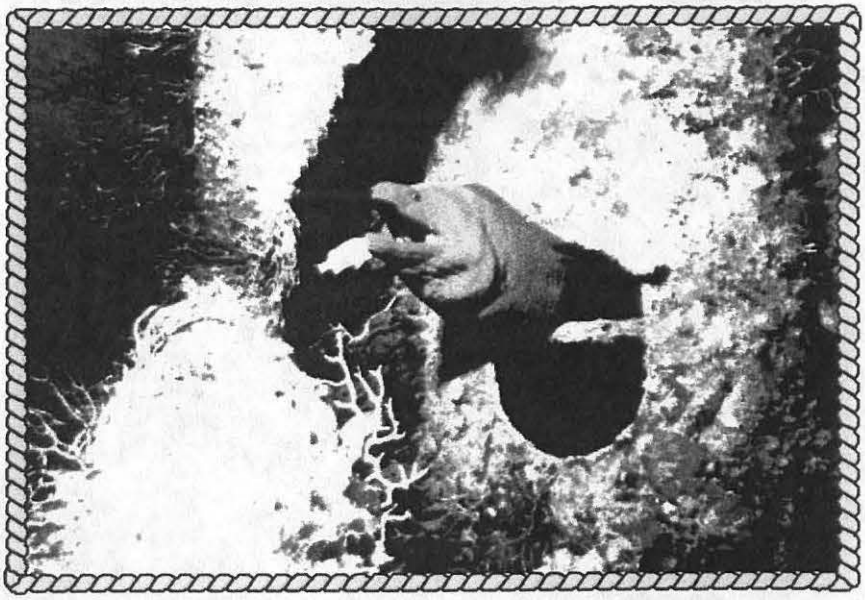
Florida Artificial Reef Summit '01

ARTIFICIAL REEFS

"INTO THE NEW MILLENNIUM"



BROWARD COUNTY FLORIDA

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

NOVA SOUTHEASTERN UNIVERSITY OCEANOGRAPHIC CENTER

Sea Grant Florida

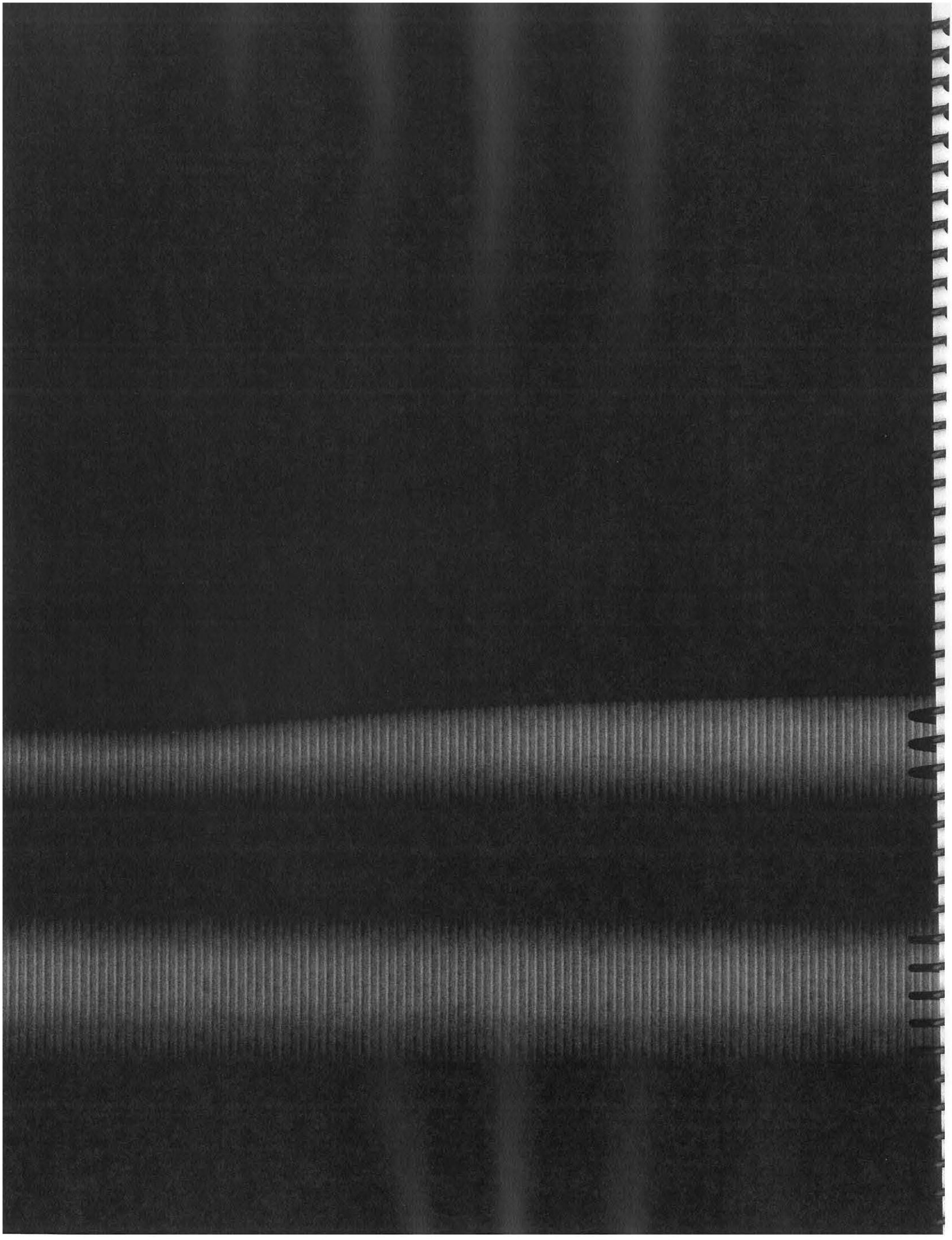


Table of Contents

FLORIDA ARTIFICIAL REEF SUMMIT '01

OCTOBER 17-20, 2001

FT. LAUDERDALE, FLORIDA

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Foreword 3
William Horn, Artificial Reef Program
Florida Fish & Wildlife Conservation Commission (FWC)

OVERVIEW & PROGRAM UPDATES

Welcoming Address and Overview 6
Jon Dodrill, Moderator, FWC, Artificial Reef Program
Welcoming Introductory Comments, Division of Marine Fisheries 10
Dr. Roy Crabtree, Director, FWC Division of Marine Fisheries

GOVERNMENT AGENCY UPDATES

U.S. Army Corps of Engineers, Artificial Reef Permitting 13
Clif Payne, Corps of Engineers Pensacola Regulatory Office
Artificial Reefs: Habitat for Marine Resources-National Policy? 16
Ronald Lukens, Gulf States Marine Fisheries Commission
United States Coast Guard, Artificial Reef Project Summary 21
Lt. Daniel Gronski, US Coast Guard, Miami
The Maritime Administration's Ship Disposal Program 23
Curt J. Michanczyk, Maritime Administration Ship Disposal Program
Charting of Artificial Reefs 26
Kenneth R. Forster, National Oceanic and Atmospheric Administration (NOAA)
National Ocean Service, Source Data Section
FDEP Environmental Resources Permitting for Artificial Reefs 28
Timothy Rach, Florida Department of Environmental Protection (FDEP)
Submerged Lands & Environmental Resources

FLORIDA'S COUNTY PROGRAMS -REGIONAL UPDATES

Artificial Reef Program Update-Northeast Region 30
Joe Nolin, Volusia County
Reef Building Activity on the Southwest Coast 32
Chris Koepfer, Lee County
Escambia County Artificial Reef Monitoring 34
Robert K. Turpin, Escambia County

INTERNATIONAL REEF ACTIVITIES

International Reef Technology and Research Trends 38
Dr. Bill Seaman, University of Florida, Florida Sea Grant Program

ARTIFICIAL REEF MONITORING PROGRAMS

Fish Census Data Collected by the Florida Artificial Reef Program 44
William Horn, FWC Artificial Reef Program

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Artificial Reef Research off Coastal Alabama 50
Andrew J. Strelcheck, FWC Division of Marine Fisheries

ARTIFICIAL REEF DEVELOPMENTS

Fish Census of Selected Artificial Reefs in Broward County, Preliminary Results 57
Dr. Richard Spieler, NOVA Southeastern University
Comparisons of Five Reef Building Materials 66
Dr. Heyward Matthews, St. Petersburg College
Economic Value of Reefs in Southeast Florida 69
Dr. Grace Johns, Hazen and Sawyer, P.C.

ARTIFICIAL REEF MITIGATION

Guidelines for Restoring Marine Epibenthic Habitats 73
Walter C. Jaap, FWC, Florida Marine Research Institute
An Overview of Recent Reef Projects in Palm Beach County..... 77
Carmen Vare, Palm Beach County
Artificial Reefs as Mitigation for Damage to Natural Reefs:
Examples from Broward County, Florida..... 81
Kenneth Banks, Broward County

ARTIFICIAL REEFS AND MARINE PROTECTED AREAS

Overview of the Use of Artificial Reefs and Marine Reserves
to Ensure Sustainable Fisheries and Healthy Marine Ecosystems..... 86
James A. Bohnsack, National Marine Fisheries Service
REEF Fish Surveys and Applications of Data..... 89
Laddie Akins, Reef Environmental Education Foundation
Fish Assemblages of Exploited and Unexploited Artificial Reefs off
Sebastian Inlet: Phase I-Experimental Design and Baseline Censusing..... 94
Jonathan C. Gorham, Indian River County

ARTIFICIAL REEF MONITORING PROGRAMS

ARTIFICIAL MONITORING WORKSHOP, FLORIDA SEA GRANT
Dr. Bill Seaman, Florida Sea Grant Program, Moderator
Evaluating Florida's Artificial Reefs for Fishes and Macroinvertebrates..... 97
Stephen A. Bortone, The Conservancy of Southwest Florida

Regional Reef Research Teams - Monitoring Grant Project Updates

The Palm Beach County Reef Research Team, What do we do? 103
Dr. Janet J. & Glenn M. Phipps
Jacksonville Reef Research Team, Bunny's Web Artificial Reef Study 107
Lex Waters
Charlotte Marine Research Team 110
Dr. Jon Hubertz
Organization for Artificial Reefs' Research Dive Team..... 113
Scott Vascavage

APPENDIX 1-List of Speakers..... 115 **APPENDIX 2**- Final Agenda..... 118

FOREWORD

WILLIAM HORN
Artificial Reef Program
Florida Fish and Wildlife Conservation Commission (FWC)

OVERVIEW

As we enter the new millennium, many changes have occurred within Florida's artificial reef program over the last few years. Foremost of these changes, has been the transfer of the state's artificial reef program from the Department of Environmental Protection (DEP) to the Florida Fish & Wildlife Conservation Commission (FWC) in the summer of 1999. The people of the state, through the ballot box, felt strongly that state's fisheries, both salt and freshwater should be managed by one agency. The artificial reef program successfully made the move with many other programs and has taken up residence within the Division of Marine Fisheries. The program has evolved over the years but was not substantially changed by the move. It would seem that the FWC reef program is on an even keel and meeting the needs of the reef community.

Artificial reefs have also evolved through the years from a back-yard, try anything "it works" attitude, to a well managed, planned and documented addition of long term essential habitat for marine species. State and federal managers now view artificial reefs as management tools for fisheries enhancement rather than environmental problems to be dealt with. Artificial reefs are many things to many people and in October of 2001, many people were gathered together in Fort Lauderdale, Florida for Summit '01 to share concerns and discuss issues surrounding the artificial reefs of Florida.

HISTORY

The 2001 Florida Artificial Reef Summit meeting was held in Fort Lauderdale on October 17-20, 2001. This meeting was generally considered the fifth statewide artificial reef summit meeting in Florida. Although there had been other previous meetings in St. Petersburg, in June 1977 (Aska 1978) and in Daytona Beach in September 1979 (Aska 1981) that dealt with artificial reef issues it was not until November 2, 1987, that the first **statewide** meeting was convened. This meeting was a one-day conference held the day before the Fourth International Conference on Artificial Habitats for Fisheries in Miami. Ninety-five people from throughout the state attended this first reef summit with an interest in artificial reefs. The objective of the meeting was to bring the artificial reef community together, in an informal setting for the purpose of getting a consensus of opinion on what the problems relating to artificial reefs were and what directions the reef program in Florida should proceed in the future. The proceedings were published by Florida Sea Grant (Andree 1988).

The second summit meeting was held in Tallahassee in 1990 and was intended to receive input on the needs of the reef community. The major needs expressed at this meeting were: (1) additional funding needs for artificial reefs; (2) the need for a statewide reef development plan; (3) the need for guidance on how to monitor the existing reefs; and (4) the need for

additional research into how artificial reefs function and what can be done to optimize their performance.

Held again in Tallahassee, Reef Summit '93 was divided into three sections. The first section consisted of updates by the various sections of the artificial reef community, local, state and national. The second part of the meeting was intended to introduce the attendees to three new Department of Environmental Protection (DEP) initiatives for the artificial reef program: (1) the Florida Artificial Reef Development Plan; (2) The Florida Artificial Reef Monitoring Plan; and (3) the DEP artificial reef assessment dive team. The last portion of the agenda consisted of presentations dealing with artificial reef research topics or innovative county reef projects. This was in response to the stated need for reef research in *Summit '90*. *Summit '93* provided summaries and results of recent research funded by DEP plus some other projects of interest. The proceedings of this meeting were published by DEP (Horn 1994).

The most recent reef summit was co-sponsored by the FDEP and Palm Beach County and was held in West Palm Beach, March 5 -7, 1998. One hundred and four attendees enjoyed a very intense three days of presentations and discussions. Proceedings for this Summit meeting were published in June of 1998 (Horn 1994).

SUMMIT '01 - AGENDA

The *Summit '01* was planned to address the current issues of artificial reef development. The same format as the *Summit '98* was used for this meeting and the agenda was divided into several sessions. The initial session was again an overview and updates from various agencies and groups involved with reefs. The main portion of the meeting dealt with reef issues such as mitigation, research, and reef stability, permitting and volunteer data collection. The entire last afternoon was spent in a reef-monitoring workshop conducted by Florida Sea Grant. The proceedings in this document contain only expanded abstracts from the oral presentations and not the wealth of information disseminated through discussions and interactions of the attendees. These discussions were the major benefits of this meeting. A well-attended evening workshop was held discussing the various issues around ships as artificial reefs, with emphasis on military ship disposal programs and options. A poster session was also held on Friday evening and a reef-monitoring dive was hosted by Broward County on Saturday afternoon, making Summit '01 a very busy and well-rounded event for all participants.

REFERENCES

Andree, S., editor 1987, Florida Artificial Reef Summit. August 1988. Proceedings of a Conference held on November 2, 1987, Florida Sea Grant, 70 p.

Aska, D.Y., editor. 1978. Artificial Reefs in Florida, Proceedings of a Conference held on June 10 & 11, 1977. 69 p.

Aska, D.Y.,editor. 1981, Artificial Reefs: Conference Proceedings, Proceedings of a conference on September 13, 14 & 15, 1979. 225 p.

Horn, W. M., editor 1994. Florida Artificial Reef Summit '93, Proceedings of a conference held on May 4, 5 & 6, 1993. Florida Department of Environmental Protection, 142 p.

Horn, W. M., editor 1998. Florida Artificial Reef Summit '98,Proceedings of a conference held on March 5, 6 , 7, 1998. Florida Department of Environmental Protection, 145 p.



Green moray eel (*Gymnothorax funebris*),
September 19, 1997, Tenneco Towers, Broward County,
(Photo by Tom Maher)

ACKNOWLEDGEMENTS

The editor acknowledges those persons, organizations and agencies that supported this summit meeting with their assistance, time, efforts and funding and particularly those individuals who helped with the logistics of the meeting in Broward County. Special thanks go to Pamela Fletcher with Broward County and Sacheen Tavares with Florida Sea Grant for their superb planning on the steering committee. Thanks also go to many other staff with the co-sponsors organizations for this conference, NOVA Southeastern University (Abby Renegar, Missy Dore and Dr. Richard Dodge), and Broward County staff (Lou Fisher, David Stout, Joe Ligas, Eric Myers, Ken Banks, Steve Higgins, Brenda Kirk and Steve Somerville). Also greatly appreciated were the volunteers that assisted with a great deal of time and extraordinary efforts, Dave Kaplan and Laurie Kaplan with the South Florida Reef Research Team who performed tirelessly in all the tasks that needed doing. Great job!

I would also like to thank my colleagues within FWC for their expert clerical and editorial assistance, Tom Maher, and Keith Mille. Also, special thanks to Jon Dodrill, Bob Palmer and Roy Crabtree for their full support and assistance in the planning and execution of this conference. Thanks again, it was a team effort and I look forward to seeing you all at the next Summit Meeting.

William Horn
Editor
March 2002

WELCOMING ADDRESS AND OVERVIEW ARTIFICIAL REEF SUMMIT 2001

JON W. DODRILL
Artificial Reef Program Administrator
Florida Fish & Wildlife Conservation Commission

The other day in Orlando, Florida I saw a banner stretched across the entrance to a hotel that said "WELCOME MISSILEERS!" I was curious about who Missileers were so I stopped an older gentleman wearing a Missileer reunion name tag. The man said he was attending the second annual reunion of the men who manned the Mace and Matador missile batteries in Europe and elsewhere during the cold war period of the mid 1950's to late 1960's. I told him that I very much appreciated the fact that he and his reunion comrades didn't press any wrong buttons in those days but hoped that at this reunion they could finally have a real blast.

Today we are welcoming "Reef Summiteers". This is also a reunion of friends and colleagues. I also hope everyone has a blast. However, this conference has also traditionally been called a Summit. What is a summit? A summit is technically a high level meeting of government officials to discuss important policy issues of national or international importance. Cold war summits were held to set policy to insure no Missileers or their superiors misused the missiles in their intended capacity as a deterrent to a "hot" war.

In this case the Florida 2001 Artificial Reef Summit, the fifth since 1987, is in part, a statewide meeting of governmental artificial reef managers, administrators and regulators who develop and/or implement policies, programs, rules, and regulations that affect how Florida's artificial reef programs are run. Ideally by following and understanding regulatory requirements, as well as providing input into the development of these regulations and policies, the effective use of artificial reefs as management tools and recreational and economic resources is maximized. By engaging in responsible artificial reef development, we avoid the figurative accidental push of the wrong buttons that can result in the immediate or gradual self-destruction of local or state artificial reef programs.

I still get calls from individuals who express great surprise when the miscellaneous materials of opportunity they propose to take offshore as artificial reefs or as thinly disguised waste disposal don't conform to materials standards in permits, and/or that in fact permits are required. Unfortunately other individuals never check at all, as is the case with deployments of non-permitted lobster casitas in the Florida Keys National Marine Sanctuary (FKNMS) that serve as illegal lobster aggregation fishing tools for commercial divers. Sometimes reef managers themselves express dismay about the time and effort involved in securing artificial reef permits. The reality is that there is too wide a range of activity taking place in Florida's coastal and adjacent federal waters for any artificial reef development to be occurring without regulatory guidance and direction, outside comment by concerned parties, and close

cooperation of reef managers with the regulatory agencies. Just last week I received notification from the Minerals Management Service's gravel and sand section, saying they wanted to be informed about all future proposed artificial reef permit activity. They are becoming increasingly involved in identifying offshore sand sources for beach renourishment. They would like to avoid having a structure like a 10,000 ton ship or scores of patch reefs placed in the middle of a key sand recovery site, or in the way of a pipeline route to the beach. That same week the state of Georgia notified me that the US Fish and Wildlife Services (USFWS) was banning the use of explosives for use in vessel sinking during winter months from Georgia to Cape Canaveral to protect Northern Right Whales during their calving season. This condition had become a special condition in Georgia's artificial reef permits.

The first series of talks this morning will be talks by state and federal regulatory and coordinating agencies who have involvement with some aspect of artificial reef permitting, planning, development, coordination, and enforcement. These speakers will review their agencies' responsibilities and current or new policies.

The 2001 Artificial Reef Summit reflects the fact that Florida's Artificial Reef Program is unique among all other states. As a result of Florida's extensive Gulf and Atlantic shorelines, artificial reef activities are not exclusively run or funded at the state level. Florida's artificial reef program has for over two decades been a collaborative effort with local coastal governments who hold the liability and responsibility for over 98 % of the state's current 110 active artificial reef sites. This afternoon you will hear regional reports from local government reef coordinators about regional artificial reef activities at the local government level.

Collaboration in reef programs extends beyond local coastal governments. It also includes research organizations, who provide the scientific information that reef managers need to integrate into their programs to better direct the development and successful achievement of program objectives. Tomorrow morning reef research, technology and engineering topics will be discussed.

Agencies such as Sea Grant also provide an important collaborative role in the state artificial reef program. The technical assistance and facilitation skills that Sea Grant staff have brought to Florida's artificial reef program over the years have lifted artificial reef management in Florida to a higher plane. Sea Grant serves along with Broward County, Nova Southeastern University, and the FWCC in a collaborative sponsorship role to make this summit possible. Sea Grant's Dr. Bill Seaman will be giving an international reef perspective later today. His new artificial reef monitoring book will serve as a foundation for an artificial reef monitoring workshop this Saturday morning.

The history of artificial reefs in the United States has primarily been one of development of reefs as fishing or diving destinations. While these objectives remain, in Florida and elsewhere, the role of artificial reefs as habitat for reef obligate and reef associated organisms is becoming increasingly important. The loss of hard bottom due to burial from beach

renourishment projects, fiber-optic cables, gas pipelines, and vessel groundings, is resulting in the replacement of this lost natural habitat with artificial reef habitat. Artificial reef mitigation in southeast Florida and the qualities of mitigation habitat will be discussed in a series of presentations tomorrow afternoon.

Despite initial resistance to the concept of Marine Protected Areas (MPAs), their effective use has grown internationally. In recent years Florida has made some strides in the planning and implementation of Marine Protected areas. Special Protection Areas or SPAS exist in the FKNMS as well as the new Tortugas North and South MPAs. There are protected areas of the Oculina Banks off the Florida east coast, and grouper spawning protection areas in the eastern Gulf of Mexico near Florida's Middle Grounds. It is not out of the question that artificial reefs may have a research and habitat enhancement role to play in the development of future MPAs. A focus on artificial reefs as habitat to benefit overexploited reef fishes and the expansion of artificial reef use as a potential tool in association with Marine Protected Areas will be discussed in a series of presentations late tomorrow afternoon.

In 1997 the Artificial Reef Statute, Chapter 370.25 F.S., was modified to allow for two new activities. Firstly, qualified 501 c(3) nonprofit organizations could compete for state and federal artificial reef grant funding. Secondly, monitoring and assessment projects were eligible for funding where previously only reef related construction projects could be funded under the state reef grant program. Since then, non-profit and volunteer artificial reef research teams have played an increasingly active role in performing basic artificial reef compliance and performance monitoring. Regional artificial reef team presentations will be given mid-morning on Saturday. Volunteer non-profit and private organizations are also playing an important role in the development of military ship projects in Florida such as the *Spiegel Grove* and *Hoyt Vandenberg* as well as preparation of ships for deployment coming out of the Miami River. An important workshop on use of ships as artificial reefs, and updates on big ship projects will be facilitated by Kurtis Gregg of the Department of Environmental Protection later this afternoon.

SUMMARY

It is evident from this Summit Program that neither the state nor individual local artificial reef programs can operate in a vacuum. In fact, we have reef managers from at least two other states (New York and Louisiana) here today. The level of professionalism with which local governments, nonprofits and the state reef program pursue artificial reef development will reflect upon the overall reputation of the State of Florida as a leader in artificial reef planning and development. This requires collaboration and communication with a range of stakeholders who are represented at this meeting, including nongovernmental organizations and the media. In the same way that extensive and consistent collaboration and information sharing will be critical to the level of success in President Bush's campaign against global terrorism, a similar commitment to long term collaboration, communication and dissemination of information among the various parties gathered today at this reef summit will be critical to the continued professional growth and enhanced management of a statewide artificial reef program.

One of the goals of this Artificial Reef Summit 2001 is for all attendees to come away from this meeting with new information learned and other important information reviewed. I hope this summit will inspire all of us to renew our joint vision that artificial reef projects, whether for recreational, economic, habitat, or fisheries enhancement purposes, should be pursued in a well planned science-based fashion. We undertake artificial reef projects with specific objectives to achieve. I hope that we will continue to do so with the intent of doing no harm to human health, the marine environment, or navigation and commerce.

ARTIFICIAL REEF SUMMIT 2001
WELCOMING INTRODUCTORY COMMENTS

DR. ROY CRABTREE
Director, Division of Marine Fisheries
Florida Fish & Wildlife Conservation Commission

On behalf of the Florida Fish and Wildlife Conservation Commission I would like to welcome all of you to the 2001 Florida Artificial Reef Summit. As the agency's new Director of the Division of Marine Fisheries, I want to express my appreciation to all of you who have made the commitment to be here, and to the other sponsors and the program coordinators who made this Summit a reality. The FWCC is a strong supporter of these information and idea sharing meetings that involve a diversity of stakeholders. It is one of my objectives to ensure that proceedings of this important meeting will be developed by my staff, printed, and made available to all attendees.

