monitoring report results/methods. Uses monitoring results to consider modifications of future projects to minimize impacts (e.g., transect lengths, fill volumes, more intensive monitoring needs).

Resource Trustee Agencies:

- FWC Artificial Reefs uses monitoring results to adjust/improve future artificial reef construction projects, as references in environmental assessments, and support of grant applications for future funding.
- NMFS, USFWS and FWC all use monitoring results from previous projects when reviewing future projects.

If you do not agree with the conclusions of the monitoring reports or think there is something incorrect with the analysis, what recourse is available to your agency?

Sponsors:

- Generally agree with monitoring data/results.
- Usually sponsors and consultants communicate during review of draft report to reach agreement. Any mistakes in report are corrected during review. Inconsistencies in data/conclusions are reviewed for consistency with scope. Can withhold retainer until final deliverable is approved. If contract does not specify the final deliverable in detail, then no recourse is available.

Regulatory Agencies:

- Coordinate with permittee to ensure impacts are well documented.
- State will interpret the data and make their own conclusions. If conclusions do not meet permit conditions, contingency mitigation is required, and fines can be imposed. State has opportunity to pursue additional mitigation if applicant is not compliant at the time of application for next permit.

Resource Trustee Agencies:

- FWC Imperiled Species conducts their own data analyses for turtle nesting data.
- FWC Artificial Reefs withholds reimbursement/payment unless the methods/analyses are corrected in the final report to the satisfaction of the agency.
- NMFS defers to the USACE initially for compliance.
- USFWS has authority only if incidental take is exceeded under the ESA; otherwise, defers to USACE for compliance.

What is your recourse for non-compliance of monitoring to approved monitoring plans?

Regulatory Agencies:

- USACE issues a Notice of Non Compliance and administrative penalties may be assessed.
- FDEP can issue Warning Letter and/or Notice of Violation. State can withhold future permit, and C&E can issue fines to contractors. State can withhold cost-share payment only if determination is made within 30 days. No formal system in place for tracking compliance with monitoring plans.

Resource Trustee Agencies:

- FWC Artificial Reefs can withhold payment for non compliance.
- USFWS will refer project to enforcement if required incidental take monitoring is not being conducted.
- NMFS defers to FDEP and USACE to enforce compliance.

What are your QA/QC procedures for data collection, entry, and analysis?

Sponsors:

- It depends. Some check for inter-observer variability. Data are entered by one person, and then checked by others for accuracy/consistency. Reports are only proof-read; data and statistical analyses are not checked. Some sponsors have no QA/QC procedures and leave it up to the consultants.

Consultants:

- Multiple people review the data and perform a comparison of intra-observer variability in the field and during Point Count analyses. It is a function of costs, number of staff, and training purposes. All staff collecting data must meet FDEP qualifications.
- For data collection, conduct replicate quadrat sampling in order to analyze and reduce inter-observer error. A senior scientist reviews all data analyses and monitoring reports to ensure quality control.

Are statistics routinely used in evaluating impacts of construction activities? If so, are the hypotheses to be tested formulated prior to designing the monitoring plan? What statistical tests are typically used? If statistics are not used, why not?

Consultants:

- Most consultants are using statistics to evaluate impacts and attempt to develop programs based on statistical design. Some suggested that the BACI design should be used in every "new and different" project. Hypotheses to be tested are generally formulated prior to design. Typical parameters/statistical tests include percent cover, ANOVA, diversity indices, evenness, and non-parametric statistics using PRIMER and/or SAS such as Bray-Curtis similarity matrix, MDS ordinations, CLUSTER analysis, and ANOSIM.

In general, do monitoring reports provide the information needed to make decisions about the ecological impacts of coastal construction projects and the ability of mitigation to replace lost ecological services? If not, in the ideal world, what information do you need that is currently lacking? What are the obstacles to getting this information?

Sponsors:

- In general, reef monitoring can detect ecological impacts; however, mitigation monitoring is not sufficient. Ecological assessments to determine the replacement value of mitigation reefs are not typically performed.
- There are no permit conditions which require mitigation to be successful. Enforcement action should include detailed monitoring of mitigation.
- Some impacts cannot be mitigated. UMAM was not designed to evaluate reef/hardbottom communities.
- Difficulty in variability of nearshore habitats; how to compare the value of one habitat to another? How do you measure value if you don't know value before impact?
- Lack of valid controls and time/funding constraints for multiple pre-construction monitoring events are main obstacles. Need research to review and synthesize all project monitoring results.
- Need agreement among all parties on the definition of ecological impact.

Regulatory Agencies:

- Monitoring reports generally provide the information needed to make decisions. If there is no evidence that mitigation is not working, FDEP must assume that it is working. A study on the functions of nearshore hardbottom has been funded by the State and is currently underway; this study may provide information that is lacking for replacement of nearshore hardbottom functions. Political issues and funding are obstacles to collecting more robust data.

Resource Trustee Agencies:

- Staff have been proactive in developing specific monitoring and data submittal protocols. Obstacles include institutional differences in agency opinion resulting in differences in definition/purpose of monitoring. Need a prioritized list of research questions.
- Need standardized artificial reefs with fishing restrictions.
- No data provided to determine mitigation success and does not link mitigation to lost ecological services.

GENERAL QUESTIONS

What do you think is effective with the current system?

Sponsors:

- Communication and relationships with agencies are effective as long-term staff have been involved in these projects and are dedicated to their responsibilities. Protection of nearshore resources has improved over the past 25 years. We are recently utilizing monitoring results to design less impactive projects.