Since the 1998 Summit, there have been some organizational changes related to the state artificial reef program. In July 1999, the artificial reef program was moved from the Department of Environmental Protection to the Florida Fish and Wildlife Conservation Commission. The FWCC was created through constitutional amendment by merging the former Game and Freshwater Fish Commission and Marine Fisheries Commission (FWCC) with elements the Department of Environmental Protection's Division of Marine Resources, the Florida Marine Research Institute, and the Marine Patrol. Through this merger and subsequent transition process, the operations of the state artificial reef program were unaffected.

Within my Division our primary artificial reef thrust continues to be that of providing grants-in-aid funding, and technical assistance, to local coastal governments and qualified non profit organizations for the planning, construction, and assessment of artificial reefs in state and adjacent federal waters. For the last three years we have been level funded with $600,000 in state and federal funds available for statewide artificial reef grant construction and monitoring projects. During this time FWCC staff have administered approximately $180,000 through 65 grants to support artificial reef activities around the state. We also disseminate reef related information, encourage communication among reef managers and other stake holders, maintain a public reef database, provide input to regulatory agencies, and represent Florida on artificial reef issues on the Gulf and Atlantic States Marine Fisheries Commission. Our vision is the promotion of a progressive and diversified statewide artificial reef program in partnership with local coastal governments, non profits, regulators, researchers, and the fishing and diving user groups. This vision also includes strongly encouraging and promoting the pursuit of artificial reef activities in a professional, science-based manner.

I want to mention several recent and proposed artificial reef activities that our FWCC reef program has engaged in. In May 2001 the Commission approved rule 68E-9 F.A.C., an update of the reef program's grants-in-aid rule that will better clarify the administration of the state reef grants program. Also in May, the Commission secured from the U.S. Maritime Administration a certificate of transfer for the ex naval vessel *Spiegel Grove.* Through a Memorandum of Agreement, the FWCC transferred title to the vessel to Monroe County, allowing progress on this vessel project to move forward again. As a result of increasing interest in ship sinking issues, FWCC staff have also been working in conjunction with DEP on a draft vessel use policy. The draft policy will be presented on November 2 at the FWCC Commission meeting in the Florida Keys. The Commission and DEP wish to have a planned, thoughtful approach to future large ship projects to make sure environmental, safety, and marine resource, and allocation issues are proactively addressed. Some informative presentations and a workshop addressing ship use will be held later on today.

In July 2001, the agency completed the permitting reauthorization process for two large artificial reef development areas off Escambia County. This reauthorization will allow for the continuation of both public and carefully regulated private reef deployments. This program will be further discussed tomorrow by Robert Turpin during his northwest Florida reef activity regional reef report later today.

Since the 1998 reef summit in Palm Beach, other new initiatives the agency has worked to support financially have included two regional socio-economic studies on artificial reef use. The first was completed in 1998 for five counties of the Florida Panhandle. A second regional study covering four southeast Florida counties was just released and will be reported on tomorrow. The FWC is a strong supporter of cooperative regional projects that assist both local artificial reef programs as well as the state program in more wisely determining and effectively measuring objectives for reef development.

In 1999, the reef program worked in partnership with Lee County and coastal engineers to develop a pilot computer software program to get a first cut estimation of the stability of artificial reef materials. We are glad to see that many of you have been using this program to evaluate material stability, red flag potential problems, or modify deployment plans to make sure the reef materials are stable on the bottom. Stability issues relating to reef materials remain a concern and will be addressed in a talk by Dr. Lee Harris tomorrow.

FWC reef staff have continued to take an active role in contributing to interstate artificial reef projects such as the 1998 Coastal Artificial Reef Planning Guide, and the ongoing updating of the Guidelines for Artificial Reef Materials. These and other interstate cooperative efforts will be discussed by Ron Lukens shortly.

The FWCC program reef assessment dive team led by Bill Horn and Tom Maher have continued their field efforts to look at various reefs structures around the state. The team has amassed over 160 sets of fish census data since 1992. Bill Horn will report on these data later this afternoon. Another of our Division staff, Andy Strelcheck will also be reporting on his Master's thesis work on artificial reefs later on today.

Looking ahead to the near future, reef staff will be working on developing a state strategic artificial reef plan as an update to the 1992 Department of Natural Resources State Artificial Reef Development Plan. This strategic plan will guide our reef activities and resources over the next several years. I encourage your active involvement and input in this process.

I am very pleased to be present at my first Artificial Reef Summit. I am confident that we will all find the Summit informative and useful.

U.S. Army Corps of Engineers, Artificial Reef Permitting

Clif Payne
Jacksonville Regulatory Division, Pensacola Field Office

Introduction

It is my pleasure to speak to you this morning. I am Clif Payne with the Jacksonville District Corps of Engineers (Corps) Regulatory Division. I'm the Team Leader for the Pensacola Regulatory Office and was asked to speak to you this morning on behalf of the Division. I would like to present a brief overview of the methods the Corps utilize in reviewing artificial reef applications and address some recent changes we have implemented to better accomplish our service to our customers. Our Division oversees the Corps regulatory interests throughout the State of Florida, Puerto Rico and the Virgin Islands.

Permit Authority

The Corps issues permits pursuant to Section 10 of the Rivers and Harbors Act, and Section 404 of the Clean Water Act. Section 10 authority extends from the limit of tidal influence on the shoreline to the limit of the territorial sea (3 nautical miles in the Atlantic and 9 nautical miles in the Gulf of Mexico). Section 4(f) of the Outer Continental Shelf Lands Act of 1953 extends Section 10 jurisdiction to the seaward limit of the shelf which is defined as the 200 meter/109 fathom depth or beyond that limit to where the depth of the super adjacent waters admit of the exploitation of natural resources (1964 United Nations Convention 14 S.T. 473). Section 404 jurisdiction extends from the limit of tidal influence on the shoreline or the landward extent of wetlands to the limit of the territorial sea for discharge of fill material. Section 103 addresses the transportation of dredge material waterward of the Mean Low Water Line.

A permit is required pursuant to Section 10 of the Rivers and Harbors Act if the project involves the building of certain structures in, over, under navigable waters of the United States or involve work affecting navigable waters of the Unites States. A permit is required pursuant to Section 404 of the Clean Water Act for the discharge of dredge or fill material into waters of the United States including their adjacent wetlands. In the past year the Jacksonville District Regulatory Division evaluated nearly 7000 permit applications and the projects associated with those applications. The projects range from very small projects such as a mooring pile for a pier to larger projects such as multi-thousand acre residential developments, airports, marine shipping terminals, and artificial reefs, etc.

History

On July 26, 1985 the Corps published proposed regulations to implement a portion of the Corps' responsibility pursuant to the National Fishing Enhancement Act. The regulations, which implement the Corps responsibilities for evaluation and permitting of artificial reefs may be found at 33 CFR 322.5 (b) of the November 13, 1986 Federal Register. The Corps' regulations closely mirror the evaluation standards established by the National Fishing

Enhancement Act (NFEA) of 1984 and guidance provided in the National Artificial Reef Plan (NARP) that was developed pursuant to section 204 of the NFEA.

REGULATORY PROGRAM

In reviewing the Corps' regulatory program one must be aware of how the Corps defines the term artificial reef. The term artificial reef, as defined in Corps regulations and the NFEA, means a structure which is constructed or placed in the navigable waters of the United States or in the waters overlying the outer continental shelf for the purpose of enhancing fishery resources and commercial and recreational fishing opportunities. Since the NFEA is integral to the Corps evaluation and permitting of artificial reefs, I would like to briefly review several sections of that act. Section 202 of the NFEA basically states that Congress is cognizant of the importance of fishery resources to the economies of coastal communities and the nation as a whole.

In light of the nation's energy and nutritional needs, congress supported properly designed, constructed, and located artificial reefs. To ensure design, construction, and location were properly addressed, Section 203 provides the standards which should be utilized with the best scientific knowledge available to site, construct, monitor and manage reefs. The standards suggest enhancing fishery resources to the maximum extent practicable; facilitating access and utilization by United States recreational and commercial fishermen; minimize conflicts among competing uses; minimize environmental risks and risks to personal health and property; being consistent with generally accepted principles of international law; and not create an unreasonable obstruction to navigation. To assist in implementing the evaluation standards, Section 204 requires the Secretary of Commerce, with consultation, to develop and publish a long-term plan, which we refer to as the NARP.

Section 205 requires that the Corps of Engineers, in association with its evaluation of applications for permits for artificial reefs, consult appropriate federal, state, and local agencies as well as interested private parties. The NARP places special emphasis on the need for planning, long term monitoring, and evaluation of monitoring results against reef goals and objectives. As such, the Corps is required to review the applicant's objectives for artificial reef construction as well as the applicant's provisions for siting, constructing, monitoring, and managing the proposed reefs. Clear evidence of title and responsibility for maintenance is also required as is information on the financial ability of the applicant to assume liability for future damages resulting from the reef or associated activities. The Corps permits are required to specify the design and location of the reef and the types and quantities of material to be deployed.

All permits must include terms and conditions for the construction, operation, maintenance, monitoring, and managing the reef to ensure compliance with applicable provisions of law as well as conditions that may be necessary for the protection of the environment and human safety and property. The liability of the United States government, the applicant, and reef material donors is also addressed. The NFEA provides for a civil penalty of up to $10,000 for each violation considering the nature, extent, circumstances and gravity of the violation.

PROGRAM CHANGES

I would at this point, like to change the focus of our discussion to allow me to touch on some of the changes the Jacksonville District Corps has implemented as a result of numerous meetings held since the Fall of 1997 on the subject of artificial reefs. During the meetings, concerns were voiced on a number of subjects including but not limited to ensuring proper coordination of artificial reefs, which are being evaluated for permit, ensuring proper materials are deployed and clearance is maintained. As well, concern existed over accuracy of deployment location and ensuring existing essential fishery habitats (EFH) are not impacted. A call was made as well for the development and implementation of reef monitoring programs.

To address concerns regarding proper coordination, the Corps created and implemented an artificial reef public notice mailing list. The list includes federal, state, and local agencies, fishery commissions and councils, special interest groups, and interested citizens. Coordination and evaluation concerns existed for projects which were authorized by SAJ-50 which was a Regional General Permit. On January 19, 2000, SAJ-50 was allowed to expire and therefore projects are no longer authorized by SAJ-50. The Corps has implemented a pre-deployment notification which requires notification of appropriate federal and state agencies of a proposed deployment, provides information regarding the materials to be deployed, the dockside location of the materials to allow inspection, transport vessel information, and the proposed deployment location site conditions. In assessing proposed deployment materials the Corps will assess the durability and stability of the materials and consult published guidance and experts in the field.

In regards to adequate water depth or clearance above the deployed material, the Corps requires deployment locations be charted on the most recent National Oceanic and Atmospheric Administration (NOAA) chart and coordinates be submitted using Latitude and Longitude in decimal minute format. In an effort to further verify the depth of water above the deployed material the Corps requires soundings using a fathomer with a verified level of accuracy. In an effort to address concerns over monitoring and protection of existing EFH, inspections of deployment sites are occurring using such techniques as SCUBA and submersible video camera. The Corps also suggests that permitted reef areas support a square or rectangular shape to aid in locating reef boundaries and associated buffer zones. To further assess compliance with permit conditions regarding location of the deployments in some instances agency monitors are observing deployments. Physical monitoring of reef assemblages is occurring on an alternating year basis with monitoring reports and photographs required within 2-4 weeks.

CONCLUSION

The Corps is pleased to have been provided this opportunity to discuss artificial reef permitting with you this morning and shares your interest in marine resources and artificial reefs.

ARTIFICIAL REEFS: HABITAT FOR MARINE RESOURCES-NATIONAL POLICY?

RONALD R. LUKENS
Assistant Executive Director, Gulf States Marine Fisheries Commission

THE NATIONAL FISHING ENHANCEMENT ACT AND PLAN IMPLEMENTATION

The National Fishing Enhancement Act of 1984 (Act) established artificial reef development as a national priority. In doing so, it made a case for the positive benefits from creating habitat for fisheries and established a number of broad guiding principles that are expected to positively impact the way in which artificial reefs are developed. The Act directed the U.S. Army Corps of Engineers (COE) to institute a permitting and regulatory framework within which artificial reefs would be developed. In addition, the Act mandated that the National Marine Fisheries Service (NMFS) develop the *National Artificial Reef Plan* (1985) (Plan), intended to establish national standards and provide broad national guidance for creating regional and state plans for artificial reef development. Implementation of the Act and the Plan resulted in a permit and regulatory program under the COE dredge and fill program. The sole authority provided to the NMFS was development of the Plan, which was completed one year after enactment of the Act in 1985. True implementation, however, occurred at the state level, evidenced by the magnitude of artificial reef development activity undertaken by state programs over the last 16 years, including development of state artificial reef plans.

IMPETUS FOR NATIONAL PLAN REVISION

Why should the Plan be revised? The Plan itself calls for periodic revisions, recognizing that progress, including plan development, research, and data collection, would reveal new and better ways to conduct programs. Such progress has been evident through the variety and frequency of research and policy publications, periodic international conferences, and regional and local meetings dealing with all aspects of artificial reef development and management. In addition, since the mid 1980s, the Gulf and Atlantic States Marine Fisheries Commissions have been providing a regional forum for state artificial reef programs to come together to work on regional and national scope issues. Finally, the recognition that artificial reefs are tools for fisheries management has contributed to the need to re-evaluate our current national guidance and policies for artificial reefs.

The combination of these and other factors led the Gulf, Atlantic, and Pacific States Marine Fisheries Commissions to request from the NMFS in 1996 that the states, through the Commissions, be given the responsibility to take the lead in revising the Plan. In December 1996, the NMFS agreed, and by letter encouraged the states to begin revising the Plan. Through a series of meetings, some sponsored by the NMFS and some sponsored by the Commissions, the revision was completed in December 1998. Soon thereafter, the three Interstate Marine Fisheries Commissions submitted the document to the NMFS for consideration to replace the 1985 Plan and establish new national policy on artificial reef development and management. In addition, the three Interstate Marine Fisheries

Commissions adopted the document as interstate policy, entitling the document *Coastal Artificial Reef Planning Guide (1998)*.

REVISED NATIONAL PLAN

During the process of revising the Plan, the states and commissions recognized the high quality of the work done by the original plan writers, such that much of the original Plan is embodied in the revision. Of significance, the National Standards were established by the Act and continue as the broad principles under which all other policies and recommendations are established. Those National Standards are as follows:

- Enhance fishery resources to the maximum extent practicable.
- Facilitate access and utilization by US recreational and commercial fishermen.
- Minimize conflicts among competing uses of waters covered under this title and the resources in such waters.
- Minimize environmental risks and risks to personal health and property.
- Be consistent with generally accepted principles of international law and not create any unreasonable obstruction to navigation.

While the first National Standard admonishes us to "enhance fishery resources," the primary focus of artificial reef programs over the past 16 years, and prior, has been enhancing fishing success through the creation of known locations where fish would be accessible. The revision places a greater emphasis on the habitat implications of artificial reef development. It should be noted that the revision does not diminish enhancement of fishing success as an important goal of artificial reef development, but rather elevates the importance of the habitat implications.

The original plan established four criteria that should be considered when determining the kinds of materials that should be used in artificial reef development. Those criteria include:

1. function - effective habitat for marine organisms,
2. compatibility - compatible with the marine environment,
3. durability and stability - materials should be able to withstand the marine environment for a desired length of time and remain stable on the bottom where placed, and
4. availability - readily available for use

These criteria were deemed generally to be applicable, with the exception of "availability." While it is important that materials be readily available for use by artificial reef programs, it is inaccurate to think of availability as a criteria for consideration of using a material, since if it is not available, it will not be used. The revision has deleted "availability" as a criterion, while continuing to recognize the importance of availability of suitable materials. In addition, the revision splits "durability" and "stability," because it was determined that, while the two are associated, they are significantly different and should be treated separately. For example, a material can be quite durable and be inherently unstable in salt water, such as an automobile tire. Conversely, it is possible for a material to lack durability and yet be relatively stable.

As described above, materials used to create artificial reefs constitute an important programmatic issue. In recent years, the issue of materials selection has also become quite controversial. Many have heard the criticisms that artificial reef programs are nothing more than waste disposal programs. Years ago, that criticism had a kernel of truth in it; however, more recently state programs have strived to move to materials that follow the established criteria. The original Plan went to great lengths to identify selected materials and describe their attributes. Today, the variety of materials has increased to the point that it would be unwieldy to continue to address them all within the text of the Plan. As a result, the revision incorporates, by reference, the document entitled *Guidelines for Marine Artificial Reef Materials (1997)*, developed by the Gulf and Atlantic States Marine Fisheries Commissions. That document is currently under revision.

One of the most important issues addressed in the revision is qualifications for holding an artificial reef permit. Currently, under the COE permitting program, any citizen of the United States can request and receive an artificial reef permit by following established procedures and showing proof of liability coverage. Unfortunately, the liability criterion has not been applied in most cases; consequently, individuals with no capability to withstand a liability suit have been granted permits. In addition, a fishing organization may be able to qualify, but could easily disband well before the life expectancy of the reef they build has run its course. Who then is liable? This issue has not been addressed. The revision recommends that the COE issue permits only to the state agency with responsibility to manage marine resources. The drafters consider this appropriate because the state agency 1) is legislatively authorized to exercise stewardship responsibility over marine resources, 2) can ensure compatibility with fishery management planning, and 3) can assume liability for the life of the artificial reef. The language in the Act does not allow the COE to make this a requirement; however, its appearance in the revision elevates it as an important issue that the COE should consider and identifies it as an issue that should be addressed in any future amendments of the Act.

Mitigation has continued to be an issue that involves artificial reef development. Many cases have emerged in which artificial reefs have been proposed as a way to mitigate for the destruction of dissimilar habitats. The revision attempts to put in perspective the position of the states in this regard, stating that if mitigation is to be considered necessary, it should be in kind/in place. The revision recognizes that this cannot always be done; consequently, the revision strongly recommends caution when applying artificial reefs as mitigation. For example, an offshore, high salinity artificial reef should not be acceptable as mitigation for the loss of estuarine marsh.

The revision recommends that the COE require project objectives as a part of the permitting process. All artificial reef projects should have well defined objectives that are consistent with fishery management objectives. In addition, in order to determine if projects are successful in meeting stated objectives, baseline evaluation and monitoring should be conducted, with follow-up evaluation and monitoring to assess the change brought about by the project. The revision recognized the importance of specifying compliance monitoring and performance monitoring, as found in the original Plan. Compliance monitoring is required to assure that program activities do not significantly vary from permit requirements.

Performance monitoring, while not required by most permits, is equally important in determining whether stated objectives are being met, and equally important to assess the overall impact of artificial reef development.

The revision emphasizes the importance of recognizing that artificial reefs should be fishery management tools. Artificial reefs can be used to restore damaged habitats or can be used to enhance habitats for selected species. There have been many discussions recently about using artificial reefs to establish sanctuaries, or marine protected areas, as a way of addressing the criticism that establishing a no-take area penalizes the citizenry by taking away reef areas historically open to commercial and recreational fishing. In addition, we have many examples of using artificial reefs as special management areas in which effort control and spatial and use conflict management measures can be applied.

As mentioned above the draft Plan revision was submitted to the NMFS in late 1998. The draft has undergone internal review by NMFS, and has been reviewed by the relevant federal agencies. Currently, NOAA General Counsel is holding approval of the document until the new administration has had an opportunity to evaluate its impact on federal fisheries policy. The next step is to publish the document in the *Federal Register* and get public comment. It is not known when this might take place.

EMERGING ISSUES

Because our world is ever changing, there are always a variety of emerging issues for the state and federal agencies to address. Here are three important emerging issues.

1) As mentioned above the *Guidelines for Marine Artificial Reef Materials (1997)* is currently being revised. This document, while non-regulatory, is an important resource to all programs seeking to become involved in artificial reef development. The Commissions are attempting to increase the opportunity for public input into the process by involving the affected communities in the development of sections.

2) The issue of durability of materials has come under scrutiny. There are some who believe that an artificial reef does not need to last longer than one year. Others believe that artificial reefs should mimic the natural environment to the maximum extent possible in order to establish long-term habitat. Who is right? It will be vitally important to resolve this issue in the coming months so that we can engage in responsible artificial reef development.

3) Finally, you will be hearing much more at this Summit about the impending availability of military ships for artificial reef development. This is an issue of national scope, and as such, will be debated by the interstate marine fisheries commissions, who expect to play a significant role in establishing criteria for ship availability and regional coordination for ship distribution. These are just a few of the important issues of regional and national scope that will be addressed in the next year or two.

LITERATURE CITED

Atlantic, Gulf, and Pacific States Marine Fisheries Commissions. 1998. *Coastal Artificial Reef Planning Guide*. Gulf States Marine Fisheries Commission, P.O. Box 726, Ocean Springs, Mississippi 39566-0726. 45p.

Gulf States Marine Fisheries Commission. 1997. *Guidelines for Marine Artificial Reef Materials*. Gulf States Marine Fisheries Commission, P.O. Box 726, Ocean Springs, Mississippi 39566-0726. 118 p.

Stone, Richard B. 1985. National Artificial Reef Plan. NOAA Technical Memornadum NMFS OF-6. USDOC, NOAA, NMFS. 39pp. + appendices.

ARTIFICIAL REEF PROJECT SUMMARY

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INTRODUCTION

The U.S. Coast Guard (USCG) through their Marine Safety Offices (MSO) has the responsibility to assure that vessels used as artificial reefs are non-polluting, safe and not a hazard to navigation. The Coast Guard has five areas of concern that apply to artificial reefs, they are (1) Artificial Reef Applications, (2) Benefits to Marine Life, (3) Artificial Reef Inspections and Applicable Federal Law, (4) Tow Plans and (5) Safety Zones and Broadcast Notice to Mariners.

ARTIFICIAL REEF APPLICATIONS

The person responsible for the reef deployment needs to file a reef application with the USCG not less than 30 days prior to sinking. The Captain of the Port has to approve or modify the application in advance of the sinking. The applications must include the following information: the vessel's name, media interest, vessel preparation location, date and time of sinking, and sinking site.

ARTIFICIAL REEF INSPECTIONS

In order for the USCG to be assured that the vessel will not cause pollution, the vessel must be cleaned of all sources of pollution. The vessel must pass an inspection by staff from the local MSO office prior to the deployment. To pass inspection all hazardous materials, petroleum products, and debris must be removed from the vessel. All hatches, scuttles, portholes, and windows must be removed or welded open. All tanks and voids must be open or have openings cut and a certified contractor must scrub all tanks. Also all rigging and booms must be secured to the vessel to prevent movement during towing and sinking.

VESSEL TOW PLANS

A vessel tow plan must be submitted to the MSO documenting how the vessel will be moved to the site and deployed. The Coast Guard for navigational safety purposes must approve the tow plan. This plan must be received two weeks prior to sinking. The plan must include: number of towing vessels, horsepower of towing vessels, and manning requirements. The number and size of pumps used, name and size of the artificial reef vessel must also be included in the tow plan. Additionally, the route the vessel must take from the preparation site to the deployment site must be included and approved by the Captain of the Port. Depending on the condition of the vessel the Captain of the Port may deny access through certain navigational channels or require that a different channel to be utilized by the tow vessel.

SAFETY ZONES AND BROADCAST NOTICE TO MARINERS

The USCG requires some reef deployments to have safety zones around them and the MSO is responsible for the enforcement of these zones. Not all deployments need to have safety zones. They are established by the Captain of the Port for high media and high attendance reef projects, particularly if explosives are going to be used. Safety and environmental protection are the paramount concerns of the Captain of the Port. Additionally, broadcast notices to mariners are transmitted for every artificial reef project every half hour on VHF-CH-16, twelve hours prior to the sinking to notify mariners of the proposed reef deployment.

THE MARITIME ADMINISTRATION'S SHIP DISPOSAL PROGRAM

CURT J. MICHANCZYK
Ship Disposal Program, Maritime Administration (MARAD)

SHIP DISPOSAL PROGRAM OVERVIEW

The Office of Ship Operations (MAR-610), located in Washington, D.C, manages the ship disposal program. This office works closely with the Division of Reserve Fleet (MAR-612), and the managers of the National Defense Reserve Fleet (NDRF), which includes the Ready Reserve Force (RRF).

MARAD now has custody of 132 obsolete, non-retention ships primarily in four locations nationwide (Figure 1). MARAD is the Federal Government's disposal agent for merchant type vessels of 1,500 gross tons or more, which includes Navy non-combatants. As more vessels become obsolete and Navy transfers continue, by the end of FY 2006 it is estimated the number will be 155.

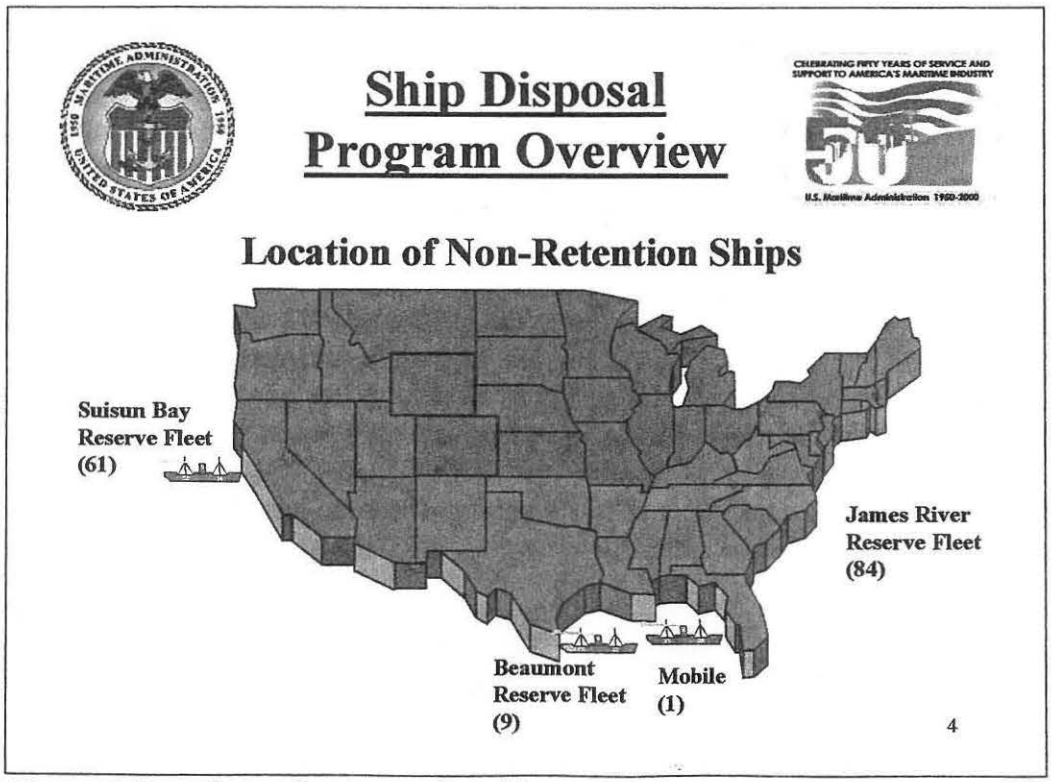


Figure 1-Locations of non-retention ships.

DISPOSAL OPTIONS PAST AND PRESENT HISTORICALLY

Until 1994 the main method for disposal of these ships was foreign sales for scrapping. "Artificial Reefing", the use of these ships as artificial reefs in relatively shallow water, historically was robust in the 1970's and 1980's. Domestic sales for scrapping has had limited success in the 1990's. The least effective method of disposal is vessel donations.

As an interim method, domestic contracts for scrapping are the most expedient method for disposal of the highest risk ships. However, the current approach seeks out the most cost-effective approaches with emphasis on pilot projects to prove effectiveness.

MARAD'S MANDATE TO SOLVE THE DISPOSAL PROBLEM

The U.S. Congress and the Secretary of Transportation are interested in cost-effective solutions to the ship disposal program, but there are many challenges. There are multiple ship disposal alternatives to pursue and multiple government agencies at all levels to interact and coordinate with.

There are environmental, health and safety, economic, and political issues to be considered when disposing of a large vessel. Many of these ships are in extremely deteriorated condition. Funding levels are already reduced with tight budgets in many areas of the government and private sectors.

MARAD'S SHIP DISPOSAL APPROACHES

MARAD's disposal courses of action have several branches. The short-term action deals with the worst condition ships. A Draft Request For Proposal (RFP) was released for industry comment, followed by final RFP for technical and cost proposal submissions (October 2001). The longer-term action is to soliciting industry proposals for innovative methods for disposal of a large numbers of ships through the Program Research & Development Announcement (PRDA) (October 2001).

MARAD ARTIFICIAL REEF POLICY

The MARAD Artificial Reef Program was established in 1972 under Public Law 92-402. This law authorized the Secretary of Commerce to transfer obsolete Liberty Ships to any states filing applications. This transfer is to be "at no cost to the federal government" and the state would take custody of the vessel "as-is, where-is". It allowed for states to salvage-strip the vessel to offset the towing, preparation and sinking costs. The Law was amended in 1984 by Public Law 98-623 to include any NDRF ship that was designated for scrapping and gave the Secretary of Transportation authority to transfer the vessels.

CURRENT ARTIFICIAL REEFING EFFORTS

(1) **Spiegel Grove** - The ship's title was transferred to State of Florida and the vessel is at a Virginia shipyard in the process of reefing preparations.
(2) **Vandenberg** - The vessel in hold status while funds are being raised to cover costs of reefing.

(3) **Texas Clipper** - The Federal agency approval process is in progress by the State of Texas and fund raising is near completion.
(4) **Two Others** - Two vessels, are in the works but not as far along and no substantive permitting/fund raising have been done to date.

CURRENT ARTIFICIAL REEFING CHALLENGES

The reefing disposal option has several challenges. The permit and approval process can be very lengthy. There is a lack of national environmental standards for reefing preparation (How clean is clean?). Towing and preparation costs can be very high for these large ships. There are also many unknown risks associated with the vessel's conditions due to age, lack of available information, and costs to survey the ship.

GOVERNMENT ACTIONS RELATED TO ARTIFICIAL REEFING

U.S. NAVY:

The goal of U.S. Navy's REEFEX initiative is to reduce Navy's ship disposal costs with a strategy to obtain the USEPA's approval to sink surplus ships with PCBs. The Navy would pay for preparing, towing and sinking. This initiative includes studies to satisfy regulator's concerns about the environmental risks of reefing. There are four scientific studies underway with EPA scientists participating. Also, the RAND artificial reefing feasibility study has been commissioned by the Navy and will integrate the results of the scientific studies.

MARAD:

There are on-going discussions with USEPA in pursuit of national PCB remediation standards for reefing. The USEPA decisions regarding national standards may be dependent on confirmation by Navy studies that reefing poses no unreasonable risk to environment. MARAD will work with the Navy and the EPA as scientific and RAND studies results are known. There will be a determination of remediation costs associated with national EPA standards assuming successful Navy studies and timely EPA action. MARAD will also work with the Navy to identify legal authorities to incur partial or total costs to prepare, tow and sink ships as artificial reefs.

SUMMARY

MARAD would like more ships to be used as artificial reefs and believes greater potential exists for this disposal option. However, assuming successful scientific studies and progress is made in establishing national environmental standards, challenges still remain. There are differing state and local environmental standards and permitting processes, which has significant effect on time and costs to accomplish artificial reefing. There is also competition for limited funding with other disposal methods. Therefore artificial reefing will have to be cost-effective and timely relative to other disposal methods.

CHARTING OF ARTIFICIAL REEFS

KENNETH R. FORSTER
National Oceanic and Atmospheric Administration
National Ocean Service, Source Data Section

The Office of Coast Survey of the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service (NOS) is congressionally mandated to produce nautical products for U.S. waters. Our mission is to ensure safe navigation by maintaining approximately 1000 nautical products.

Permits issued by the U.S. Corps of Engineers (USACE) are the sole source for charting obstructions classified as artificial reefs/fish havens. The NOS treats artificial reefs and fish havens similarly. Upon receipt of a USACE public notice, cartographers will perform pre-processing, check for inaccuracies, completeness, and potential charting conflicts. If there is a charting problem, NOS will notify the USACE in writing within the comment period. After an artificial reef site is permitted by the USACE, a questionnaire is sent to the applicant requesting construction status. NOS charts the artificial reef at the start of construction.

Essential information is required for NOS to accurately chart artificial reefs. NOS requires accurate geographic positions (GPS/DGPS) expressed in a standardized format. NOS requires the accurate dimensions of the reef. If the reef is a square or rectangle, the four corner points and orientation is needed. If the reef is circular, NOS requires the center position and radius. Finally, NOS must receive an authorized minimum clearance. This is needed so we can portray the available water. NOS must be assured that no conflicts with other charted items (i.e. safety fairways, anchorages, etc.) exist.

When NOS reviews public notices sent to us by the USACE, we look for potential charting conflicts such as:

- Safety Fairways
- Anchorages
- Entrance Channels
- Critical Habitats
- Missile Test Areas
- Pipelines/Cables
- Unexploded Ordinances
- Isolated dangers to Navigation

NOS charting policy is to delete all soundings greater than the authorized minimum clearance. All charted details within the fish haven's limits are deleted except features of less or unknown depths. It is critical that we receive accurate information. Inaccurate and incomplete artificial reef information cause processing delays and potential charting conflicts.
Recently, NOS has been involved in five unique case histories.

1. Tampa Bay (west central Florida)
2. St. Joseph Bay (northwest Florida)
3. Panama City (northwest Florida)
4. Jacksonville (northeast Florida)
5. Port Everglades (southeast Florida

(1) TAMPA BAY

The Bahia Beach and Port Manatee Artificial Reefs are charted on NOS nautical chart 11416. These reefs were permitted by the USACE in the early 1990's with Latitude and Longitudes that were converted from Loran positions. Subsequently, NOS used these converted positions to chart the previously mentioned artificial reefs. In late 2001, NOS received a new permit for these reefs that included DGPS positions. These positions shifted the reefs slightly to the northeast of the original charted ones. NOS will not be able to remove the previously charted artificial reefs until there is a survey proving that these areas are clear of debris.

(2) ST. JOSEPH BAY

On NOS nautical chart 11389, the approaches to St. Joseph Bay, Florida, a fish haven was permitted in the middle of a safety fairway. A safety fairway is the main navigable channel for deep draft vessels. The fairway is the usual course followed by vessels of commerce and military vessels either entering or leaving a port. The safety fairway was charted in 1977. The fish haven was subsequently permitted and charted in 1997.

(3) PANAMA CITY

Another example of a fish haven being established in a safety fairway is depicted on NOS nautical chart 11391, approaches to Panama City. Even though only half of this reef falls inside the fairway, it still poses a hazard to navigation. Establishing a fish haven within the boundaries or in close proximity to a safety fairway presents a danger to marine traffic.

(4) JACKSONVILLE

In September 1997, NOS contacted Jacksonville regarding a potential problem with an offshore reef site designation. It has taken three modifications by the USACE to correct the permit for this reef. NOAA vessel, WHITING, was diverted to conduct hydrographic surveys in the area to provide a safe corridor into the Port of Jacksonville. These reef site areas, as permitted, overlapped and formed one huge artificial reef encompassing over a thousand square miles of sea floor. The charting of this reef, as permitted, would have significantly impacted maritime commerce and military operations.

(5) PORT EVERGLADES

The USACE permitted an artificial reef with a minimum clearance of 7½ feet and covered two previously established (and charted) commercial anchorages. Interagency coordination led to an agreement on the modification to the permit. The resulting reef site was modified off of the commercial anchorage areas and by banding, (three tangent areas with their own authorized minimum clearance).

The National Artificial Reef Plan, co-authored by the Atlantic States Marine Fisheries Commission and Gulf States Marine Fisheries Commission, is currently in NOAA's General Councils office for review. NOS appreciates the effort to coordinate the federal, state and private sectors to address these marine safety issues.

ENVIRONMENTAL RESOURCES PERMITTING FOR ARTIFICIAL REEFS (FDEP)

TIMOTHY RACH
Florida Department of Environmental Protection
Environmental Manager, Submerged Lands & Environmental Resources Permitting

INTRODUCTION

The Florida Department of Environmental Protection (FDEP) is responsible of regulating activities that impact submerged bottomland under state jurisdiction. A permit from FDEP's Submerged Lands & Environmental Resources Permitting (ERP) section would be required for an artificial reef structure that impacts state waters. State water jurisdiction is defined as 3 nautical miles seaward from the land on the East Coast and 9 nautical miles from land on the Gulf Coast. This permit application would have to go through two separate types of reviews; one is a *Regulatory Review* and the other a *Proprietary Review*.

REGULATORY REVIEW

The permitting Regulatory Review process for an artificial reef would determine which of the types of permits is required by a reef project. These types of authorizations would be: (1) Notice General Permit under Ch Chapter 62-341, F.A.C., (2) Standard General Permit under Chapter 62-330, F.A.C. or (3) Individual Permit under Chapter 62-343, F.A.C..

NOTICED GENERAL PERMIT

To qualify for a Noticed General Permit under (Chapter 62-341, F.A.C.), a project would have minimum impacts to water resources and have no mitigation required. An application must be submitted and receive approval, along with a $100 application-processing fee.

There is a General Permit for the Construction of Artificial Reefs under Chapter 62-341.600, F.A.C. The general criteria for this permit are:

- Clean concrete, rock, steel boat hulls, other heavy gauge steel, or a mixture of clean concrete and steel;
- Material free of pollutants and debris;
- Firmly anchored to the bottom;
- Not indiscriminately dumped; and
- Top of reef shall not exceed 1/2 distance from the bottom to the surface of the water

The Specific Criteria for this permit are:

- Site shall not be located on grasses, corals, or other hard bottom communities
- Water depths shall not be less than 12 feet deep
- No "white goods", asphalt, or tires
- Site marked with buoys during deployment
- Not located within shipping lanes
- Notify State and Federal agencies of location

Most Limiting Criteria is the size of the boundaries of the reef shall not exceed 1/4 mile on any side. Also, if the project exceeds the thresholds or criteria of the Noticed General Permit, then it must have either a: *Standard General Permit* or *Individual Permit*.

Standard General Permit

A project can qualify for a standard general permit if the area of work or deployment does not exceed 1 acre (43,560 square feet). There is $600 application processing fee. The submitted application must include, project drawings and a survey (sketch, video, still photos) of area. A joint site visit with FDEP staff is also required.

Individual Permit

An individual permit would be required if the area of work/deployment is greater than 1 acre. The Application processing fee ranges from $3,000 for greater than 1 less than 2 acres to $10,000 for greater than 100 acres.

PROPRIETARY REVIEW

A *proprietary review* of an artificial reef project would also be required because the state owned bottomlands would be impacted and a permit issued from the trustees of this state resource (FDEP) would be required. This can be done through either a *Consent of Use* under Chapter 18-21, F.A.C. or a *Management Agreement* under Chapter 18-20, F.A.C. (Aquatic Preserves).

The *Consent of Use Agreements* under Chapter 18-21.005(1)(a)(8), F.A.C. is the most common proprietary approval process. The project must be for public use and there are no size limits. The application is reviewed concurrently during the regulatory process.

A *Management Agreement* under Chapter 18-21.005(1)(c), F.A.C. is for an educational, recreational or scientific study and may involve monitoring to examine stability and public benefit or use. The application is reviewed concurrently during the regulatory process, however is not used frequently.

ON THE HORIZON

Standard monitoring conditions between Office of Beaches and Coastal Systems and ERP permits are being coordinated as well as standard monitoring conditions between FDEP and Army Corps of Engineers.

For more information contact the FDEP Southeast District Office at (561) 681-6600. For links to rules, statutes, and the ERP application forms go to the FDEP web site at http://www.dep.state.fl.us.

ARTIFICIAL REEF PROGRAM UPDATE NORTHEAST FLORIDA REGION

JOE NOLIN
Manager, Ponce de Leon Inlet & Port District

INTRODUCTION

Thank you for this opportunity to share information regarding artificial reef programs located along the Northeast coast of Florida. I am Joe Nolin, Manager of the Ponce de Leon Inlet & Port District in Volusia County. For those of you unfamiliar, Volusia County is centrally located on the eastern seaboard of Florida comprising the greater Daytona Beach and New Smyrna Beach communities around Ponce de Leon Inlet.

The Ponce de Leon Inlet and Port District is a division of Volusia County government that serves primarily as the 'Local Sponsor' for the U.S. Army Corps of Engineers' inlet stabilization efforts aimed at a maintaining Ponce de Leon Inlet as a safe and navigable oceanic access from the Intracoastal Waterway to the Atlantic Ocean. Over the last two decades however, the Inlet & Port District has expanded its' role into the broader realm of Coastal Zone Management and throughout this time the Inlet & Port District has managed a highly successful and popular artificial reef construction program.

VOLUSIA COUNTY

Our program currently manages 13 artificial reef construction sites. Each reef construction site is a 2,500' X 2,500' square area of barren, sandy seafloor composed primarily of firm shell hash. We have made 38 reef deployments among these sites using clean steel ships, tugs and barges, concrete culvert, concrete bridge demolition rubble, aluminum aircraft and concrete roadway construction barriers often referred to as "Jersey Barriers".

Our program also enjoys tremendous support and assistance from the Halifax Reef Research Dive Team. This team of highly trained volunteer divers monitors our artificial reef network by annually visiting each reef placement. Information recorded by this effort includes identification and relative abundance data for a variety of typical reef species as well as observations on reef material condition and performance. The team also provides reef deployment oversight and verification assistance and pre-deployment site environmental evaluation. I can confidently state that our program would not be nearly as popularly successful without the dedicated support of the Halifax Reef Research Team, particularly the President of that group, Mr. John Lane.

Finally, our agency publishes an Artificial Reef Location Brochure listing LORAN-C and Global Positioning System (GPS) Coordinates for each site. This brochure is updated from time to time as necessary and is available for free on the Internet and at area dive shops and fishing tackle stores.

This concludes the Volusia County information I have. As for the remainder of the Northeast Florida coast I have some basic reef program update information regarding the Flagler, St. John's, and Duval County programs that I will share with you.

FLAGLER COUNTY

In Flagler County there are two permitted reef sites offshore Matanzas Inlet with 5 reef placement locations among them. One site has had 4 reefs deployed and the other a single reef deployment. Materials used were concrete rubble and formed concrete Reef Balls. There has been very little recent artificial reef construction activity offshore the Flagler coast due to personnel changes within Flagler County government.

ST. JOHNS COUNTY

Offshore St. Johns County there are 3 actively permitted reef construction sites. Recent deployments include single bargeloads of clean concrete culverts deployed on 2 of the sites and a deployment of formed concrete Reef Balls at the 3rd site. The Reef Ball deployment is notable in that it was conducted entirely by a group of High School students called the Sea Scouts. This drop was made in 55' of water and the site has become popular for the conduct of Open Water SCUBA Certification checkout dives.

Mr. Jim Netherton of the University of Florida provided the information above to me, Whitney Marine Research Lab located at Marineland. Mr. Netherton has been active in artificial reef construction in the Flagler, St. John's County area for quite some time and is an excellent source of information on artificial reefs in that area.

DUVAL COUNTY

In Duval County the City of Jacksonville in conjunction with the Jacksonville Offshore Sport Fishing Club and the Jacksonville Reef Research Team has a very active artificial reef program managing 28 permitted reef constructions areas. Since 1997, 15 reef placements have been made in depths ranging from 60' to 100'. Reef materials deployed have included 5 large steel ships, 500 concrete Reef Balls and a vast amount of concrete culvert and bridge demolition debris.

Mr. Ed Kalakauskis of the Jacksonville Offshore Sport Fishing Club is the primary reef construction contact in the Jacksonville area and he provided me with the information above.

CONCLUSION

In conclusion, all the reef programs mentioned owe a debt of gratitude to the Florida Fish & Wildlife Conservation Commission and their staff for their grant funding support and it is my strong conviction that all of these publicly supported reef construction programs enjoy widespread and popular success.

Reef Building Activity on the Southwest Florida Coast

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Biologist, Lee County Natural Resources
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This presentation detailed the reef building activity along the west coast of Florida from Levy to Collier County. It dealt primarily in general terms and did not get into specific details regarding each County's reef program. The Power Point presentation had slides that showed the number of deployments for each County, expenditures for each County, a breakout of where the expenditures came from and deployments by material type from 1990 to the present.

Table1. Deployments per year (average 250 tons per deployment)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	TOTAL
LEVY	22					2							24
CITRUS						1					1	1	3
HERNANDO			1			3							4
PASCO	2			2	2	1		1	2				10
PINELLAS		10	14	13	30	12	16	10		29	12		146
HILLSBOROUGH	6	10	20	10	4	2	2	5	0	3	1	14	77
MANATEE			1					1	1	1	2	6	12
SARASOTA	2	4	1	1	2	4	3	4	1	2	3	3	30
CHARLOTTE	1				1					2	8		12
LEE	4	1	4	4	6	3	2	4	1	3	5	6	43
COLLIER	1	2	2	1	1	2	2	6	0	1	3	5	26
TOTAL	38	27	43	31	46	30	25	31	5	41	35	35	387

It was noted that Pinellas County has the greatest activity in terms of tonnage of material deployed. It was also noted that Citrus, Manatee, and Charlotte have all become active within the last few years, while Pasco has become inactive.

Table 2. Expenditures by year (thousands of dollars)

	90	91	92	93	94	95	96	97	98	99	2000	2001	TOTAL
LEVY	350					40							390
CITRUS						40					48	31	119
HERNANDO			25			120							145
PASCO	25			50	25	25		25	25				175
PINELLAS		80	81	83	121	85	151	85.1	85*	85*	85*	85*	686.5
HILLSBOROUGH		34.6		25						30			89.6
MANATEE			25					30	25	25	50	155	310
SARASOTA	25	65	25	25	45	125	34.8	50	25	50	50	50	569.8

CHARLOTTE					15					3	51		69
LEE	30.4	25	192	178	143	95	34.5	60.3	55	76.3	98.7	85	1073.5
COLLIER	74.4	86.7	65	25	25	45	45	55	0	25	40	85	571.1
TOTAL	505	291	413	386	374	575	266	305	130	209	338	406	4198.5

***-estimate**

It was noted that Lee County was the most active in terms of dollars spent and that almost 4.2 million dollars had been spent in the region since 1990.

Table3. Expenditure breakout (thousands of dollars)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**TOTAL**
STATE	400	75	129	154	122	400	50	130	105	147	135	190	2037
LOCAL	74.4	186	186	204	157	120	187	145	0	76.3	184	206	1725.2
PRIVATE	30.4	30	76.4	25.5	95.9	5	29	30	0	5	0	10	337.2
TOTAL	505	291	391	384	375	525	266	305	105	228	319	406	4099.4

It was noted that the largest proportion of dollars spent was from the State coffers, while local dollars were a close second. Private funding had decreased in recent years.

Table 4. Deployment by material type

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**TOTAL**
CULVERTS	3	3	4	5	3	3	2	6	2	3	4	1	39
SHIPS	1	1	1					4		2			9
HOPPER CARS					2								2
BARGES	1		1	1	1					1	1	1	7
RUBBLE	6	21	36	23	34	13	17	17		31	14	15	227
LIMESTONE				1									1
MODULAR	22				3	8	5	2	3	2	8	11	64
TANKS						30							30
POWER POLES	2	1	1	2		1	1	2	1		2	1	14
BOXES/RISERS	2		1		2				1	1		4	11
	37	26	44	32	45	55	25	31	7	40	29	33	404

It was noted that modular units had increased in recent years.

ESCAMBIA COUNTY ARTIFICIAL REEF MONITORING (2000-2001) SUMMARY

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Results of a survey of records, databases, and "public" artificial reef lists indicate that a total of 31 artificial reefs were deployed (or intended to be deployed) within Escambia County Artificial Reef Site 7, in the Gulf of Mexico approximately 10 miles southeast of Pensacola, Florida. Materials originally used to construct the artificial reefs include: steel (vessels, barge, battle tanks, and automobile bodies); concrete (preformed artificial reef modules (PARMs), pipes, culverts, and bridge rubble); and plastics (plastic materials bolted together, or embedded into concrete).

Using LORAN, Differential Global Positioning System (DGPS) equipment, hull-mounted SONAR (fathometer) and the Preliminary Site 7 Artificial Reef List, the latitude/longitude coordinates of 20 artificial reefs were determined. Visual surveys by the Principal Investigator (PI) were performed to confirm the artificial reef materials. Five of the deployed artificial reefs could not be located; the types of materials used (e.g., plastics, and automobile bodies) have been shown to be unstable (Turpin and Bortone, in press), and are presumed to have been moved offsite by recent hurricanes. Six concrete rubble ("CSX- Al Johnson") deployments were listed as separate reefs, but are actually one large deployment. One artificial reef ("Preform Concrete Units 7L") was not monitored, due to an unintentional omission from the Preliminary Site 7 Artificial Reef List.

Thirty-three monitoring dives were conducted on the artificial reefs deployed in Site 7. Water depths ranged between 81 and 102 feet. Additionally, two monitoring dives were conducted on a steel barge that sank prematurely in October of 1995 as it was being towed offshore to be deployed as an artificial reef. Because the 65 ft. X 20 ft. barge is in the Safety Fairway (i.e., shipping lanes), data are needed by county, state, and federal government agencies. Water depth at the site is 79 feet; minimum water clearance over the barge was measured at 66 feet. The barge is in "good" condition; approximately 15% of the barge has subsided into the sand seafloor.

A comparison of published LORAN coordinates and LORAN coordinates obtained in this study provides information regarding stability (i.e., tendency to remain "in place") of the artificial reefs during recent hurricanes (e.g., Erin and Opal, 1995, and Georges, 1998). Generally, there was little or no movement of most artificial reef materials. Notable exceptions are "Reefmaker Plastic Modules" and automobile bodies. The "Reefmaker" reefs were constructed from recycled plastic materials formed into "lumber"; the lumber was bolted together into cubic and tetrahedral configurations, and ballasted with concrete cylinders. The reefs were deployed in 1993 at depths of 90 feet. Post-hurricane (Opal and

Erin) artificial reef monitoring in 1996 indicated that similar materials placed in a nearby artificial reef site had been destroyed and/or moved offsite (Turpin and Bortone, in press). In fact, one of these objects was discovered via sidescan SONAR; visual inspection by research divers revealed that a number of the bolted connections had failed and the unit lay flat on the seafloor. Plotting of its position relative to original deployment coordinates suggests that it was originally deployed within Site 7, but was moved several miles to the northwest during Hurricane Opal (Turpin and Bortone, in press).