Consultants:

- There have been improvements in project design and monitoring during past 10 years. Mitigation can offset some impacts if done appropriately.
- Coordination and communication lines with agencies are effective.
- The willingness for self analysis (e.g., MICCI, this project).

Regulatory Agencies:

- The system works reasonably well to meet existing regulatory requirements.

Resource Trustee Agencies:

- Baseline monitoring and agency communication/coordination of reviews is done well.

What about the system needs improvement?

Sponsors:

- Agencies need to review monitoring objectives and clearly define what needs to be assessed.
- Lessons learned from previous monitoring results must be considered.
- Funding is a major obstacle to continued monitoring.
- Need more project comparisons from adjacent counties. Meetings and/or workshops with adjacent counties to discuss their monitoring results/ lessons learned would be very beneficial.
- Cross-training and sharing information between agency staff and local sponsors. Local sponsors should be viewed as partners, not adversaries. Include an outside facilitator to understand motivations of all interested parties.
- Need to depoliticize decision making.
- Agencies need to be more open to alternative mitigation strategies, opportunities to pursue water quality improvements in lieu of "like-for-like" mitigation.

- Watershed approach to assessing cumulative impacts; regional, long-term water quality monitoring data are needed.

Consultants:

- Lack of consistency and established protocols on cause/effects relationships. Regulators need better training to understand projects and impacts.
- Need more standardized approach to reporting; less influence in personal relationships with agency staff for reporting styles.
- Increase science-driven and adaptive management approach.
- Minimal approach to monitoring for compliance with permit conditions; monitoring is checklist and does not evaluate the big picture.
- High agency staff turnover creates problems in monitoring program review.

Regulatory Agencies:

- Need quicker response time for review; additional staff are needed for report review.
- Monitoring data should not be filtered by applicants and/or engineers during impact evaluation.
- Conflict of interest in current system; applicant is given the responsibility of providing impact analysis for own project.
- Need field QA/QC by agency staff and statistical verification of monitoring data.
- Need to increase the sample size and the amount of baseline data in potential impact areas.
- Increase the ability to assess fines on the enforcement side.

Resource Trustee Agencies:

- Increase funding for monitoring programs.
- Create prioritized list of research questions.
- Increase compliance/enforcement staff. Each agency needs a repository for easy access and tracking of monitoring reports.
- Establish a code of ethics to be adopted by all parties to alleviate concerns for conflicts of interest.
- Increase the minimum requirements of individuals performing the monitoring. Graduate students could be used for summarizing data from monitoring reports.
- Prioritize conservation objectives so that monitoring is structured to meet objectives.
- Improve relationships with USACE Planning Division as agency comments are not always incorporated into monitoring plans.

- Increase communication and transparency between all parties.

What are the major obstacles to improving the system and any thoughts on how this can be accomplished?

Sponsors:

- Time, funding, staff.
- Too much red tape involved in obtaining permits.
- System is over-regulated, and state regulators are not looking at the big picture. Reviews are performed according to checklist of required items.
- If project has net benefit to environment, it should be examined differently from projects with adverse impacts (e.g., tire removal from reef areas).
- Regulatory obstructionists can prevent permit issuance for personal agenda.
- Final section of reports should include lessons learned and recommendations.

Consultants:

- Obstacles include funding and justification for monitoring.
- Economic climate is reducing potential impacts of projects; proposed impacts are not similar to past projects.
- Need lessons learned workshop to discuss monitoring methods.
- Better agreement among scientists in current understanding and approach.
- System is broken and needs change; yet regulatory environment is business as usual. Current policy for boulder placement for loss of nearshore hardbottom doesn't work, yet it is still the accepted mitigation methodology. No adaptive management strategy is in place.

Regulatory Agencies:

- Need to increase funding for monitoring programs.

Resource Trustee Agencies:

- Agency philosophies need to change. Lack of prioritized list of research questions and research needs. Minimum requirements for monitoring would help.
- Third party independent review of monitoring reports is needed.
- Lack of funding.
- To correct conflict of interest, need field QA/QC by agency staff and statistical check of data. Need agency wide QA/QC program for hardbottom/reef monitoring.

Is there anything else I did not ask that you feel is important for improving the ability of future coastal construction project monitoring to detect ecological impact and to mitigate for those impacts?

Sponsors:
- Statistical design is constrained by funding.
- Synthesize all monitoring information into a central database at the state level.
- Need hypothesis driven research with statistical analyses to determine number of sites needed to detect impacts. Need valid controls and to determine natural variability.
- Academic research is a more cost-effective means for research. Need a program at the state level.

Consultants:
- Lack of willingness for direct research. How to mitigate for dredging through a reef?
- No real controls left in southeast Florida. Monitoring is performed because current policy requires it; no effort directed to science based monitoring.
- Biological consultants are often given a scope of work or monitoring plan without opportunity to make changes/comments. Often, the cost of effort is not warranted, especially in the nearshore zone.

Regulatory Agencies:
- Cumulative impacts must be assessed. There is a push to reduce monitoring scope/costs at the state level.

Resource Trustee Agencies:
- We are not capturing cumulative knowledge; rely too much on individual staff knowledge.
- Need forum for discussion of monitoring results between those doing monitoring and those requiring/reviewing monitoring.
- Need third party independent review of monitoring reports.
- Need agency QA/QC procedures associated with monitoring plans.
- Need an alternative mitigation strategy for nearshore hardbottom. FDEP nearshore hardbottom mitigation study is important for nearshore hardbottom mitigation development.