Two "Scrap Steel" artificial reefs were deployed by the Escambia County Marine Recreation Committee in 1998 at depths of 80 and 90 feet. Each of these artificial reefs consisted of 10 automobile bodies. Only remnants of 2 ½ car bodies were found at one site. Very little of the 2 ½ cars remain; average relief was estimated to be less than 1 foot above the seafloor. A LORAN/fathometer search was conducted at the other deployment location, but no artificial reef materials were detected. A dive at the published reef coordinates confirmed the presence of one small (2 feet long) piece of steel. Automobile reefs in a nearby artificial reef site were destroyed by Hurricane Opal; automobiles were discovered via sidescan SONAR several hundred yards northwest of the original deployment locations (Turpin and Bortone, in press).

The steel Tug *Heron* and steel Landing Craft *Elsie M* "composite" artificial reef was deployed in 1990 at a depth of 90 feet. The Landing Craft landed upright on the seafloor and the tugboat landed upside-down inside the Landing Craft. When the artificial reefs were monitored in 2000, the tug was found up-right, approximately 50 feet to the NNE of the Landing Craft (see Figure 18). This suggests the tugboat was moved by hydrodynamic forces (i.e., "wave surge") during recent hurricanes.

Both *Heron* and *Elsie M* exhibited signs of structural damage. The *Heron*'s pilot house was torn open, and the starboard side of the Landing Craft was badly damaged. This damage likely occurred when the tug was "washed out" of the Landing Craft. It is interesting to note that the *Heron* has subsided into the seafloor, especially at the stern (where the sand is within 1 foot of the gunwale).

The steel tug *Born Again* was deployed in 1991 at a depth of 95 feet. Twenty-one steel pipes (18 feet in length) were stacked in the engine spaces. Several of the steel pipes were observed on the seafloor near the vessel's stern; however, it is not known if this occurred during deployment or as a result of hurricane-induced wave surge. The *Born Again* was observed to be in "good" condition.

Two "ARCOA Reef Modules" artificial reefs were deployed in 1989 at depths of 80 and 85 feet. The reefs were constructed from corrugated plastic materials embedded within a concrete foundation. A thorough LORAN/fathometer search of the deployment coordinates did not locate these artificial reefs. The PI investigated these reefs in 1992; the plastic materials were brittle and crumbled when touched. These reefs were likely destroyed by recent hurricanes; the concrete slabs probably subsided into the sand seafloor.

The following artificial reefs were found at their original deployment locations in "good" condition: steel Kingry barge, battle tanks, Blackwater bridge rubble, Bayou Chico bridge rubble, CSX – Al Johson concrete pieces, concrete pyramids, steel oilfield supply vessel *Pete Tide II*, "Preform Concrete Units" (concrete culverts), and steel Tug *Philip*.

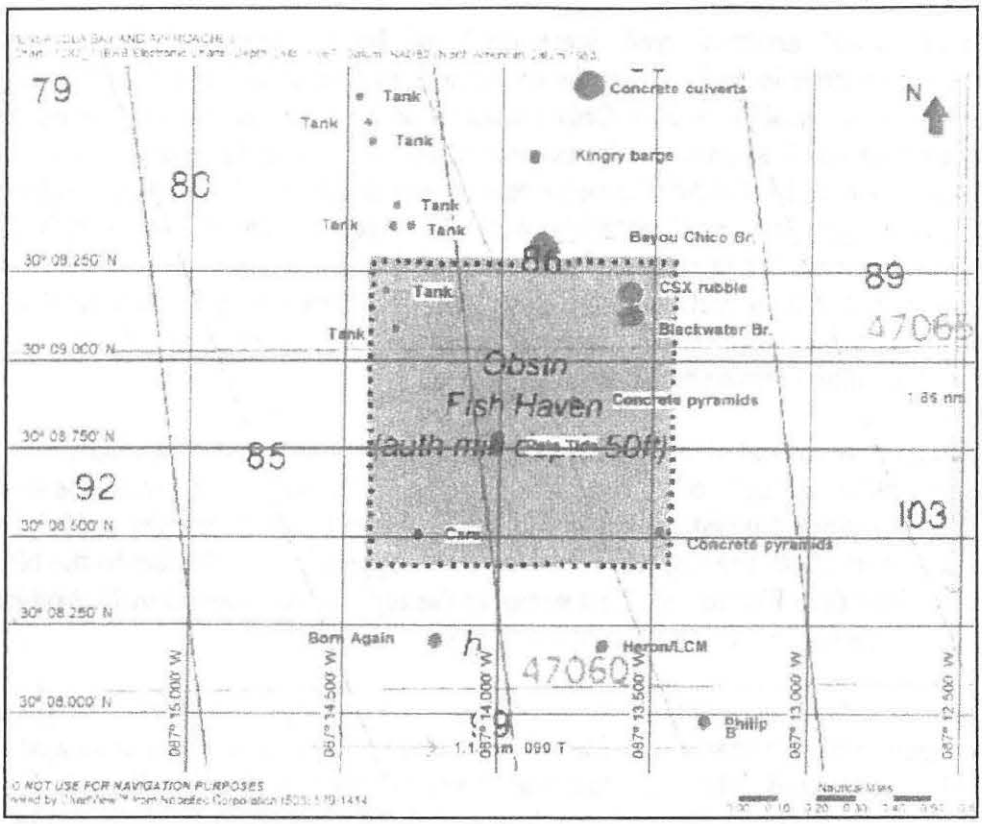


Figure 1. Site 7 (and surrounding) Artificial Reefs (dot size relative to reef size).

Although most of the artificial reefs were found at the original deployment locations, when the exact latitude/longitude coordinates were determined and plotted on NOAA Navigation Chart #11382, twelve of the artificial reefs were outside the Site 7 permitted area (Figure 1). These artificial reefs include three steel vessels, a steel barge, six battle tanks, concrete bridge rubble and concrete culverts.

The stability and durability of artificial reef materials in Site 7 generally agree with recommendations offered in *Guidelines For Marine Artificial Reef Materials* and *Coastal Artificial Reef Planning Guide*. Local artificial reef managers may utilize the stability/durability results from this project (specifically, performance during Hurricane Opal) to plan deployments of similar artificial reef materials at similar depths. Many of the artificial reefs have been in place for ten or more years, and are expected to achieve the recommended 20-year lifespan for "long-term" habitat. This information is vital to

local, state, and federal agencies for management of artificial reef programs, navigation and safety, as well as other potential uses of the seafloor.

Although Escambia County's artificial reefs have been constructed primarily to facilitate access to fishery resources, more consideration is now being given to the other purposes listed in the Florida and National Artificial Reef Plans. These purposes and considerations include: enhance fishery resources to the maximum extent practicable; minimize conflicts among competing users; minimize environmental risks and risks to personal health and property; and be consistent with laws and not create any unreasonable obstruction to navigation.

INTERNATIONAL REEF TECHNOLOGY AND RESEARCH TRENDS

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INTRODUCTION

The use of reefs worldwide is expanding in terms of both number of places and number of applications. This paper offers a brief review of the science and technology of using human-made reefs in coastal ocean settings globally. First, it describes practices, materials and geographic sites for 12 representative applications of reef technology. Secondly, it identifies advances, trends and emerging needs concerning planning, research and information/technology exchange.

REEF TECHNOLOGY APPLICATIONS

There is no central or official global database of artificial reef usage, management or research. Thus the annotated list below is based on review of literature, for which access is sometimes limited, and contact with recognized authorities in the field.

The principal way in which the worldwide "artificial reef community" communicates is through quadrennial international conferences. These events attract a few hundred individuals and offer oral reports, posters and field trips. Broader circulation of information from the meetings depends on publication, which has varied according to the organizers. For example, the 1991 conference (Long Beach, California, United States) led to peer-review papers in the Bulletin of Marine Science (1994); the 1995 conference (Tokyo, Japan) papers were distributed on site (Japan International Marine Science and Technology Federation); and the 1999 conference (Sanremo, Italy) distributed a book of abstracts (Relini, 1999) and is in the process of having up to 50 papers published by the ICES Journal of Marine Science and others in the Journal of the Società Italiana di Biologia Marina.

The advent of electronic mail has increased communication among people who meet at the international conferences, and also among other interests. There may be greater inclusion of "foreign" speakers in national meetings on reefs, too. For example, the national workshop on marine ranching in Korea (Yi 2000) included speakers from Japan (3), England (2), China (1) and the United States (1), who joined 19 Korean speakers.

1. Research and Education – Sound planning of reefs, whether as individual units (modules) or in complexes (of sets and groups), depends on a research foundation. Thus, in addition to the applications-oriented purposes annotated below, some reefs are valuable if they are dedicated strictly for study and possibly also teaching. Compared to natural reefs, human-made reefs offer a powerful experimental tool due to our ability to manipulate their attributes, such as size, shape and distribution.

2. Conservation of Biodiversity – A few nations have used reefs to provide habitat for the re-establishment or enhancement of depleted organisms. In Monaco, for example, specially designed "caves" of concrete have promoted colonization and growth of red coral (Corallium rubrum) in the Undersea Reserve. This species is economically important, but was depleted.

3. Restoration of Habitat – Damage and destruction of aquatic habitat is caused by pollution, dredging and mechanical action. In the United States, a coral reef that was destroyed by a sand dredge that was poorly placed is being restored through deployment of modules of concrete and native limestone rock that provide surfaces for colonization by coral larvae and shelter for mobile animals of the reef ecosystem.

4. Mitigation of Habitat Loss – An issue in more industrialized nations is replacement of habitats destroyed or damaged by private and public works such as harbor development, coastal construction and discharge of effluents in water bodies. The destruction of beds of kelp, an aquatic plant, in California, USA, by heated water released from an electric generating station caused a governmental regulatory agency to require that the utility company construct reefs in another area. The reefs are of rock boulders and designed to promote growth of a new kelp "forest."

5. Protection of Habitat – In the northern Mediterranean Sea, reefs are deployed as physical barriers to protect valued seagrass communities from damage by trawling. In turn, this provides a nursery for species sought by artisanal fishing.

6. Recreational Diving – A growing number of localities deploy visually interesting structures such as surplus ships to provide attractions for scuba divers, and for snorkelers in shallow water. While tropical areas might have the largest number of reefs (and divers), more temperate areas such as British Columbia, Canada, have active reef deployment efforts as well.

7. Submarine Tourism – One of the newest uses of reefs is in providing destinations for submarines carrying passengers on underwater tours. This is part of the growing economic endeavor known as nature-based tourism, or eco-tourism. Objects such as boats or customized sculptures are deployed in places such as Mexico, the Bahamas, and Hawaii, to provide destinations for commercial tour operators.

8. Recreational Fishing – Enhancement of recreational fishing, or "sea angling," has been the principal use of reefs in Australia and the United States. Reefs sometimes are deployed close to shore and inlets to provide safe access for smaller boats. In many cases, surplus "materials of opportunity" have been used, although disposal of solid waste at sea is falling into disfavor. Often private interests such as sport fishing clubs take the lead to organize such efforts.

9. Artisanal Fishing – The oldest and most widespread use of reefs is in subsistence fishing to harvest fish and invertebrate species as foodstuffs for family and community

diets. Coastal fishermen in India, the western tropical Pacific basin, western Africa and the Caribbean Sea deploy natural materials such as logs, bamboo and branches.

10. Commercial Fishing – Possibly the largest investment of funds for reef deployment has been made by Japan, which worked for 50 years to develop a modern system of harvest at reef sites. This national effort has included long-range planning, and focus on physical design and performance of structures. Reef units may be of steel, concrete or fiberglass, assembled in various geometric shapes that may be the size of small multi-level buildings.

11. Aquaculture – In contrast with fishing in the waters adjacent to a reef, aquaculture involves a more controlled and extensive interaction between humans and the reef. For example, mussels and oysters are harvested from reef surfaces in Italy, and abalone are raised on custom-designed concrete modules in Japan. In these situations, the reef provides a site of attachment or residence. Clearly, knowledge of the life cycle of reef-related organisms will establish the basis for new applications in what has been an effort embraced by Asia, but not yet fully appreciated in other areas.

12. Control of Fishing Mortality – Reefs can be deployed as physical barriers to exclude fishing operations such as trawling from designated areas inhabited by particular species or stages of the life cycle, as in Spain and Italy. Further, the designation of locations with individual reefs or reef complexes as "protected areas" or preserves is a concept of increasing popularity.

Finally, there can of course be multiple objectives for a given reef site, whereby various of the preceding applications are combined. For example, in the Adriatic Sea of Italy reefs protect seagrass habitat from trawling, provide hard substrate for production of bivalves, and promote small-scale artisanal fisheries (Bombace et al. 2000).

ADVANCES, TRENDS AND NEEDS

The continuing application of reef technology to new objectives and geographic sites reflects a creative process in fishery and aquatic science. To advance that process, several activities have made contributions while others are either beginning, planned or needed, as suggested below.

NATIONAL PLANNING

All aspects of reef deployment, such as siting, design and selection of materials, obviously benefit from planning. In the United States basic regulatory considerations (e.g., clearance, hazards) provide a foundation for responsible reef deployment, and certain individual states build on that in terms of overall statewide management of reef systems.

Internationally, there seems to be increased attention to planning both at a national level and also in large regions within a country. For example, in March 2001 about 25 individuals gathered in Canada for the "National Workshop on Artificial Reefs: Evaluation and Assessment." In November 2000, perhaps 100 persons attended Korea's "Symposium

on Marine Ranching" in which the topic of artificial reefs was strongly embedded (10 of 26 papers). And the Central Marine Fisheries Research Institute of India proposed between one and 16 artificial reefs, of 10,000 square meters each, for all coastal states of that nation (Murty 1997). In 2001, a delegation of 10 individuals from the Chinese province of Guangdong visited the United States (Florida, Louisiana, Washington, D.C., Washington state) in preparation for multi-objective reef program development along its extensive coastline.

LONG-TERM DATABASES

Complete understanding of artificial reefs—whether for basic science purposes or for management of resources—can only come from data acquired over long periods of time. Whereas many studies report findings from reefs that may be only a few years old, a few publications indicate long-term developments of assemblages of flora and fauna. In the U.S. perhaps the best example of a long-term dataset comes from King Harbor, Santa Monica Bay, California, for which Stephens and Pondella (1999) reported on a 24-year study of fish larval assemblages.

Beginning in 1974, artificial reefs were deployed in the northern Adriatic Sea of Italy (Bombace, et al. 2000). Initially experimental reefs financed by federal government research and fishery programs were built. Subsequent reefs used this experience, and were built both for additional research and for fishing. A series of studies have addressed physical stability, molluscan shellfish culture and fishery catch. The impact of having a long-term multi-disciplinary database has been to influence reef design and dictate patterns of reef usage to minimize conflict.

MANIPULATIVE EXPERIMENTS

From analysis of reef literature, it appears that much study worldwide is "descriptive." For example, an investigator may report on succession at a given reef site. Other effort is experimental: "mensurative" experiments address characteristics of reefs to make comparisons under different naturally occurring conditions; while "manipulative" experiments address reef factors in situations where the investigator imposes changes. The lack of studies with controls, treatments and replication was described as recently as 1997 by Lindberg.

Only a relatively small number of large-scale manipulative studies have been reported. Florida has been recognized, justifiably, for its large "underwater research laboratory" in the Gulf of Mexico off Cedar Key and the Suwannee Sound.

In Scotland, plans are underway for a large reef that will support experiments. Deployment of 42,000 metric tons of concrete units was to have started in 2000 (Sayer et al. 1999). This has been said to be the world's largest artificial reef.

ECOSYSTEM MODELING

Modeling of reef systems is only beginning. Calls for increased effort make the case that having predictive capability is useful to managers. Application of the ECOSPACE model

to reefs in Hong Kong was initiated by Pitcher and colleagues at the University of British Columbia. This involves "spatially-explicit simulation of whole ecosystem dynamics" (Pitcher et al. 1999). Their analysis includes projection of fishery harvest in systems using protected areas.

BIOLOGICAL-PHYSICAL DESIGN FACTORS

Among the new generation of questions for reef science and management is how reefs satisfy the life history requirements of species. Indeed, a North American symposium in 1995 recognized that the time-worn "attraction-production question" needed to be supplemented by more focused attention to issues of biological-physical linkages (Fisheries 1997).

Increasingly, there is consideration of how reefs fit into overall marine ranching, or sea farming. This is particularly true in eastern Asia. A project of the Korea National Fisheries Research and Development Institute offers a good case study (see Kim et al., 2000). Here, physical design of a 2x2x2-meter concrete cube reef structure is based not only on stability under environmental conditions such as current but also upon life history of species. Different sidewall hole sizes plus varying interior shading provide favored habitat for two target species.

TRANS-BOUNDARY RESEARCH COORDINATION

Since the mid-1990s Europe has developed an exemplary system, the European Artificial Reef Research Network (EARRN). Under the auspices of EARRN a series of continental meetings on research protocols have been conducted and research results reported, so that the flow of information among technical and management interests is rapid. To a lesser degree, research coordination is occurring in other areas, such as Brazil, where three local teams are communicating from three geographically separated sites, and Korea as noted above. The next international reef conference will be held in late 2003 in Louisiana, USA.

REFERENCES

Bombace, G., G. Fabi and L. Fiorentini. 2000. Artificial reefs in the Adriatic Sea. pp. 31-63 in: A.C. Jensen, K.J. Collins and A.P.M. Lockwood (ed.) Artificial reefs in European Seas. Kluwer Academic Publishers, Dordrecht.

ECOSET '95 Secretariat. 1995. Proceedings, The Sixth International Conference on Aquatic Habitat Enhancement. Japan International Marine Science and Technology Federation Fisheries, 1997. (Special Issue on Artificial Reef Management) 22(4):4-36. American Fisheries Society.

Lindberg, W.J. 1997. Can science resolve the attraction-production issue? Fisheries 22(4):10-13. Murty, V.S. (ed.) 1997. Status of research in marine fisheries and mariculture. Central Marine Fisheries Research Institute. CMFRI Special Publication No. 67. Indian Council of Agricultural Research.

Kim, C.G., H.S. Kim, T.H. Kim, J.W. Lee, J.T. Kim and E.C. Jeong. 2000. Designs of box reef for marine ranching in Tongyong coastal waters. pp. 167-181 in: S-K. Yi (ed.) Proceedings of the International Symposium on Marine Ranching Toward 21st Century. Ministry of Marine Affairs and Fisheries, Republic of Korea.

Pitcher, T.J., E.A. Buchary and T. Hutton. 1999. Forecasting the benefits of no-take artificial reefs using spatial ecosystem simulation. pp. 17-36 in: Proceedings, Seventh International Conference on Artificial Reefs and Related Aquatic Habitats.

Relini, G. (ed.) 1999. Proceedings, Seventh International Conference on Artificial Reefs and Related Aquatic Habitats. Universita di Genova.

Sayer, M.D.J., T.A. Wilding and A.M. Bullock. 1999. Planning, licensing and stakeholder consultation in an artificial reef development: the Loch Linnhe Reef, a case study. pp. 198-200 in: Proceedings, Seventh International Conference on Artificial Reefs and Related Aquatic Habitats.

Stephens, Jr., J.S., and D. Pondella, III. 1999. Productivity of a mature artificial reef—the ichthyoplankton of King Harbor, CA, USA: 197401997. Pp. 78-93 in: G. Relini (ed.) Proceedings, Seventh International Conference on Artificial Reefs and Related Aquatic Habitats.

Yi, S-K. (ed.) 2000. Proceedings of the International Symposium on Marine RanchingToward 21st Century. Ministry of Marine Affairs and Fisheries, Republic of Korea.

FISH CENSUS DATA COLLECTED BY THE FLORIDA ARTIFICIAL REEF PROGRAM

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INTRODUCTION

Florida has been a very active with artificial reef development, with over 1,821 documented artificial deployments statewide (FWC reef database, 2002). Since 1980 the state has implemented a grants program to provide financial assistance to local reef developers, primarily counties and cities, to construction and monitor artificial reefs. Grant funds originate from a combination of Federal Aid in Sport fish Restoration and revenue from the sale of Florida saltwater fishing license.

Florida has had an artificial reef *dive assessment program* since 1992, when three staff were hired to manage the grants program and to perform SCUBA assessments on selected artificial reefs. Since 1999 this program has been with the Fish and Wildlife Conservation Commission (FWC). The staff from the artificial reef program has conducted 264 underwater assessments on artificial reefs throughout Florida. The data taken on these artificial reef assessments are intended to document the physical and biological status of the reef to determine compliance with FWC artificial reef construction grant conditions. Where conditions and objectives warranted, divers have collected visual fish census data with the Artificial Reef Assessment Dive Team (ADT). This paper discusses fish census data from 165 assessment dives on Florida's artificial reefs.

The major objective of these assessments is to confirm compliance with specific grant conditions such as deployment locations, materials types and use of non-polluting materials. Permit compliance is also checked on these reefs indirectly since a valid artificial reef permit must be issued from the U.S. Corps of Engineers (COE) and the Florida Department of Environmental Protection (DEP) for state waters. This permit is required prior to a grant being issued.



Figure 1-Locations of FWC fish census dives.

However, the artificial reef program does not have the authority to issue artificial reef permits or take non-compliance enforcement actions. Fish census data was also routinely taken by the ADT divers on reefs whenever possible to gather information on the

biological functioning of the artificial reefs and to document the success of the artificial reef in providing habitat and sport fish enhancement.

METHODS

Since the FWC dive assessments are a time-limited 'snapshot' of the conditions of the reef on the day of the assessment, the Roving Diver underwater visual assessment method (Schmitt and Sullivan, 1996) was chosen over other fish census methods due to its ability to gather a broad species list in a short time without replicates. This method provided the flexibility for FWC dive staff to perform additional tasks during these reef assessments, such as video, still photography, reef measurements and some mapping.

Data was recorded in-situ on waterproof data sheets during these reef assessments. This multifunction data sheet consists of two sides of data fields. Physical data is recorded into four data types: (1) water information; (2) bottom characteristics; (3) reef materials information and (4) dive data fields. The dive specific variables of: bottom time, depth, water temperature and dive times are collected on this sheet as well as reef variables such as relief and types of materials.

Fish census information was recorded on the reverse side of this waterproof data sheet. Each fish census form lists reef and pelagic species that may be commonly encountered on the reef. This form has two versions with different species lists, depending on the latitude of the dives. A 'temperate species' version is used from Tampa/Cape Canaveral north, while a 'tropical species' version is utilized in the southern parts of Florida. Relative abundance is noted next to each species based on the following categories:

'A' for abundant, (over 100 individuals),
'M' stands for many (from 11 to 100) individuals,
'F' for few, (from 2 to 10 individuals) and
'S' for a single individual of that species.

Data collected are transferred from these field sheets into the FWC's fish census database using an Excel spread sheet format. This spreadsheet was developed to be able to be used with any of the major fish census methods. Data fields include: common species name, scientific name, number for fish or abundance category, dive date, county, latitude, longitude, water temperature (°F), depth (feet), dive number of the day, diver's initials, bottom time (minutes), estimated visibility (feet), whether underwater photos or video were taken on the dives, reef name, reef materials, reef age (years), reef tonnages, reef footprint (square feet), the reef's maximum relief off the bottom and the deployment date of the reef materials.

RESULTS

For this paper data was analyzed for 165 fish census events. This accounts for 126 different reef sites, since 26 reef sites had multiple counts on the same site. The survey dates ranged from December 4, 1992 until August 16, 2000. The fish census events dives occurred in 24 different counties throughout the state.

Statewide a total of 245 species were recorded during the study period. The average number of species observed was 16 (MEDIAN =15) species per survey. The species richness (number of species recorded for each fish census) ranged form 3 to 53 species.

The variables associated with these fish census surveys can be grouped into two categories; they are (1) dive-dependent variables and (2) reef-dependent variables. Dive-dependent variables are conditions encountered during the dive that may affect the number of species encountered, (e.g. environmental variables such as underwater visibility of water temperature). Reef-dependent variables are those associated with the reef structure itself that may affect the number of species seen on the reef (e.g., relief, material type or structural complexity). These physical parameters of the reef would not change greatly over time.

The total number of species seen over the course of this project was 245. Table 1 below lists the top ten species ranked by sighting frequency. The percent sighting frequency (%SF) is the number of times the fish was sighted divided by the number of fish census events (Schmitt, Feeley and Sullivan, 1998).

RANK	PERCENT	# OBSERVED	COMMON NAME	SCIENTIFIC NAME
1	75.76%	125	tomtate	*Haemulon aurolineatum*
2	66.67%	110	gag	*Mycteroperca microlepis*
3	63.64%	105	gray snapper	*Lutjanus griseus*
4	56.36%	93	belted sandfish	*Serranus subligarius*
5	54.55%	90	white grunt	*Haemulon plumieri*
6	49.70%	82	slippery dick wrasse	*Halichoeres bivitattus*
7	49.09%	81	Atlantic Spadefish	*Chaetodipterus faber*
8	46.67%	77	sheepshead	*Archosargus probatocephalus*
9	46.06%	76	gray triggerfish	*Balistes capriscus*
10	44.24%	73	blue angelfish	*Holocanthus bermudensis*

Table 1-Species sighting frequency.

$$\%SF = \frac{S+F+M+A}{\text{Total number of surveys}}$$

The tomtate grunt (*Haemulon aurolineatum*) was the most frequently sighted species recorded, being seen 125 times for a 75.76% sighting frequency. The other top five species observed on more than 50% of the surveys were gag, gray snapper, belted sandfish and white grunt, respectively.

A relative abundance density coefficient is a measure of how many individual of a particular species were observed when the species was present on a survey dive. This was calculated by multiplying the relative abundance categories by 1 (single), 2 (few), 3 (many) or 4 (abundant) (Schmitt, Feeley and Sullivan, 1998), summing for all categories and then dividing by the number of survey in which the species was observed.

$$\text{Density} = \frac{(S*1) + (F*2)+(M*3)+(A*4)}{\text{\# of surveys in which species was observed}}$$

Using this ranking round scad was the most abundant with a ranking of 3.90 out of a possible 4.0. This scale indicates that round scad, when observed, were recorded in large numbers, usually greater than 100. Rounding out the top five in relative abundance include scad family (spp.), herring family, tomtate and vermillion snapper.

When combined with GIS mapping techniques, these data produce species-specific maps of their geographic ranges on artificial reefs within Florida. Representative maps presented for gag (n = 110), black sea bass (n = 51), banks sea bass (n = 29), yellowtail snapper (n = 19), black grouper (n = 6) amberjack (n = 48) and gray snapper (n = 105).

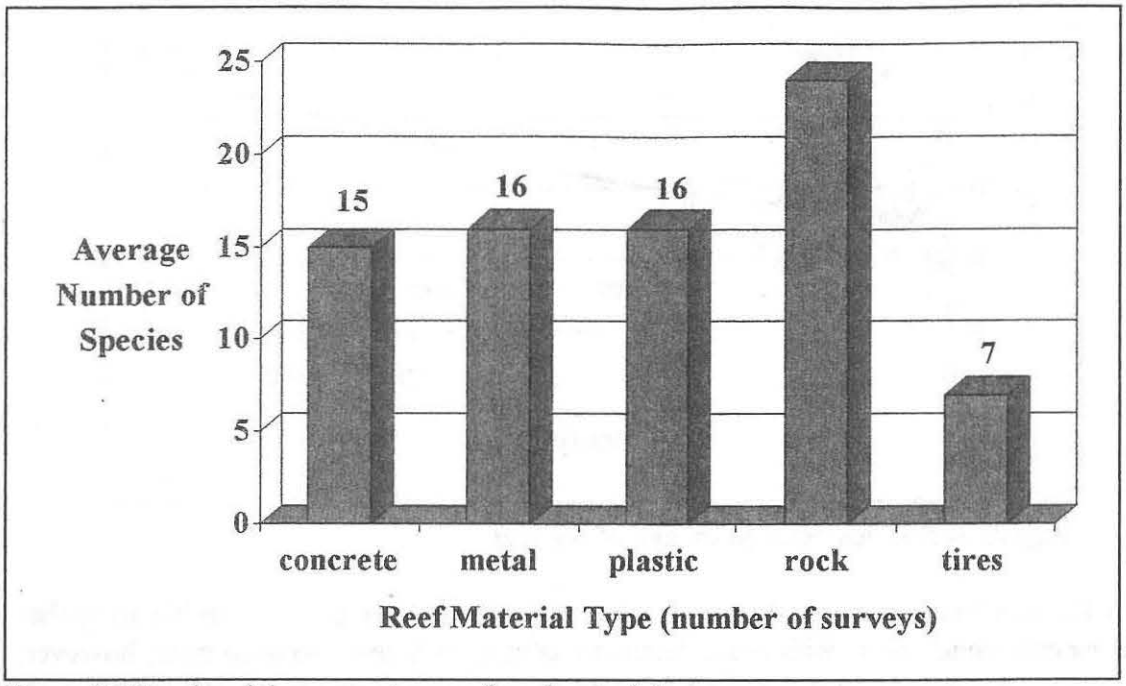


Figure 2- Species richness vs. types of reef materials.

The success of fish habitat to hold fish can be estimated by looking at the species richness for different type of reef materials. Figure 2 listing the average number of species for that type of reef materials. Natural rock reefs (n = 10) held more fish with an average of 25 species. This apparent increase in species may be partly due to the fact that all rock reefs surveyed here were in the southern part of the state where species richness is generally greater than the northern parts of the state. Tire reefs held the least number of species with an average of 7 species. The other three major types of reef materials, concrete (n = 97), metal (n = 49) and plastic & fiberglass (n = 5) were about equal with an average of 15, 16 and 16 species, respectively.

The species richness of a survey was also compared with the age of the reef. Figure 2 depicts a plot of the age of the reef and the number of species observed.

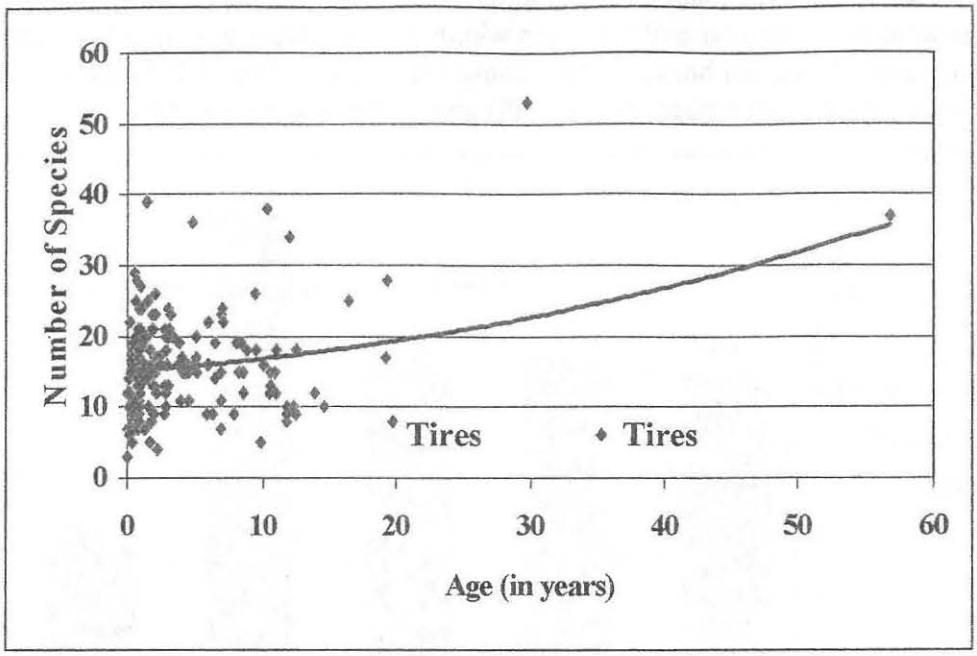


Figure 3- Species richness vs. age of the reef

While the combined data set does not show a significant trend, it is possible to gather more specific conclusions with more detailed analysis. It is interesting to note, however, that tires do not appear to make good habitats for fish based upon these fish census data. Only two tire reefs were assessed and they were off Wakulla and Broward counties. It is of note that only 6 and 8 species were observed on these reefs, yet these were among the oldest and most mature reefs at 35.2 and 19.7 years old, respectively. Each of these tire reefs were mainly comprised of single un-ballasted tires laying flat on the bottom. Out of 24 reefs assessed older than 10 years old, the two tire reefs had the fewest species recorded of these older reefs. It appears that relative to other materials, tires do not appear to make good habitats for fish based on these fish census data.

These data can also be used to look at certain species and their relationship to physical parameters such as depth or reef profile. As an example, the occurrence of 6 sport fish species (gray snapper, sheepshead, black sea bass, amberjack, red snapper, scamp and gag) was compared to each of these two variables (depth and relief). This information was then used to address two common angler questions. The first was, " Do amberjacks prefer higher profile reefs?" The minimum profile of the reefs that amberjack (n = 48) were observed was 3 feet, which is the same as 4 out of the 6 other species, showing no trend for higher profile reefs. The other question was, "Do red snapper prefer deeper reefs?" Here there did seem to be a trend since the minimum depth that red snapper (n = 24) were observed was 59 feet, while the other five species were all observed on reefs less than 30 feet.

DISCUSSION

From a statewide perspective the fish census data collected by the FWC-ADT divers are adding substantially to the body of knowledge that exists on artificial reef biological communities and the ecological functions of these reefs. Data collected here can be used for fish distribution maps since large-scale geographical information is being gathered. However, these data should not be used as a comprehensive summary or overview of the fish populations for Florida as a whole. More detailed analysis of the fish census data collected should be conducted to assist managers in determining the success of an artificial reef.

Although many parts of the state have been surveyed, both the geographical and biological distributions show biases toward the northern part of the state and the species that inhabit those waters. The depth restrictions of SCUBA also limit the depth distribution data on artificial reefs. Instead these data should be used to attempt to link the reef parameters with the relative abundance each species. Perhaps these data can also be used to model the projected reef fish assemblages for a give type and location of reef structures. Continued monitoring and assessment will contribute to the search for optimum fish habitat development for future artificial reefs.

REFERENCES

Horn, W.M. 2002. Florida Fish and Wildlife Conservation, Artificial Reef Deployment Database. 1,821 Deployments, FWC Web page, floridaconservation.org/marine/.

Schmitt, E.F. and K.M. Sullivan. 1996. Analysis of a volunteer method for the collecting fish presence and abundance data in the Florida Keys, Bulletin of Marine Science. 59(2):404-416.

Schmitt, E.F. , D.W. Feeley and K.M. Sullivan. 1998. Surveying Coral reef Fishes: A manual for Data Collection, Processing and Interpretation of Fish Survey Information for the Tropical Northwest Atlantic. 84 p.

ARTIFICIAL REEF RESEARCH OFF COASTAL ALABAMA

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INTRODUCTION

Most artificial reef studies to date have focused on environmental, ecological and physical factors influencing reef productivity. However, very few studies have focused on how reef location, and specifically reef densities, influence reef fish assemblages. In fact, reef placement remains one of the most neglected variables, and potentially one of the most important, affecting artificial reef fish-assemblages (Bortone 1998). Therefore, as an integral first step in understanding the attraction-production debate, this study took advantage of Alabama's extensive artificial reef program to help understand how artificial reef placement effects reef fish population dynamics.

The primary objective of this study was to examine variability in measures of reef fish demographics (fish abundance, biomass, etc.) among replicate artificial reef designs and determine what factors (location, reef density, reef design, etc.) might contribute to this variability. Because the artificial reefs used in this study were prefabricated, they were considered to be replicates and therefore were expected to support similar abundances and biomasses of reef fish. However, this was not the case and differences in fish abundance, biomass, and total length were partially explained by the abundance, distribution, and area of artificial and natural reefs surrounding each experimental reef.

METHODS

During March 1998, 14 prefabricated concrete artificial reefs were deployed off coastal Alabama. Seven Grouper Ghetto™ reef designs (volume = 3.5 m^3) and seven Reefballs™ (volume = 1.8 m^3) were deployed south of Mobile Bay approximately 1-16 km apart, at depths of 24-31 m. These reefs were deployed without consideration of artificial and natural reefs residing in their vicinity.

Beginning in February 1999, sampling began at each of the 14 experimental reef sites. Sampling was conducted quarterly from February 1999 – December 2000. Techniques included catch-per-unit-effort (CPUE = no. of fish per angler per hour) sampling by hook-and-line and diver visual census (diver surveys were only conducted during spring and summer). Two sampling techniques were used because each of the techniques suffers from sources of bias (i.e. – seasonal differences in catchability, limited visibility during diving, see Strelcheck 2001).

During quarterly CPUE fishing trips, each experimental reef was sampled for 30 minutes. CPUE fishing trips consisted of 8-10 anglers. While over an experimental reef site,

anglers caught reef fish by hook-and-line, one researcher measured and released all reef fish caught, and a second researcher recorded data. After each CPUE fishing trip, CPUE and reef fish biomass were calculated for each reef. Biomasses were estimated using known length-weight relationships (Bohnsack and Harper 1988; Patterson – unpublished).

During spring and summer, diver visual censuses were conducted at each experimental reef location. The diver visual census method used was a modification of Bohnsack and Bannerot's (1986) stationary visual census technique and is described in detail by Strelcheck (2001). Briefly, divers conducted two four-minute visual surveys at each reef. During each survey, divers were positioned 3.1 meters away from the reef. Divers recorded the abundance of reef fish, number of fish species, and reef fish sizes to the nearest 5 cm interval on a plastic slate. Reef fish abundances and biomasses were later calculated for each experimental reef as described above.

After estimating reef fish demographics at each experimental reef location, a digital side-scan sonar was used to quantify the abundance, distribution, and amount of bottom area (m^2) covered by artificial and natural reefs (nearest-neighbor variables) within 1 km^2 each experimental reef. The side-scan sonar consisted of a digital duel frequency tow fish, a Klein T2100 transceiver, and a coaxial tow cable. The tow fish was towed at a survey speed of 3-5 knots. Images were generated acoustically and side-scan imagery was later processed by technical support staff at Louisiana State University. Data consisted of fourteen 1 km^2 images, corresponding to the area surrounding each experimental reef site. This data was viewed using ArcView™ GIS software. Images were divided into 0.01, 0.05, 0.1, 0.25, 0.5, 0.75, and 1.0 km^2 concentric circles (**Figure 1**), and the abundance and total bottom area (m^2) of both artificial and natural reefs were quantified within each concentric circle. Additionally, linear distances (m) were measured to the five closest artificial reefs, and the closest natural reef, surrounding each experimental reef.

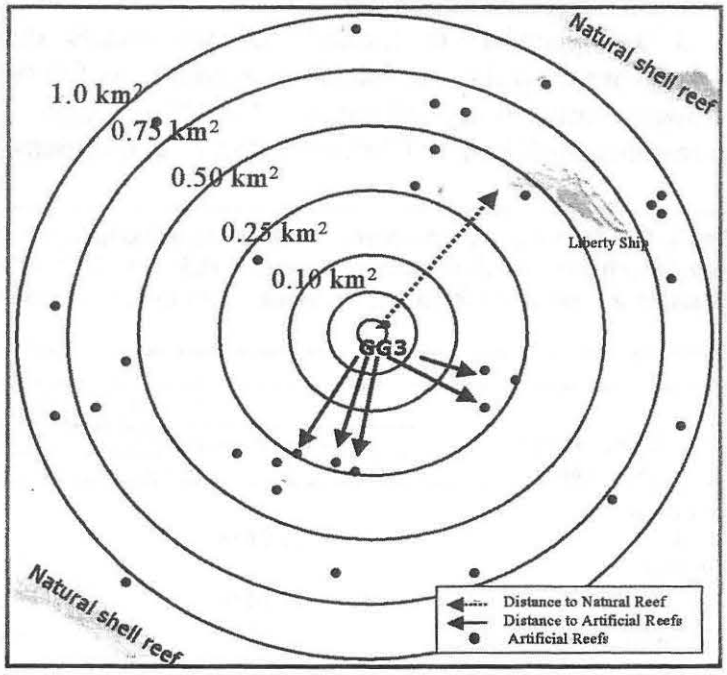


Figure 2-Illustration of 1 km^2 side scan image. Concentric circles represent the area of seafloor surrounding each experimental reef.

Analyses of variance and mixed general linear models (PROC MIXED) were performed using Statistical Analysis Software™ (SAS) to determine statistical significant differences (alpha = 0.05) in reef fish abundance, biomass, and total length among replicate reefs, between artificial reef designs (Grouper Ghettos™ vs. Reef Balls™), and among sampling seasons (spring, summer, fall, winter). To compare reef fish demographics with variables obtained from the side-scan sonar, stepwise regressions (alpha = 0.05) were performed to determine the proportion of variability in reef fish demographics explained by nearest-neighbor variables.

RESULTS

Catch-per-unit-effort. – A total of 3,330 fishes representing 26 species were caught at experimental reefs during this study. Red snapper, *Lutjanus campechanus*, and gray triggerfish, *Balistes capriscus*, were the most abundant species caught, comprising 83.2% and 6.57% of all fish species, respectively. Of the 26 species caught by hook-and-line, 10 species accounted for >99% of all species caught at experimental reefs.

Mean CPUE was highly variable among seasons and reeftypes. Mean CPUE at Grouper Ghettos (mean = 8.55 fish angler^{-1} hr^{-1}) was 70% greater than mean CPUE at Reef Balls™ (mean = 5.03 fish angler^{-1} hr^{-1}), and CPUE was greatest during fall sampling. Similar patterns were observed for reef fish biomass. Mean reef fish biomass was greatest during fall and lowest during spring and summer. Two-fold differences in biomass were observed between reef designs (Grouper Ghettos™: 25.27 kg, Reef Balls™: 13.28 kg).

Table 1. – Summary of the percent variability in biomass, CPUE, and red snapper total length explained by nearest-neighbor variables. AR = artificial reef; Linear distance 2 = distance from experimental reefs to the second closest artificial reef.

Independent Variables	Dependent Variables				
	CPUE fishing trips			Diver visual censuses	
	Biomass	CPUE	Mean TL	Biomass	Fish Abundance
reef design					7.29%
season	5.17%	21.26%			
substrate					16.33%
AR abundance 0.10 km^2	34.06%	18.05%		24.46%	
AR bottom area 0.01 km^2		2.36%		8.13%	
AR bottom area 0.05 km^2					11.96%
AR bottom area 0.10 km^2			40.18%		
AR linear distance 2	7.18%				
other variables	4.18%		4.66%	5.51%	
TOTAL	50.59%	41.67%	44.82%	38.10%	35.88%

Mean total lengths (TL) were also significantly different among reef designs. Mean TLs of red snapper caught at Grouper Ghettos™ (mean = 342 mm) were significantly larger than mean TLs of red snapper caught at Reefballs (mean = 314 mm). The percentage of legal-sized red snapper also differed among reef designs; 15.5% of red snapper caught at

Grouper Ghettos™ were > 406 mm TL (legal size limit), in comparison to only 9.6% at Reef Balls™.

Visual Census. – A total of 2144 fishes representing 24 species were observed during diver visual censuses. Similar to the results of CPUE sampling, red snapper and gray triggerfish were the two most abundant fish species. Gag, *Mycteroperca microlepis*, and greater amberjack, *Seriola dumerili*, were also commonly observed and comprised > 4.5% of all fishes, respectively.

Mean reef fish abundances were significantly different between reef designs, but biomasses estimated from visual surveys were not. Grouper ghettos™ supported 28% more reef fish (mean = 41.8 fish per reef) than Reef Balls (mean = 30.2 fish per reef). Although biomasses did not statistically differ between artificial reef designs, mean reef fish biomass was 6.7 kg heavier at Grouper Ghettos.

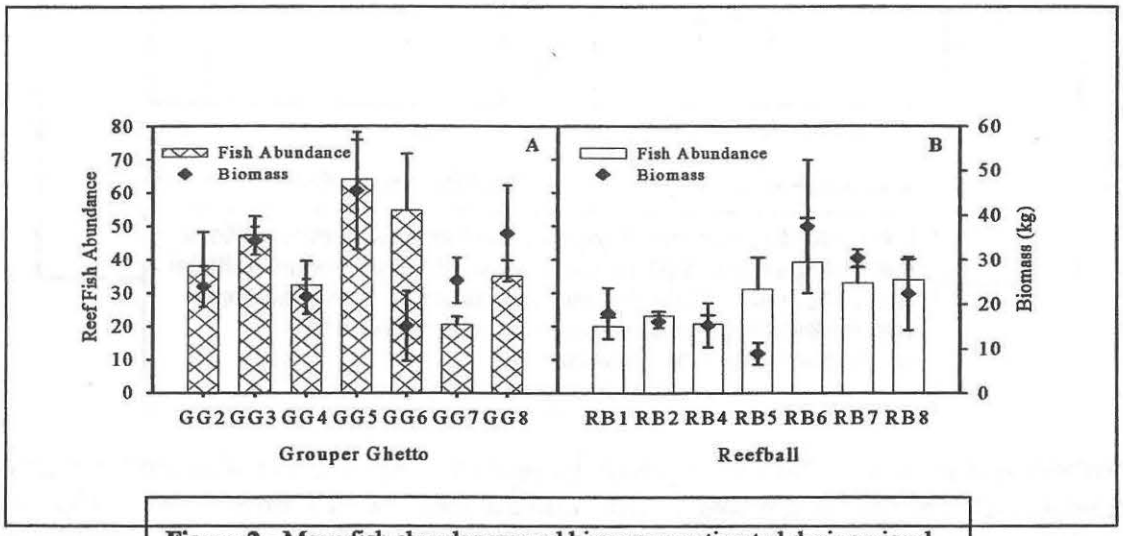


Figure 2 - Mean fish abundances and biomasses estimated during visual censuses for (A) Grouper Ghettos and (B) Reefballs. Note the variability in reef fish abundance and biomass within replicate reef designs.

Variability among replicate reef designs. – Comparison of reef fish abundance and biomass among replicate artificial reefs revealed 2-3 fold differences in fish abundance and biomass (**Figure 2**). Seasonal differences in reef fish abundance and biomass, as well as differences between reef designs, only accounted for 5-22% of the observed variability in reef fish demographics within replicate reef designs. Of the seven Grouper Ghetto™ reefs, Grouper Ghetto™ 5 supported the highest mean abundance and biomass of reef fish during this study, while Grouper Ghetto 6 supported the lowest biomass of reef fish, and Grouper Ghetto 7 supported the lowest abundance of reef fish. Reef Ball 6 supported the highest abundance and biomass of all Reef Balls™, while Reef Ball 5 supported the lowest biomass of reef fish, and Reef Ball 1 supported the lowest abundance of reef fish.

Side-scan sonar. – A total of 685 artificial reefs, comprising approximately 7,700 km^2 of seafloor, were observed within 1 km^2 of my experimental reefs. Seven-fold differences in artificial reef abundance and 16-fold differences in artificial reef bottom area were observed among experimental reef sites. Of the 14 km^2 mapped, approximately 4% was composed of low-relief natural shell bottom (relic oyster reefs). The extent of natural shell within 1 km^2 of each experimental reef site ranged from < 0.01% to > 17.3%.

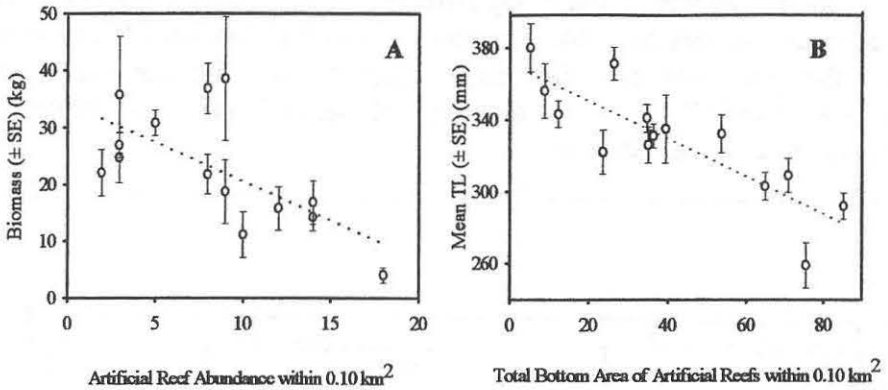


Figure 3 - Scatterplots of (A) reef fish biomass versus artificial reef abundance and (B) red snapper total length versus artificial reef bottom area. Note the decline in biomass and total length with increasing abundance and area of artificial reefs surrounding experimental reefs.

Artificial reef proximity also varied greatly by reef site. Mean linear distance from each experimental reef site to the five closest artificial reefs ranged from 22.9 - 126.2 m. Similarly, distances from experimental reefs to natural reef varied greatly, ranging from 0 to > 600 m.

Results of stepwise regressions revealed that 35-51% of the observed variability in reef fish abundance and biomass was explained by nearest-neighbor variables, season, and reef design. The abundance of artificial reefs within 0.10 km^2 of experimental reefs explained the greatest portions of variability in reef fish biomass and abundance, while the area of artificial reefs within 0.10 km^2 explained the greatest portion of variability in red snapper total length. Reef fish abundances, biomasses, and total lengths all decreased with increasing artificial reef abundances and areas (**Figure 3**). **Table 1** summarizes the amount of variability explained by nearest-neighbor variables for each of the reef fish demographics measured.

DISCUSSION

As an integral first step in understanding whether artificial reefs attract or produce fish this study took advantage of Alabama's extensive artificial reef program and sought to

understand how artificial reef characteristics, such as reef size, reef densities, and reef location, affect reef fish demographics. The results presented in this manuscript agree with the finding of previous studies (Frazer and Lindberg 1994; Lindberg 1996), which found reef spacing and reef densities to have the greatest influence on artificial-reef fish demographics. My observations of 2-3 fold differences in reef fish abundance and biomass were only partially explained (5-22%) by seasonal changes and reef design. Analysis of side-scan sonar data revealed that reef fish demographics were significantly associated with nearest-neighbor variables. I show that nearest-neighbor variables explained 35-51% of the observed variability in reef fish demographic measures, with artificial reef abundance having the most significant effect on reef fish biomass, abundance, and CPUE. In all cases, increases in reef fish abundance (densities) and area resulted in decreased reef fish abundance, biomass, and total length. This may result from increases in density-dependent interactions and/or depletion of benthic prey when artificial reef densities are high (Lindberg et al. 1990). However, more research is needed to determine if this is occurring off coastal Alabama. Based on data reported by Strelcheck (2001), increased densities of artificial reefs do not appear to be limiting the growth rates or site fidelity of red snapper tagged off Alabama.

MANAGEMENT IMPLICATIONS

Issues related to artificial reef abundance and density are especially critical to coastal Alabama, which boasts the largest artificial reef program in the United States (Minton and Heath 1998). The deployment of 20,000 artificial reefs since 1950 has inevitably changed the structure and function of Alabama's coastal ecosystem. Although the deployment of artificial reefs has expanded the range in which reef fishes may forage, the potential impacts of artificial reefs are yet unknown. High catch rates and the presence of reef fish soon after deployment of an artificial reef does not automatically translate into increased production. If fishing mortality exceeds production then coastal Alabama may be acting as a net sink for reef fish production (Schirripa and Legault 1999).

In addition, little is known as to whether reef fishes off coastal Alabama are habitat or recruitment limited. If in fact reef fish, specifically red snapper, are recruitment limited then the deployment of artificial reefs has resulted in a reduction of juvenile nursery habitat (Cowan et al. 1999). If reef fish are not recruitment limited, but rather habitat limited, then the deployment of artificial reefs may result in increased biomass production of reef fishes, as long as fishing mortality is less than production. High artificial reef densities may limit or reduce productivity (growth) by decreasing site fidelity, promoting overgrazing of benthic prey, and increasing bioenergetic demands of reef fishes, however there is no evidence, based on the results of Strelcheck (2001), that artificial reef densities are limiting or reducing red snapper growth or site fidelity off Alabama.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. U.S. Dept. of Commerce. NOAA Tech. Report NMFS 41. 15 p.

Bohnsack, J.A. and D.E. Harper. 1988. Length-weight relationships of selected marine reef fishes from the southeastern United States and the Caribbean. NOAA Technical Memorandum NMFS-SEFC-215. 31 p.

Bortone, S.A. 1998. Resolving the attraction-production dilemma in artificial reef research: some yeas and nays. Fisheries. 23(3): 6-10.

Cowan, J.H., W. Ingram, J. McCawley, B. Sauls, A. Strelcheck, and M. Woods. 1999. The attraction vs. production debate: does it really matter from a management perspective? A response to the commentary by Shipp, R.L. Gulf of Mex. Sci. 17: 137-138.

Frazer, T.K. and W.J. Lindberg. 1994. Refuge spacing similarly affects reef-associated species from three phyla. Bull. Mar. Sci. 55(2-3): 388-400.

Lindberg, W.J., T.K. Frazer, and G.R. Stanton. 1990. Population effects of refuge dispersion for adult stone crabs (Xanthidae, *Minippe*). Mar. Ecol. Prog. Ser. 66: 239-249.

Lindberg, W.J. 1996. Fundamental design parameters for artificial reefs: interaction of patch reef spacing and size. Final Project Report. Florida Department of Environmental Protection. Grant No. C-6729.

Minton, V. and S.R. Heath. 1998. Alabama'a artificial reef program: building oases in the desert.Gulf Mex. Sci. 16: 105-106.

Schirripa, M.J. and C. M. Legault. 1999. Status of the red snapper stock in U.S. waters of the Gulf of Mexico: updated through 1998. NOAA/NMFS Sustainable Fisheries Division, Miami. SFD-99/00-75.

Strelcheck, A.J. 2001. The influence of reef design and nearest-neighbor dynamics on artificial reef fish assemblages. University of South Alabama, M.S. thesis, 137 p.

FISH CENSUS OF SELECTED ARTIFICIAL REEFS IN BROWARD COUNTY, FLORIDA: PRELIMINARY RESULTS

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INTRODUCTION

Derelict ships have no doubt been used to aggregate fish assemblages long before their first recorded deployment off the coast of New Jersey in 1935 (Stone 1985). Over 400 such reefs exist in Florida, with 40+ in Broward County alone. Since 1980, ships in Broward County have been scuttled mainly for fishers and divers in shallow coastal waters, at depths less than 50 m. Despite the popularity of these structures, there have been a surprisingly small number of studies on the fish assemblages associated with sunken ships and few of these have been statistically rigorous (Tsuda et al. 1977, Higo et al. 1978, 1979, 1983, Jones and Thompson 1978, Chandler et al. 1985, Baynes and Szmant 1989, Lindquist and Pietrafesa 1989, Okamoto 1989, Shinn and Wicklund 1989, Stephan and Lindquist 1989, Brock 1994, Markevich 1994, Eggen 1997) or compared the fish assemblages on shipwrecks to adjacent natural reefs (Jones and Thompson 1978, Markevich 1994).

The objectives for this study were: 1) acquire a multi-seasonal portrait of the fish assemblages associated with six ships used as artificial reefs in Broward County, 2) compare the fish assemblages among the six ships, and 3) compare the fish assemblage structure between the ships and the adjacent natural reefs. The study is planned for two years; this paper presents the results of the first year of data collection.

MATERIAL AND METHODS

SITE

The inshore environment of Broward County generally consists of three reef tracts (inshore, middle, and offshore tracts; locally labeled first, second and third reef), each separated by sand substrate, running parallel to the coastline in sequentially deeper water. The six shipwrecks were deployed as artificial reefs at various times between the early 1970's and 1999. All vessels lie on the sandy substrate separating the middle and offshore reef tracts in approximately 20-25m of water.

DATA COLLECTION

During a 13-month period (March 2000 through March 2001) SCUBA divers used a non-destructive, visual census method, commonly called a point-count, (Bohnsack and Bannerot 1986) to determine species richness and abundance at the shipwrecks and the adjacent natural reef sites. Each ship was censused at least four times during the year, two

ships per month. The census of the adjacent natural reefs occurred at irregular intervals throughout the study period.
In brief, the technique is a point count of fishes in an imaginary 15 m diameter cylinder, which extends from the substrate to the surface. The published methodology has the diver remain in the center of the cylinder during the census. Due to the extensive topographical relief associated with the six ships, we modified this aspect of the methodology to allow the diver to swim about within the cylinder during the census.

The diver records all species seen during a 5 min period. After the 5 min species count is completed, the abundance of each fish species and the minimum, maximum and mean total length is recorded to the nearest cm. Total length estimates allow for post-census calculation of biomass using length-weight equations (Bohnsack and Harper 1988). Sample times outside of the five-minute initial count were kept to no more than 20 min. The 20 min time limit was sufficient to complete data collection and allowed divers to complete repetitive dives without the need for lengthy decompression.

The bow, stern, port and starboard sides were censused on 5 of the 6 ships to obtain an estimate of the ship's fish assemblage composition. Due to its high complexity and length, the sixth ship (Edmister) was sampled at two additional mid-ship sites. A total of 114 point-counts were made on the six ships over the 13-month data collection period.

The neighboring natural reefs were censused on east-west transects spaced every quarter nautical mile along the coastline of Broward County. On each transect, a point count was made at the eastern and western edges of each reef, as well as the center, or crest of the reef (for details on methodology see Ettinger et al. 2001). Sixteen transects were made in the vicinity of the permitted artificial reef site containing the ships. Specifically, 15 point counts on the eastern edge of the second reef and 16 counts from the western edge of the third reef are included. Only edge data nearest the ships are included because of their close proximity and the fact that the edges have the most complex habitat which harbor the highest richness and abundance of fishes (Ettinger et al. 2001). Our assumption is that, if fishes are moving between natural and artificial reef, or being aggregated from natural to artificial reef, they will most likely come from neighboring sites. Also, comparing neighboring reef areas of high topographical relief and large numbers of fishes to ships, which also show these characteristics, is probably a more realistic comparison than one incorporating low relief hardbottom.

Statistical Analysis

Fish abundance, species richness, and fish biomass data were entered into a SAS® program and analyzed by analysis of variance (ANOVA) techniques (using PROC GLM procedures) and Student-Newman-Keuls (SNK) comparison of means (SAS Institute Inc., Cary, N.C., USA). The data were not normally distributed, therefore, to be assured of optimum statistical interpretation, the data were subjected to several analysis of variance techniques. Specifically a 2-way ANOVA; a ranked (non-parametric) ANOVA (PROC RANK in SAS ≅ Kruskal-Wallis test); and, due to extreme heteroscedasticity, the log transformation [log (X+1)] was employed (Zar 1999) for abundance data. The

transformed data were analyzed with a parametric ANOVA. Both parametric and non-parametric tests yielded similar results. Therefore, results of parametric analysis of richness and parametric analysis of log transformed abundance data is reported in this paper.

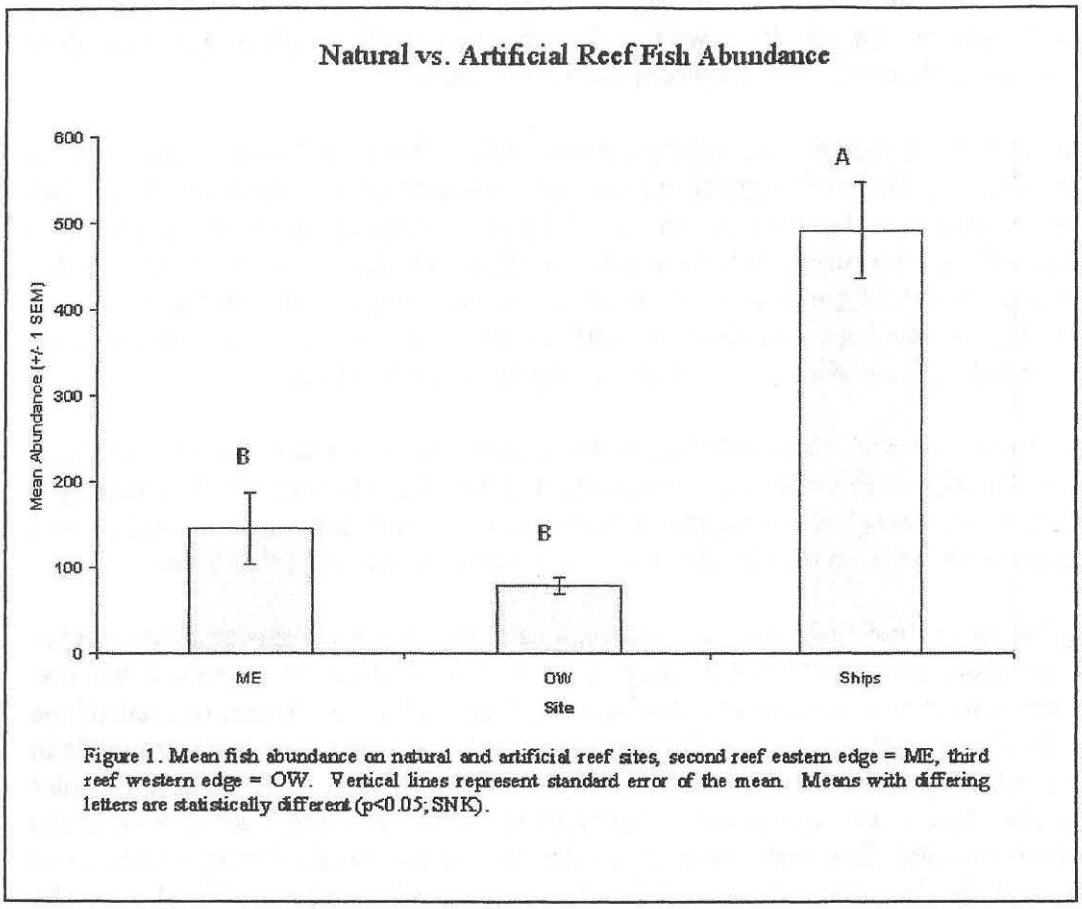


Figure 1. Mean fish abundance on natural and artificial reef sites, second reef eastern edge = ME, third reef western edge = OW. Vertical lines represent standard error of the mean. Means with differing letters are statistically different ($p<0.05$; SNK).

RESULTS

ABUNDANCE

A total of 59,467 fish were counted on ships and natural reef combined. There was no statistical difference in abundance of all ships combined among months ($p>0.05$, ANOVA). There was also no difference in fish abundance among individual ships ($p>0.05$, ANOVA). However, there was a significantly greater abundance of fish on ships than either the middle or offshore reef edges ($p<0.05$, ANOVA), but not between edges ($p>0.05$, ANOVA)(Figure 1).

A total of 191 species were counted on ships and natural reef combined. Of these, 59 were only found on natural reef and 20 only on ships. Excluding the natural sites, but with all ships combined, there was a difference amongst months with December having more species present than May ($p<0.05$, SNK). There was also a difference in richness between individual ships with the "Unnamed Barge" having more species than the Tracy

($p<0.05$, SNK). There were significantly more species on the ships than the western edge of the third reef ($p<0.05$, ANOVA) but not the eastern edge of the second reef ($p>0.05$, ANOVA)(Figure 2).

BIOMASS

There was a statistical difference amongst months on the ships with January having a higher biomass present than July ($p<0.05$, SNK). There was no statistical difference in biomass between individual ships ($p>0.05$, ANOVA). The ships had higher biomass values than either reef edge ($p<0.05$, ANOVA); edges did not differ from each other ($p>0.05$, ANOVA)(Figure 3).

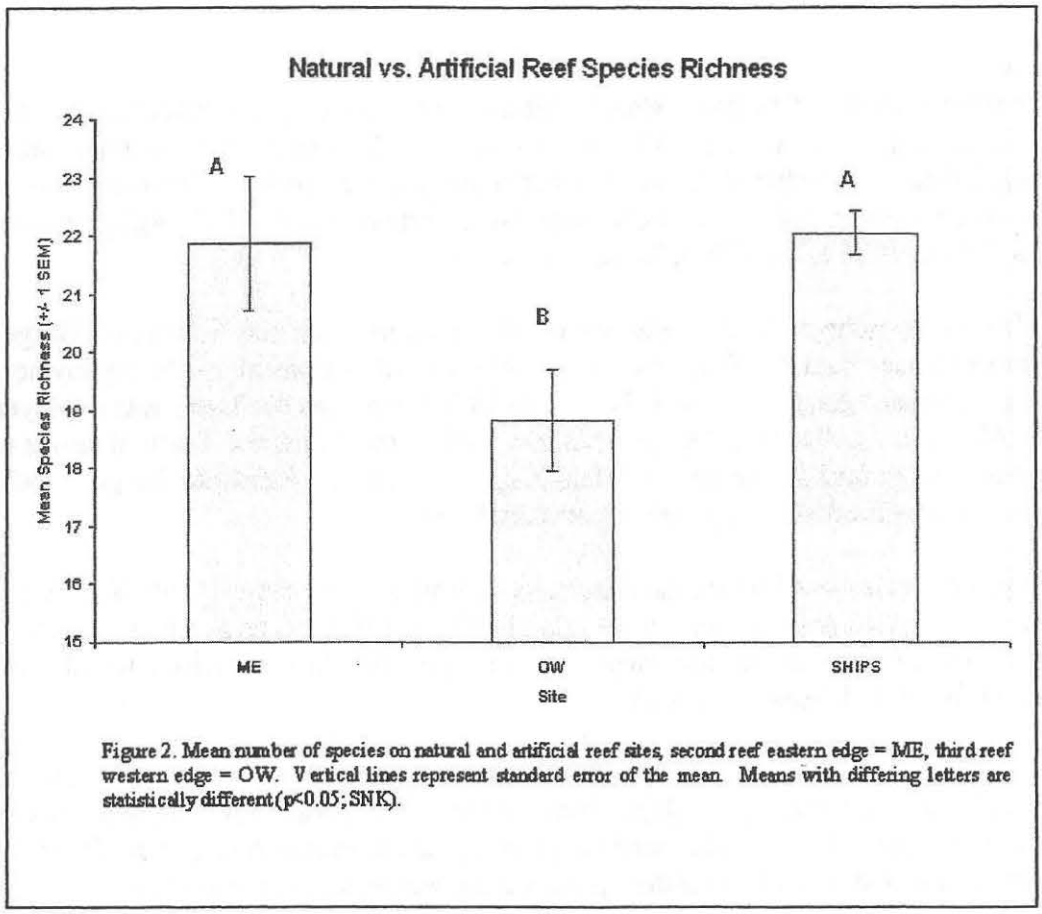


Figure 2. Mean number of species on natural and artificial reef sites, second reef eastern edge = ME, third reef western edge = OW. Vertical lines represent standard error of the mean. Means with differing letters are statistically different ($p<0.05$; SNK).

DISCUSSION

ABUNDANCE

The one thing that stands out concerning fish abundance is the greater abundance of fishes noted on the ships than on the surrounding reef. Similar differences have been reported previously (for references see Bohnsack et al. 1989). In this study there was a

mean of 146 (± 41 SE) individuals on the eastern edge of the middle reef and 79 (± 9 SE) on the western edge of the offshore reef and 491 (± 56 SE) on the ships.

The lower abundance on the natural reefs was apparently not a function of a lower sampling frequency missing a period of increased abundance. A previous study in Broward County, also using point counts, reported abundance means of 108 (± 49 SE) and 75 (± 16 SE) on the second reef eastern and third reef western edges respectively (Ettinger et al. 2001).

The reason for greater abundance on artificial reefs is not clear, but may be due to either the ships providing greater vertical relief or refuge than the surrounding reef edges, or providing access to increased food resources in the surrounding soft sediment or plankton (Lindquist et al. 1994, Lindquist and Pietrafesa 1989).

RICHNESS

The increased numbers of fishes on ships in December versus May is unexpected but not unique. Other studies in Broward County, on artificial as well as natural reefs, have repeatedly indicated a decline in species numbers during winter months. However, several of these same studies highlighted exceptions when winter months had higher species numbers (Spieler 1998 a, b, c, 2000, Ettinger et al. 2001).

The difference in richness values between individual ships, with the "Unnamed Barge" having more species than the Tracy, may be to some extent, a measure of the deployment date. The "Unnamed Barge" was sunk in the late 1970's whereas the Tracy was deployed in 1999. Although the "Unnamed Barge" has less vertical relief than the Tracy, it seems to carry a much richer fouling community. Thus, it appears that the "Unnamed Barge" would offer more diverse food and refuge resources than the Tracy.

The increased species numbers on the ships in comparison to the edge of the third reef is also not surprising, as previous reports on other artificial reefs have reported increased, as well as decreased, species richness values on artificial reefs in comparison to adjacent natural reef (Rilov and Benayahu 2000).

It is also noteworthy that of the 191 species recorded in this study, 59 were only found on natural reef and 20 exclusively on ships. Some of the latter fish are soft sediment species that would be expected to be on the sandy bottom area surrounding the ships, while others are relatively rare and it is unclear if their presence represents a preference (Table 1).

However, some of the species found only on the ships have rarely or never been recorded in natural reef surveys in Broward County i.e. yellow goatfish (*Mulloidichthys martinicus*) and blackfin snapper (*Lutjanus buccanella*). The blackfin snapper presence is particularly interesting, as this is a deep-water species of recreational and commercial value.

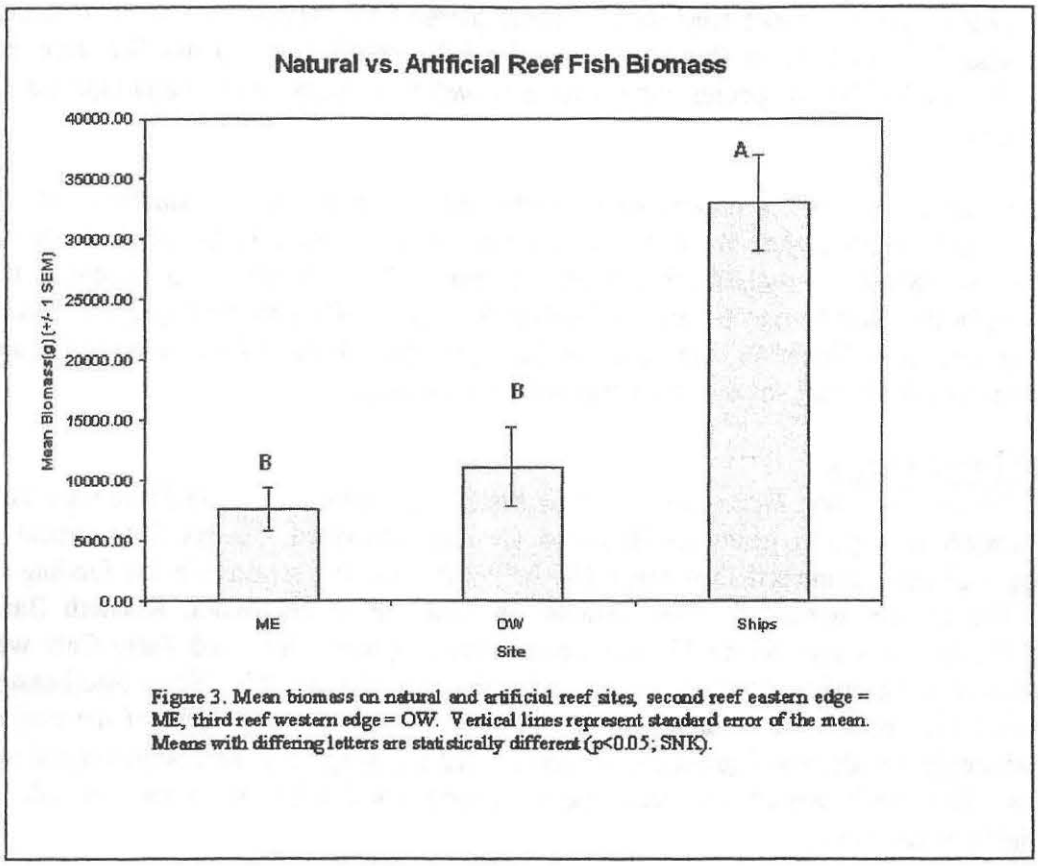


Figure 3. Mean biomass on natural and artificial reef sites, second reef eastern edge = ME, third reef western edge = OW. Vertical lines represent standard error of the mean. Means with differing letters are statistically different ($p<0.05$; SNK).

Only juveniles, ranging in size from 10-26 cm total length, were recorded. Interestingly, another deep-water species, the snowy grouper (*Epinephelus niveatus*) has also only been recorded in shallow water on artificial reef surveys in Broward County in its juvenile stage. It has previously been hypothesized that Broward County reef fish assemblages may be refuge limited (Spieler 1998c). Further, the deep-reef environment (>70m) appears to be mainly low-relief with abundant fine-grained sediment (Ken Banks, Broward County Department of Planning and Environmental Protection (DPEP), Ft. Lauderdale, Florida 33301, Apr. 1999, pers. comm.). Thus, it appears the ships may be supplying ancillary nursery/juvenile habitat for these animals that later migrate to deep water.

Biomass

Biomass has also repeatedly been reported to be higher on artificial than natural reefs (for references see Bohnsack et al. 1989). In this study, the differences in biomass parallel the

differences noted in abundance. This indicates the increased fish abundance noted on the ships is not due simply to large numbers of juveniles, as juvenile fishes normally weigh dramatically less than adults.

CONCLUSION

This study analyzes the first-year's data of a planned two-year study. The second year's data should clarify whether or not the seasonal and site associated distributions of specific species noted here represent true distributional patterns or simply chance occurrences. Nonetheless, it is clear from this study that the fish assemblages on derelict ships and neighboring reefs differ in species composition as well as numbers of fish and biomass per unit volume.

The fact that some species appear to be restricted to, or at least predominate at, the sunken vessels implies that these structures offer some unique resource(s) either not available or limited on neighboring reefs. It would be premature to conclude that increasing both diversity and biomass of fishes in Broward County by deploying derelict vessels is desirable. However, certainly the data presented here indicate a more detailed examination of deploying ships as artificial reefs is warranted.

AKNOWLEDGEMENTS

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REFERENCES

Baynes, T.W. and Szmant, A.M. 1989. Effect of current on the sessile benthic community structure of an artificial reef. Bull. Mar. Sci. 44 (2): 545-566.

Bohnsack, J.A. and Bannerot, S.P. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. U.S. Dept. of Commerce, NOAA Technical Report NMFS 41:1-15.

Bohnsack, J.A. 1989. Are high densities of fishes at artificial reefs the result of habitat limitation or behavioral preference? Bull. Mar. Sci. 44(2): 631-645.

Bohnsack, J.A. and Harper, D.E.. 1988. Length-weight relationship of selected marine reef fishes from southeastern United States. NOAA Technical Memorandum NMFS-SEFC. U.S. Dept. of Commerce.

Brock, R.E. 1994. Beyond fisheries enhancement artificial reefs and ecotourism. Bull. Mar. Sci. 55(2-3): 1181-1188.

Chandler, C.R., Sanders R.M. Jr. and Laundry A.M. Jr. 1985. Effects of three substrate variables on two artificial reef fish communities. Bull. Mar. Sci. 37(1): 129-142.

Eggen, M. 1997. That sinking feeling. Do "artificial reefs" in BC waters increase biodiversity or waste? Alternative. Vol. 23 (1):7

Ettinger, B.D., D. S. Gilliam, L.K.B. Jordan, R. L. Sherman and Spieler, R.E. 2001. The coral reef fishes of Broward County Florida, species and abundance: a work in progress. Proc. Gulf Caribb. Fish. Instit. 52: 748-755.

Higo, N. and Nagashima, M. 1978. On the fish gathering effect of the artificial reefs ascertained by the diving observation _ 2: At the sea of the Satsuma Peninsula in Kagoshima Prefecture.Mem. Fac. Fish., Kagoshima Univ., 27(1), 117-130.

Higo, N., Hashi, H., Tabata, S. and Kamimizutaru, T. 1979. On the fish gathering effect of the artificial reefs ascertained by the diving observation. At the sea of Taniyama,Kagoshima City. Mem. Fac. Fish., Kagoshima Univ., 28, 91-105.

Higo, N., Yoshiga, S, Yoshida, M., Takenoshita, Y., and Hashi, H. 1983. On the fish gathering effect of the artificial reefs ascertained by the diving observation_12: In case of the open seaoff Kanoya City. Mem. Fac. Fish. Kagoshima Unive./Kagoshima-Dai Suisangakubu Kiyo., 32: 229-243.

Jones, R.S. and Thompson, M.J. 1978. Comparison of Florida reef fish assemblages using a rapid visual technique. Bull. Mar. Sci. 28(1): 159-172.

Lindquist, D.G.. and Pietrafesa, L.J. 1989. Current vortices and fish aggregations: The current field and associated fishes around a tugboat wreck in Onslow Bay, North Carolina. Bull.Mar. Sci. 44(2):533-544.

Lindquist D.G., Cahoon, L.B., Clavijo, I.E., Posey, M.H., Bolden, S.K., Pike, L.A., Burk, S.W., and Cardullo, P.A. 1994. Reef fish stomach contents and prey abundances on reef and sand substrata associated with adjacent artificial and natural reefs in Onslow Bay, North Carolina. Bull. of Mar. Sci. 55(2-3): 308-318.

Markevich, A.I. 1994. Species composition and ecological characteristics of fishes of artificial shelters in Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology. Vol.20 (3): 169-173.

Okamoto, M . 1989. Ability of a small observation ROV to observe fish fauna around artificial fish reefs in comparison with diving observation. Nippon Suisan Gakkaishi/Bull. Jap. Soc.Sci. Fish.55(9):1539-1546.

Rilov, G. and Benayahu, Y. 2000. Fish assemblage on natural versus vertical artificial reefs: the rehabilitation perspective. Marine Biology 136: 931-942.

Shinn, A. and Wicklund, R. 1989. Artificial reef observations from a manned submersible off southeast Florida. Bull. Mar. Sci. 44(2): 1041-1050.

Spieler, R.E. 1998a. Artificial reef design: complexity and shelter size. Contract completion report to Broward County Office of Natural Resource Protection.

Spieler, R.E. 1998b. Artificial reef design: void space, complexity, and attractant. Contract completion report to Broward County Office of Natural Resource Protection.

Spieler, R.E. 1998c. Recruitment of juvenile reef fishes to inshore and offshore artificial reefs:final report. Contract completion report to Broward County Office of Natural ResourceProtection.

Spieler, R.E. 2000. Effects of module spacing on the formation and maintenance of fish assemblages on artificial reefs. Contract completion report to Broward County Department of Planning and Environmental Protection.

Stephan, C.D. and Lindquist, D.G. 1989. Comparative analysis of the fish assemblages associated with old and new shipwrecks and fish aggregating devices in Onslow Bay, NorthCarolina. Florida. Bull. Mar. Sci. 44(2): 698-717.

Stone, R.B. 1985. History of Artificial Reef Use in the United States. Pages 3-11 In: Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc., Chelsea, Michigan.

Tsuda, R.T., Amesbury S.S., and Moras S.C. 1977. Preliminary observations on the algae, corals, and fishes inhabiting the sunken ferry "Fujikawa Maru" in Truk Lagoon. Atoll Res. Bull. 212: 1-6.

Zar, J.H. 1999. Biostatistical Analysis. Fourth Edition. Prentice-Hall, Inc. New Jersey. p. 354.

COMPARISON OF FIVE REEF BUILDING MATERIALS

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St. Petersburg College

The Veterans Reef was built in Northern Pinellas County at the request of north county sport anglers. This project provided a unique opportunity to evaluate several different types of artificial reef building units presently in use around the state.

Five different types of reef building units were selected for the initial phases of reef construction. These materials were: scrap steel-hulled barges, solid concrete tetrahedrons, hollow concrete polygonals, natural limestone, and scrap concrete culvert. One objective of this study was to evaluate these five different materials and determine which type of unit attracts the most fish for the money.

Another objective of this study was to provide the answer to an age-old question in artificial reef technology. Do artificial reefs actually increase the fish population, or do they just concentrate the existing fish stocks where they can be easily caught by anglers?

While there are several ways to evaluate the "standing crop" of marine reef fish, one of the most commonly used methods are fish counts by a diver/biologist. For this study a transect line was used that was 50 meters long and a two meter wide area was counted, for a total area of 100 square meters. This reef was constructed primarily for sport anglers and divers, so the fish counts were limited to food and game fish species. A small natural reef a short distance from the Veterans Reef site was used as a "control". Fish counts were conducted on this natural reef prior to the start of the Veterans Reef construction and then counted again at the same intervals as the artificial reef.

The largest and most expensive materials used in the Veterans Reef construction were three steel barges. These were obtained by the contractor and prepared to county specifications prior to sinking. Each barge had large square holes cut into the sides and upper deck to allow light into the interior of the hull and also to allow circulation to prevent any areas of stagnant water within the barge. The total "footprint" of these barges on the sea floor is 2600 square meters. The total cost of these three barges once they were in place on the bottom was $150,000.

The second type of reef unit was a prefabricated polygonal manufactured in Pensacola from concrete. The units used were a four-sided pyramid with a hollow interior. Fifty of the units were six feet tall another fifty were four and one half feet tall. The total cost for 100 of these units placed on the Gulf floor was $58,060. These polygonals were arranged into two parallel rows making a footprint 10 meters wide and 60 meters long, for a total area of 600 square meters.

The third artificial reef unit was a solid concrete structure made from waste concrete in Dade County. This unit was a three sided pyramid made by placing molds at Dade County concrete plants and trucks returning to the plant with left over concrete would fill the molds and add a steel lifting ring. These units were not quite as large as the polygonals and were placed in a single cone shaped pile that was 6 meters tall and 60 meters in circumference at its base. This gives a footprint of 320 square meters. The total cost of these units on the Gulf floor was $40,000.

The fourth type of reef unit used for this project was a barge load of large diameter natural limestone. These rocks averaged between one and two meters in diameter and had a weight of 1500 to over 2,000 pounds each. These large rocks were pushed off the sides and front of the barge to give a horseshoe shape configuration on the sea floor 45 meters long and 25 meters wide. To determine the footprint of the limestone from outside dimensions would be inaccurate because the interior is open sand with no fish habitat. The footprint was calculated using a width of 4 meters wide and 90 meters long, for a total area of 360 square meters. The total cost for the purchase and transport of the limestone was $10,525.

The fifth type of artificial reef unit utilized on this project was large diameter concrete culvert. The culvert was dropped into a large single pile 25 meters long and 10 meters wide, for a footprint of 250 square meters. This material cost about $8,000 total.

To compare the effectiveness of each type of reef unit in terms of fish attracted per dollar spent, we can not get an accurate picture by just comparing total standing crop of fish on each unit. Most of the fish counted on the reef are not utilized by sport anglers and divers. For this reason, the grouper/snapper population was used in this study to compare these five different types of reef units.

Direct comparison of the fish counted per square meter on each 100 square meter transect would not reflect the cost effectiveness of the money spent because the footprint and therefore the fish habitat provided is different for each type of unit. The solid concrete tetrahedrons had a relatively small footprint for their total cost, but were very effective at fish attraction per square meter, while the large steel barges had a very large footprint, but a smaller amount of fish per square meter.

The numbers from the fish count transects were converted to fish (grouper/snapper) per square meter. Then the fish per square meter were multiplied by the total square meters of footprint obtained from each type of reef unit. This gives an estimate of the numbers of fish attracted to each section of the reef. If we then divide that by the total cost of each section of the reef, we can arrive at some estimate of the amount of grouper/snapper attracted per dollar spent.

The concrete culvert was the most cost effective, with a cost per fish of $12.00 per grouper/snapper attracted. The large steel barges were next at a cost of $64.00 per fish.

The solid concrete tetrahedrons were a bit more expensive at $134.00 per fish. The natural limestone was $224.00 per fish and the concrete polygonals were not very cost effective in this study at $9,676.00 per fish. The concrete culvert in large piles is by far the most cost effective of the five materials tested in this project. Even if a private contractor is used to transport the culvert to the reef site, instead of using a county crew, culvert attracts more fish for the money. Part of these savings is because the concrete culvert is already mass-produced for the construction industry, while the new "designed reef units" are custom made at much greater cost. A big advantage of the concrete culvert is that this is a type of solid waste that is generated in all urban areas and one that creates disposal problems to many municipal solid waste operations because it will not burn and takes up a lot of space in a landfill.

The natural limestone used in this project would probably have been better at fish attraction if all the stone was placed in a single continuous pile several meters high.

We found that the food and game fish populations on the natural reef did not have any significant changes during the growth period of the artificial reef. If the new artificial reef was just concentrating fish, then the grouper and hogfish on the natural reef would have decreased. This did not occur, instead the fish populations appear to have the normal up and downs expected for these types of natural fish communities.

In conclusion, until such time as mass production lowers the initial cost of these new "designed units", concrete culvert is by far the most cost effective material to use in future artificial reef construction.

ECONOMIC VALUE OF REEFS IN SOUTHEAST FLORIDA

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This study employed extensive survey research to measure the economic contribution and the use values of artificial and natural reefs in Palm Beach, Broward, Miami-Dade and Monroe counties over the twelve-month period of June 2000 to May 2001. (Johns, Leeworthy, Bell and Bonn, 2001). This study was co-funded by the four counties, the Florida Fish and Wildlife Conservation Commission, and the National Oceanic and Atmospheric Administration. The results from this study are intended to provide public officials with information important to the management of the reef system from Palm Beach County to Monroe County.

The reef users surveyed were resident and visitor boaters who are recreational fishers, reef divers, reef snorkelers and/or visitors viewing the reefs on glass-bottom boats. An intercept survey of general visitors was also conducted. Overall reef users spent 28 million person-days on artificial and natural reefs in the four counties during the twelve-month study period.

STUDY METHODS

This study conducted four surveys as follows:

Resident boaters ..... mail survey conducted in the Fall of 2000
General visitors..... intercept survey conducted in Summer 2000 and Winter 2001
Visitor boaters..... intercept survey conducted in Summer 2000 and Winter 2001
Charter/party boats..... mail survey conducted in Spring of 2001

Visitors are defined as nonresidents of the county that they are visiting. Residents are those who live within the county. The results of this study are based on the responses to these surveys. The resident mail survey resulted in 2,543 completed surveys. The general visitor intercept survey resulted in 3,855 completed surveys. The visitor boater intercept survey resulted in 2,473 completed surveys. These completed surveys provided sufficient information to estimate the economic value of the reefs to reef users and the economies of each of the southeast Florida counties. Three general methods were used to obtain the study results: data summaries; statistical analysis; and mathematical modeling.

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RECREATIONAL USE OF THE REEFS

The number of person-days of reef use by county and by reef type is presented in Table 1. A person-day is defined as one person participating in an activity for a portion or all of a day. Visitors and residents spent 28 million person-days using artificial and natural reefs in southeast Florida during the 12-month period from June 2000 to May 2001. Reef users spent 10 million person-days using artificial reefs and 18 million person-days using natural reefs. The breakdown of reef use by residents and visitors is provided in Table 2. Overall, residents and visitors each spent about 14 million person-days using the reefs of southeast Florida but the proportions vary by county.

A summary of reef use by type of activity is provided in Table 3. Overall, fishing activity on the reefs appears to dominate when snorkeling and scuba diving are compared separately. When snorkeling and scuba diving are considered together as diving activities, diving and fishing contribute about equally to total reef use in southeast Florida. In Palm Beach County, diving is a bit more prevalent than fishing while in Miami-Dade County, fishing is more prevalent than diving. In Broward and Monroe counties, the levels of diving and fishing are about equal.

Table 1
Number of Person-Days Spent on Reefs in Southeast Florida
Residents and Visitors by County. June 2000 to May 2001

	Number of Person-Days (in millions)		
County	**Artificial Reefs**	**Natural Reefs**	**All Reefs**
Palm Beach	1.41	2.83	4.24
Broward	3.98	5.46	9.44
Miami-Dade	2.95	6.22	9.17
Monroe	1.47	3.64	5.11
Total	9.81	18.15	27.96

Table 2
Number of Person-Days Spent on All Reefs
Comparison of Visitor Versus Resident Use in Southeast Florida
June 2000 to May 2001

	Number of Person-Days (in millions)		
County	**Residents**	**Visitors**	**All Users**
Palm Beach	2.98	1.26	4.24
Broward	3.72	5.72	9.44
Miami-Dade	4.51	4.66	9.17
Monroe	3.03	2.08	5.11
Total	14.24	13.72	27.96

Table 3
Number of Person-Days on All Reefs by Recreational Activity
June 2000 to May 2001 – Residents and Visitors (in millions)

Activity	Palm Beach County	Broward County	Miami-Dade County	Monroe County	Total – Southeast Florida
Snorkeling	0.74	1.09	2.11	1.75	5.69
Scuba Diving	1.73	3.85	1.14	0.83	7.55
Fishing	1.76	4.45	5.90	2.45	14.56
Glass Bottom Boats	0	0.05	0.02	0.08	0.15
Total	4.23	9.44	9.17	5.11	27.95

Glass bottom boat sightseeing is available in Broward, Miami-Dade and Monroe counties. The reported number of person-days associated with viewing the reefs using glass bottom boats applies to visitors, not residents. Only visitors were asked for their level of activity on glass bottom boats. Visitors spent about 150,000 person days on glass bottom boats in southeast Florida.

Economic Contribution of the Reefs

As residents and visitors spent money in the county to participate in reef-related recreation, income and jobs were created within the county as a result. The project team estimated the total economic contribution from the use of artificial and natural reefs as summarized Table 4. For instance, reef-related expenditures generated between $139 million and $1.0 billion in income per county during the past year. In addition, reef activities supported between 6,300 and 36,000 full and part time jobs per county. Separate values were also estimated for artificial versus natural reefs.

Table 4
Economic Contribution of Reef-Related Expenditures to Each County
June 2000 to May 2001 – Residents and Visitors

Type of Economic Contribution	County			
	Palm Beach	Broward	Miami-Dade	Monroe
Sales (millions of 2000 $)	$505	$2,069	$1,297	$490
Income (millions of 2000 $)	$194	$1,049	$614	$139
Employment (full & part time jobs)	6,300	36,000	19,000	10,000

Value that Reef Users Place on the Reefs

The value placed on the reef systems by residents and visitors was estimated using a contingent valuation survey. Use value is the maximum amount of money that reef users are willing to pay to maintain the reefs in their existing condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. Overall, visitors and residents in southeast Florida who use the artificial and natural reefs would be willing to pay $255 million annually to protect the artificial and natural reefs of

southeast Florida in their existing condition. Natural reef users are willing to pay $228 million per year to maintain the natural reefs in their existing condition. Artificial reefs users are willing to pay $85 million per year to maintain the artificial reefs in their existing condition. Visitor and resident artificial reef users are also willing to pay $27 million per year to invest in and maintain "new" artificial reefs in southeast Florida.

Opinions on "No-Take" Zones

The study also estimated the value that reef users place on investment in additional artificial reefs and resident opinions regarding "no take" zones. It is apparent from the survey results that a majority of resident reef-users endorse the idea of "no-take" zones in their county. A majority of residents would support "no take" zones on 20 to 25 percent of the existing natural reefs. Such a result provides public officials with information important to the management of the reef system from Palm Beach County to Monroe County.

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References

Johns, Grace M., Vernon R. Leeworthy, Frederick W. Bell and Mark A. Bonn, 2001, Socioeconomic Study of Reefs in Southeast Florida, prepared by Hazen and Sawyer in association with Florida State University and the National Oceanic and Atmospheric Administration for Broward County, Florida, Fort Lauderdale.

GUIDELINES FOR RESTORING MARINE EPIBENTHIC HABITATS

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Florida's crown jewels, her coral reefs have been scarred, fractured, and flattened, thanks to a variety of human impacts: beach renourishment, channel dredging, cable and pipeline installations, and vessel groundings or collisions. Over the past 20 years, groups from state, federal, and private sector research organizations, have developed a number of techniques to restore epibenthic habitats. Restoration's primary focus is to replace that which was damaged and is the first step in the recovery process.

Restoration elements include replacing lost structural relief, stabilizing the loose substrate, and transplanting epibenthic organisms on the restoration structures, with an eye to providing refuge for mobile fauna and suitable settling habitat for recruitment of typical sessile benthic flora and fauna. Details of the restoration for coral reefs were reported in Jaap (2000). In this paper we will focus more on success criteria for all types of epibenthic habitat (hard bottom, reef, ledge, and ridges).

The first priority after a disturbance is removing or stabilizing the loose rubble from an accident, since storms may move pieces around and do additional harm. The techniques include physical removal, planting large structures atop the rubble, using a cement or epoxy grout to immobilize the rubble, or engineering a replacement structure that will use the loose material within the structure. The method of covering the area of loose rubble with an articulated concrete mat has not proven a good solution; the connecting cables break and allow the pieces to scatter. Planting bits and pieces of sponges among the rubble is a biological way to stabilize substratum. Sponges in the genus *Haliclona* grow rapidly and potentially could provide this service.

Restoration goals should be to repair or recreate the damaged habitat. For example, the width, height, and surface topography of formations at Looe Key that were damaged in 1994 by the *R/V Columbus Iselin* incident were well documented in aerial photos. The restoration project repaired the spur formations using limestone boulders, fiberglass reinforcement rods, and hydraulic cement. If this type of information is unavailable, the typical approach is to base the restoration design on the nearby, undisturbed habitat. The principal guideline should be to mimic the natural as much as possible. If the habitat contains two to three foot high ledges, then the module design should use this as a model. Prefabricated structures should maximize use of natural materials. In the past decade, two types of structures were installed off Dade, Broward, and Palm Beach counties in Florida.

The first was called the "DERM" module. It uses a concrete base with embedded limestone boulders. Subsequent evolution of the DERM module added culvert pipes

covered with small limestone rocks. The first DERM modules were installed off Sunny Isles to compensate for damage from a beach renourishment project. They have been stable (survived passing of several tropical storms, including Hurricane Andrew) and the recruitment of algae, sponges, corals has veneered the rock surface with a diverse benthic community. The galleries that lead into the interior surface provide refuge for mobile invertebrates and fish. The second method was to set piles of three to four-foot limestone boulders on the seafloor. These restoration structures are a distinct improvement over aero jacks, rubber tires, automobiles, airplanes, and ships. However, even they can be improved with attention to details.

Coral transplanting is as much an art as a science. The conventional method is to imbed the coral piece in a blob of hydraulic cement. Alternatives include epoxy, wire ties, stainless wire, bolts, and anchoring pins. It is fairly easy to reattach boulder-type corals on horizontal surfaces; it is more challenging to attach a fragile plate-type coral such as *Agaricia fragilis* on a vertical surface. Quick setting epoxy and reinforcement rods work best to do this type of reattachment. Bolting corals to a surface was tested in the *Firat* restoration. Although it proved relatively successful, it was not attractive to see bolts, nuts, and washers sticking through the coral heads.

In strong currents and wave surge, transplanted corals can be held in place using soft weights or sand in plastic sacks; after the cement or epoxy sets, the weights are removed. Octocorals and sponges have also been successfully transplanted, taking the sponge(s) and octocoral(s) with a piece of the substrate and reattaching that to the structure with cement or epoxy. Hudson (personal communication) successfully transplanted numerous octocorals directly into hydraulic cement.

The texture and the type of material used in a restoration structure is important. Virtually any material put under water will eventually attract some plants and animals; however, the texture of the material is an important consideration. Pianki (1966) reported that higher species richness was observed on spatially complex surfaces in the intertidal. Dahl (1973) classified surface rugosity (texture or roughness) by the ratio of the substrate surface with a flat-smooth surface. Dahl reported that surface rugosity has three components: the topography of the substrate (primary); topography or shape of the organisms on the substrate (secondary); and the surface texture of the organism (tertiary). A rounded ridge has a primary rugosity index of 3.7; a half-meter high branching coral with 10 cm distance between individual branch tips has a secondary rugosity index of 3.0; and if the corallites on the branches were 5 mm in diameter, 5 mm apart, and 2.5 mm deep, the tertiary rugosity index would be 2.5. The sum of the rugosity values equal 9.2 (the surface area is 9.2 times greater than a flat surface of an equivalent footprint). Creating roughened textures has been achieved by inserting rocks into concrete, using water pressure to wash out fine material as the concrete sets up and building multi-layered structures using rock and cement. Our observations are that a complex surface texture tends to attract (settle and survive) far more plants and animals than a smooth cement surface.

The structure(s) should be designed to create mini-gyres along the structure. Carleton et al. (2001) showed that an indentation in the reef front retains water in a circular closed eddy. The eddy conserved larvae, provided food for the larvae, and enhanced their settlement. The combined forces of tide, wind-driven currents and the structure of the reef face propagated the eddy. To generate an eddy with a restoration project, the hydrographic properties of the area should be known [tide current (speed and direction), principal wind direction, and other processes that have a relatively stable nature].

Seeding the project area with larvae is still in the experimental stages. Morse et al. (1996) discovered a coral morphogen that attracts the larvae of *Agaricia hummlis* to settle. The potential is that this morphogen (originally isolated from crustose coralline alga) could be added to the structure to stimulate coral larval settlement.

The mobile faunas are generally attracted to a reef-like structure for refuge, possibly food, and nesting sites. The nominal design of most recent structures provides refuge habitat by creating open spaces within the structure. Some structures have large and interconnected open spaces, allowing predators easy access, a shortcoming in design. A preferable design includes: different sizes and isolated tunnels and galleries to sustain various sizes of mobile animals.

Other structures such as old oil and gas production platforms that have been in place for decades, have evolved into unique communities with extensive sponge, bryozoan, coral, mollusk, and barnacle epibenthic communities with abundant fish. These structures are very important recreational fishing and diving assets in the western Gulf of Mexico. Gas and oil structures and sunken ships were installed for very different reasons.

In the past our restoration projects focused solely on trying to enhance fisheries or to repair damaged habitat following a marine accident. We should, however, also consider the recreational skin and scuba divers in the planning of new restoration projects in depths to 100 ft., since southeast and southwest Florida are focal points of the recreational diving community. Structures that are interesting to divers have multidimensional space, highly diverse and abundant species of plants and animals, and are accessible. The success criteria for a restoration project for recreational diving would include many elements that are similar to a fishery or ecological restoration project.

The need to pursue restoration can be reduced significantly if appropriate management is applied to coastal engineering projects. Beach renourishment is not cost effective, has a short term benefit to a few individuals, and should be assessed and paid for by the coastal land owners and not the tax payers. Beach renourishment is a high risk action for epibenthic communities and current technology can't contend with a multitude of environmental insults to the biological resources. Sea level is rising, and the costs of maintaining barrier islands as places to build housing and commercial buildings will become very costly. State, local, and federal governments should neither underwrite

insurance nor continue throwing money into the sea for keeping sand on the beach (Kaufman and Pilkey 1979).

LITERATURE CITED

Carleton, J.H., R. Brinkman, and P.J. Doherty. 2001. The effects of water flow around coral reefs on the distribution of pre-settlement fish (Great Barrier Reef, Australia). pp 209-230 in E. Wolanski (Editor). Oceanographic processes of coral reefs. CRC Press, Orlando.

Dahl, A.L. 1973. Surface area in ecological analysis: quantification of benthic coral-reef algae. Mar. Biol. 23: 239-249.

Jaap, W.C. 2000. Coral Reef Restoration. Ecological Engineering 15: 345-364.

Kaufman, W. and O. Pilkey, 1979. The beaches are moving: the drowning of America's shoreline. Anchor Press/Doubleday, New York. 326 pp.

Morse, D.E., A.N.C. Morse, P.T. Raimondi, N. Hooker. 1996. Morphogen-based chemical flypaper for *Agaricia humilis* coral larvae. Biol. Bull. (Woods Hole) 186 (2): 172-181.

Pianka, E.R. 1966. Latitudinal gradients in species diversity. Amer. Naturalist 100: 33-46.

AN OVERVIEW OF RECENT ARTIFICIAL REEF PROJECTS IN PALM BEACH COUNTY

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INTRODUCTION:

Palm Beach County has been building artificial reefs since the 1960's with the West Palm Beach Fishing Club providing most of the manpower in the early years. By the mid-1980's responsibility for the program shifted to County staff with its first official sinking being the placement of a Rolls Royce in 90' of water. Rationale was that the County lacked a program to acquire the approximate 200' coastal freighter *M/V MERCEDES* that washed ashore on Palm Beach Island that received significant public attention during its several months uninvited stay on Palm Beach. Broward County, having an active reef program at the time, acquired the vessel that instantly became the most popular dive site in southeastern Florida. Palm Beach County realizing its lost opportunity countered with a Rolls Royce and the captioned read ... "Broward County got a Mercedes but Palm Beach has a Rolls."

Since 1986, the County has been involved in scuttling 35 ships and barges and the placement of over 70,000 tons of concrete and limestone boulders involving 80 total reef projects. Most recently, the program has shifted towards constructing nearshore artificial reefs as mitigation for beach nourishment projects. The County has also focused on the construction of inshore artificial reefs including the "snook ledges" made from concrete roof trusses, jersey barriers, and small limestone rock.

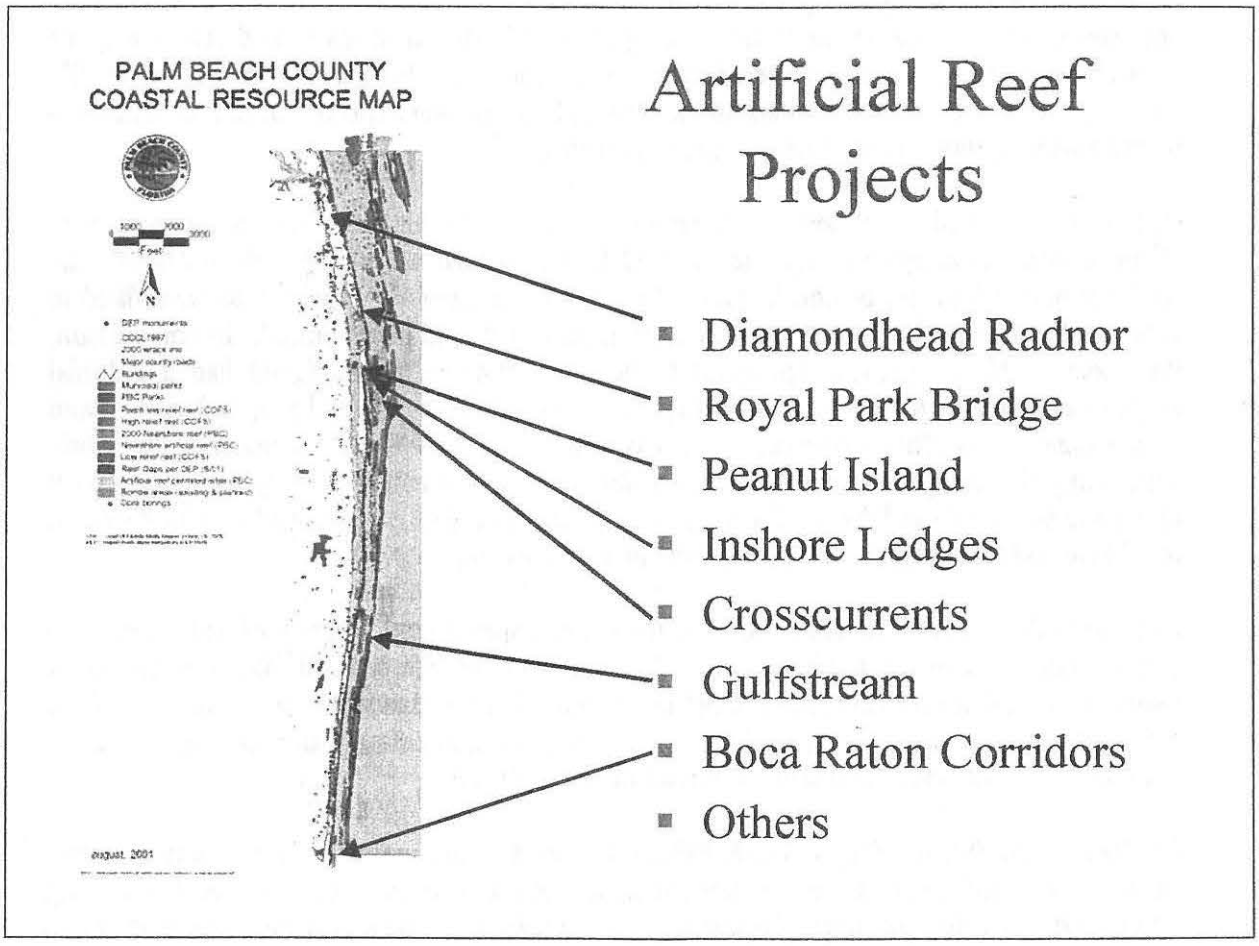
What is particularly unique about Palm Beach County diving is the closeness of the Florida Current and its prevailing northbound currents, sometimes in excess of 2 knots. There is an advantage to the current if the diver "goes with the flow" as opportunities to cover 1 mile of bottom area can be attained. This region is where a mixing of warm subtropical Floridian and cooler temperate Carolinian currents meet resulting in a unique interaction of two marine ecological communities.

Recent Artificial Reef Projects

Since 1998, the County has been involved in the construction of over 25 projects including the sinking of 16 vessels and placement of 17,350 tons and 26,500 tons of concrete and limestone boulders, respectively. Total costs for those projects have exceeded $2 million dollars with almost 60% of those funds derived from tax revenues generated by the County's Tourist Development. Another 30% came from the County Vessel Registration Fees. The final 10% came from the Florida Fish and Wildlife Conservation Commission, the Florida Inland Navigation District and the Florida Department of Environmental Protection.

Diamondhead-Radnor Nearshore Artificial Reef Habitats: A particularly unique project that has been ongoing since 1998 is the construction of nearshore artificial reefs to mitigate for impacts attributable to beach nourishment projects (See Figure 1). The beach projects located along shorelines adjacent to Carlin Park and Juno Beach have resulted in the burial of several acres of nearshore reef situated within the beaches that were widened. The County has wholeheartedly supported the replacement of these reefs with the construction of artificial reefs in proximity to the impacted areas. The construction of nearshore reefs without an under-burden of rock has presented problems.

Figure 1.Palm Beach County Nearshore Artificial Reef Projects



Project 1. Geotextile or Cloth Reefs with Limestone Boulders. In 1998 the County began constructing limestone boulder rock reefs in open sand in 14' to 18' of water using geo-textile or filter fabric to provide support for the rocks placed on top. The theory was that the 300' rolls of fabric would be laid out underwater using trailer anchors to fasten the strips to the ocean bottom. Once the cloth were secured, limestone boulders

approximately 1 ton each were carried by barge to the project site. There the boulders were placed individually onto the geotextile using an excavator with a pincher-like attachment arm. This effort resulted in the construction of 17 strips of fabric or a little less than one mile of material with rock to cover approximately 95% of the area of the fabric.

Total rock necessary to cover the 5100' by 8' wide fabric approached 10,000 tons of limestone boulders a minimum of 140 lbs./cu. ft.. Goal of the work was to lay rock onto the fabric as a single layer but poor visibility and heavy seas made it difficult to achieve. As a result of these situations, the Contractor was permitted to double stack a small portion of the fabric strips provided it did not exceed 10% of the project area and provided that the top of the rock did not exceed -6 feet in elevation relative to MLW.

In order to create a good edge-effect the strips of fabric were laid out with 8-10' spacing between them. It was thought that the open sand between strips would create a more natural condition in replacing the nearshore reefs that were typically bands of low profile Anastasia rock with sand between them. The cloth strips were laid out in four orientations to the currents, wind directions and sand movement.

Based on 3 years of study several observations were made that have lead to the refinement of more recent nearshore reef projects. Depth of water played a major role in whether the rock formation became buried in sand. Depths of less than 15' appeared to have filled in with sand and only the higher profiles of rock have survived being buried. In comparison, the reefs in 18' or greater appeared to be less impacted by sand and had a colonial organisms attached to the rock including Sabellarid worm rock, sponges, soft corals, and hydrozoans. Another observation worth noting was that the sand beneath the fabric supporting the weight of the boulders would undermine creating a sloughing of the rock along the edges of the fabric. The rock would roll towards the open sand on either side of the fabric and fabric edges would become exposed and tear.

Even with these performance problems, the entire approximate 3 acre reef had become an instant success with the fishing community as schools of bigeye shad, blue runners, cigar minnows would utilize this area almost constantly. During that same time, portions of the old Donald Ross Bridge were taken to a 1 acre site immediately offshore of the fabric reefs in 18'-20' of water and have survived the test of time.

Project 2. 2000-2001 Royal Park Bridge Concrete. In the fall of 2000 a second group of artificial reef projects were constructed. As the beach projects were covering ephemeral reefs, the permitting agencies requested that a 1 acre portion of the reefs been constructed in very shallow water to simulate reefs that would be covered over with sand and reappear periodically. Slabs no thicker than 3 feet and no heavier than 10 tons originating from the demolition of the old Royal Park Bridge were taken to the same area and placed in 8'-10' of water. A total of approximately 4,000 tons of concrete were placed in these depths to create an area approximately 1.5 acres in size. Although it was felt that these slabs would not survive the shifting of sand, it was a requirement of the

agencies and therefore constructed. Fortunately, the costs to build this reef was covered by the Florida Department of Transportation as part of the costs to demolish the bridge.

Project 3. Geogrid Mats with Limestone Boulders. In an effort to address the rolling of the rocks off the geotextile, a new and improved foundation for supporting rock was constructed consisting of geogrid units, a stress resistant polypropylene grid mess that was 38' wide and 13' long. The geogrid units were picked up individually using a spreader bar and crane and placed end to end so that the reef sections, equaling 10 units, were approximately 120' long by 38' wide. Geogrid mattresses consisting of smaller mesh grid units with rock fill were placed along the edges of the geogrid units with the theory that rock placed along the inside edges of the mattresses would not roll outside the grid.

Four of these reef units were constructed in approximately 20' of water oriented eastward slanting at 45 degree angles north and south. A modified version of the geogrid unit was also constructed at the suggestion of our Contractor. We substituted interlocking block for the geogrid mattresses and constructed three additional units. The units were placed along the outside ends of two of the geotextile reefs to provide protection from storm waves and sand movement. In an effort to finish the ends of the reef sections, the Contractor placed concrete piles with an average weight of 2-3 tons at the ends of the reef sections to prevent the rock from sloughing into open sand.

The geogrid units seem to provide good habitat for juvenile fishes as they can easily swim in and out of the 1 inch size grid openings and avoid predation (Phil Light, Palm Beach County Department of Environmental Resources Management, West Palm Beach, Florida 33406, July 2001, pers. comm.). The recommendation was to duplicate this type of habitat in future artificial reef construction projects.

Project 4. Scuttling of a 110 foot Deck Barge. We also scuttled a 110' deck barge in 20' of water in alignment with Donald Ross Bridge materials to determine the success of a flat-topped vessel in relatively shallow water. There has been a limited period of observation of these latest projects but several observations have been made of note. The deck barge, although in relatively good shape prior to its sinking, has considerable structural damage at the stern or leeward portion of the barge.

Future Projects. We are currently planning the construction of an additional 2 acres of nearshore reef in an area off of Coral Cove Park situated approximately 5 miles north of the Diamondhead Radnor Site. This rock will be placed in open sand with an under burden of rock found within 1'-2' below the surface. Placing rock onto under burden is the best way to insure its long-term durability and success.

As part of the state and federal permit conditions, all of these reefs will be monitored over the next several years to collect quantitative and qualitative physical and biological data on artificial reefs and nearshore hardbottom to determine the relative effectiveness of these reef materials and designs.

ARTIFICIAL REEFS AS MITIGATION FOR DAMAGE TO NATURAL REEFS: EXAMPLES FROM BROWARD COUNTY, FLORIDA

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Human activities in the offshore environment often result in damage to marine habitats. These activities may be intentional, such as marine construction, installation of pipelines and telecommunications cables, and beach restoration projects, or they may be unintentional as in the case of vessel groundings. Whether driven by economics or human error, however, the results are the same and efforts must be undertaken to restore or mitigate the damage done to the resources.

Restoration of reef damage is the actual replacement of substrate with like-material and structure and may involve transplantation of slow-growing benthic organisms. Mitigation is compensation for damage using different substrates and may or may not include transplantation of benthos. Restoration efforts are generally significantly more expensive than mitigation. A five-step approach to habitat damage and repair has evolved in Broward County in recent years that includes mapping the extents of physical damage and assessment of biological impacts, design of a goal-oriented mitigation or restoration project for the damage, securing funding for the project and compensation for assessment activities, construction of the project, and monitoring for success of the project and recovery of the damage site. Three examples of the use of artificial reefs as mitigation for damage to natural reefs in Broward County are 1) for the grounding of a US Navy submarine (Banks *et al.*, 1998), 2) installation of fiberoptic cables over a coral reef, and 3) proposed mitigation for impacts to nearshore hardbottom communities by a beach nourishment project.

The first example, the grounding of the USS Memphis, represents mitigation for damage to reef substrate and destruction of the benthic community. The USS Memphis, a Los Angeles Class attack submarine (length, 110 m; beam, 10 m; and max draft, 9 m), ran aground on a reef terrace (depth, 8 m) offshore of Hollywood, Florida, in 1993. The area of impact was mapped and quantified by staff from the Broward County Department of Natural Resources Protection as part of litigation by the State of Florida against the US Government for damages. A Circular Strip Mapping technique, as described by Halusky (1982), was used to define the total areal extent of impact and to classify the damage as trench, gouge or surface scrape; scour areas; dense rubble; sparse rubble; or sand cover (Broward County DNRP, 1994). Additional mapping included bathymetric and aerial photography.

To determine biological impacts, abundance and distribution of stony coral species on the reef adjacent to the grounding site was assessed using 20-meter belt transects (Dodge, 1982), and that data extrapolated to the damaged reef. Stony corals were examined because they have slow growth and recruitment rates, and are the last component of the community to recover. The results of mapping indicated that 2310 m^2 of reef were physically impacted and 1205 m^2 of the reef's biological community were totally destroyed. A mitigation plan was developed to include the deployment of a variety of artificial reef modules, monitoring of modules and reef recovery, stabilization of rubble and fractured reef framework, and coral transplantation to the damaged site.

A claim of approximately $2 million dollars for marine resources damage was filed in Federal Court by the State of Florida against the US Navy. After four years of litigation a settlement of $750,000 was reached, and $520,000 was granted to Broward County by the State for mitigation and monitoring. The remainder was used by the State for costs accrued during litigation with the Navy. Settlement funds were inadequate to carry out the original mitigation plan. A modified mitigation included the deployment of limestone boulders and a variety of concrete modules (tetrahedrons, Reef Balls™, A-Jacks™ , Warren Modules) (Figure 1). In addition, stony coral colonies found detached on nearby coral reefs, not associated with the grounding, were transplanted to the mitigation structures using Portland cement as an adhesive. Currently, a research project is underway to look at the use of attractants to accelerate settlement of coral larvae, and, in turn, accelerating reef recovery.

Another example of mitigation is for damages to stony coral colonies caused by the laying of fiberoptic cables. Nine, 13-cm diameter subaqueous cable conduits were directionally drilled under the nearshore reef terrace and beach. Cable laying operations on the offshore reefs resulted in the dislocation of stony coral colonies and abrasion and contact stresses to attached colonies.

A two-part mitigation effort was undertaken. First, dislocated colonies (n=160) were reattached to the nearby reef using Portland cement and tagged for reference. After one year of monitoring, the data indicates that there is a greater than 90% survival rate of reattached corals (PBS&J, 2001). Second, thirty artificial reef modules (DERM Modules (Figure 2)) were deployed on sandy substrate to mitigate for potentially fatal impacts to coral colonies, such as abrasion or over-shading by cables. DERM modules are concrete pipes covered with limestone rocks and were used because they are stable, provide good substrate for epibenthos and economic feasibility. Stony coral recruitment to the modules is being monitored for five years and first-year data indicates that coral recruitment to modules is detectable, although numbers are not available at this time (PBS&J, 2001).

The final example of mitigation involves the deployment of limestone boulders to mitigate for impacts to a nearshore reef caused by a proposed beach nourishment project. Beach fill will be not placed directly on nearshore hardbottom, but it is predicted that approximately 13.5 acres of hardbottom habitat will be buried as beach fill migrates offshore over time. This nearshore habitat is generally low profile limestone pavement

colonized by sparse cover of stony corals, octocorals, and sponges. More significantly, this habitat may be used by juvenile reef fishes and is considered Essential Fish Habitat (EFH) by the National Marine Fisheries Service.

Limestone boulders (1 to 2 meter diameter) will be deployed in a single layer in sand areas along the nearshore reef edge (approximate depth, 3 to 4 meters) (Figure 3) to create substrate of similar texture and relief to the natural reef. The planform mitigation ratio is proposed to be one to one. Limestone has been selected because of its textural and structural similarity to natural reef substrate. It allows rapid colonization by epibenthos and is suitable habitat for boring organisms. It is hoped that the higher complexity of the mitigation, although not identical to the natural reef, will provide a quality habitat for epibenthos and juvenile reef fishes.

The challenges inherent in design of nearshore artificial reef projects are stability from wave action, settling of shallow water structures into the sand, avoidance of wave refraction impacts to downstream beaches, precision placement of boulders, and construction in shallow water among existing natural reefs. Stability and wave refraction analyses are underway to predict the size and vertical elevation of boulders that will remain stable and not cause increased beach erosion by refractive wave focusing. Sediment thickness in the mitigation area has been measured to avoid areas where the boulders might sink and be buried by sand. Boulders will be crane placed to ensure positional integrity. Positioning of the crane barge, however, will require the design of an anchoring strategy to provide horizontal stability without damaging nearby reefs. Methods under consideration include installation of permanent mooring eyes and deployment of mooring blocks. Mooring eyes would involve drilling and cementing steel eyebolts into the reef. Pullout strength of the bolts is critical to this system, and the softness of the substrate may not allow such an installation. Mooring blocks of concrete are more obtrusive but may be designed in a manner that will provide habitat by adding voids in the blocks.

Artificial reefs can not be expected to exactly replace natural reefs, but when reef damage is unavoidable they can be used to provide productive habitat for reef organisms. Artificial reef design philosophy should attempt to match structural and functional elements of the damaged reef and should attempt to meet the goals outlined. Texture and hardness of substrate, structural complexity, vertical relief, and orientation of surfaces should be functional considerations. Positional stability in the wave climate, scour from wave and wind generated currents that may sink the structures, and local sediment transport that could result in burial of the artificial reefs are concerns that must be addressed, particularly in shallow water. Lastly, but of great importance is proper monitoring of the reef mitigation or restoration. A monitoring program should evaluate the recovery of the damaged reefs, as well as examine biological development of the artificial reefs in comparison to natural reefs. Suitable experimental controls are necessary to test hypotheses that may provide information that will aid others in mitigating for reef damage in a functionally and economically effective manner.

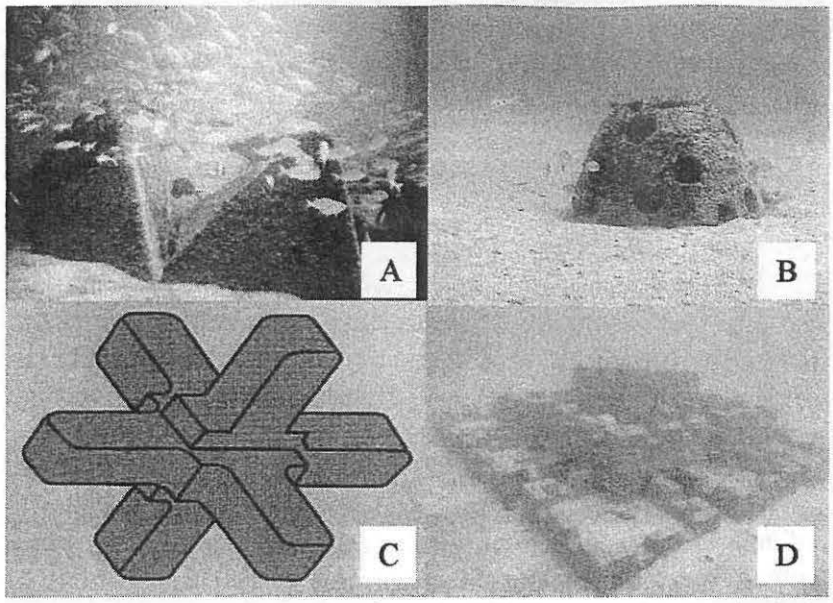


Figure 1. Artificial reefs deployed at the USS Memphis grounding site A) tetrahedrons B) Reef Ball ™ C) A-Jacks™ D) Warren Modules



Figure 2. DERM artificial reef modules are fabricated of concrete with limestone attached to the external surfaces.

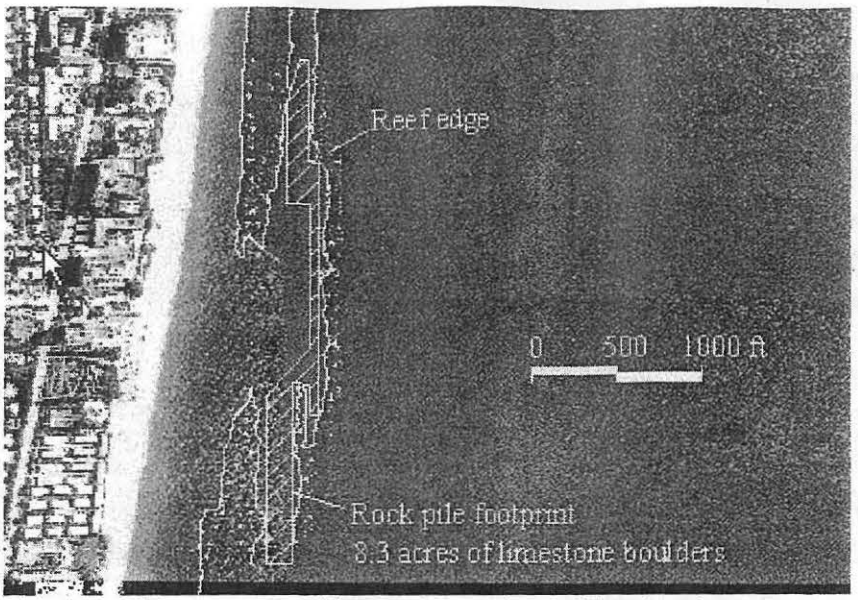


Figure 3. Configuration of limestone boulders to be used as mitigation for nearshore reef impacts resulting from a beach nourishment project in Broward County, Florida. This figure shows a portion of the mitigation area.

REFERENCES

Banks, K., Dodge, R.E., Fisher, L., Stout, D. and Jaap, W., 1998. Florida coral reef damage from nuclear submarine grounding and proposed restoration. *Journal of Coastal Research*, Special Issue 26, 64-71.

Broward County DNRP, 1994. *Grounding of the Submarine USS Memphis: Reef Community Impact Assessment*. Broward County Department of Natural Resources Protection, Biological Resources Division, 218 SW 1st Avenue, Fort Lauderdale, Florida 33301, Technical Report 93-5, March 7, 1994, 26p.

Dodge, R.E., Logan, A., and Antonius, A., 1982. Quantitative reef assessment studies in Bermuda: a comparison of methods and preliminary results. *Bulletin of Marine Science*, 32(3): 745-760.

Halusky, J.G., 1982. Mapping-Circular Strip Map. In: *Artifical Reef Research Divers Handbook*. Ed.: J.G. Halusky. Florida Seagrant College Program Tech. Paper TP-63, 99-100.

PBS&J, 1999. Mitigation Plan for the Deployment of Telecommunication Cables in the Nearshore Waters off Hollywood, Broward County, Florida. PBS&J, Inc., 7785 Baymeadows Way, Suite 202, Jacksonville, Florida 32256, August 24, 1999, 44p.

PBS&J, 2001. *One-Year Monitoring Report for Repaired Corals and Six-Month Report for the Artificial Reef Modules*. PBS&J, Inc., 7785 Baymeadows Way, Suite 202, Jacksonville, Florida 32256, August 24, 1999, 19p.

OVERVIEW OF THE USE OF ARTIFICIAL REEFS AND MARINE RESERVES TO ENSURE SUSTAINABLE FISHERIES AND HEALTHY MARINE ECOSYSTEMS

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Artificial reefs and no-take reserves (NTRs) are the two non-traditional management actions that have generated the most public interest and offer the greatest potential for restoring fish populations (Bohnsack 1996). While fishing requires removing organisms from the ocean, artificial reefs and marine reserves are two ways to give something back. Their use differs in that artificial reefs are designed to increase the number of fish by increasing the total amount of suitable habitat, while marine reserves are designed to increase the number of fish by reducing fishing mortality. Both measures can result in high concentrations of fishes in small areas. Here I describe the potential role of marine reserves and artificial reefs for achieving sustainable fisheries, providing ecosystem protection, and enhancing non-extractive human activities. I also briefly explore the potential use of no-take artificial reefs in a comprehensive system of marine management.

NTRs are marine protected areas closed to all fishing and other forms of extraction. They are a new and additional, spatially and ecosystem-based management tool designed to protect marine ecosystems and support sustainable fisheries. NTRs differ from other forms of fishery management tools in that they permanently protect all species from fishing and other forms of extraction. Specifically they eliminate all extraction of targeted species, unwanted bycatch mortality, and habitat damage from fishing. Habitat and populations depleted or damaged from previous exploitation can recover within reserves by biological processes. Colonization initially occurs by juveniles that settle from the plankton or that immigrate from surrounding areas. Individuals in reserves can grow and persist while those that settle in fished areas tend to be removed. Over time the population abundance of exploited species increases. Biological diversity also increases as rare and vulnerable species accumulate. Within reserves the ecosystem returns to a less disturbed state in terms of community composition, species diversity, population age structure, and dynamic interactions. Ideally, reserves should be established based on precautionary principles of withholding some areas from extractive exploitation until we have a complete understanding of the impacts of fishing.

Marine reserves directly benefit fisheries by spillover and increased total reproduction. Spillover occurs from fishes that migrate from reserves into surrounding areas where presumably competition is lower and food is more available. Spillover is predicted to be primarily a local benefit strongly influenced by habitat distribution and species behavior. Greater total reproduction and dispersal of offspring is likely to be a more important

direct fishery benefit, especially when surrounding areas are heavily fished. Because fecundity tends to be an exponential function of fish size, higher density and larger fishes in reserves can result in greatly increased total production of eggs and larvae compared to exploited areas. Eggs and larvae are then dispersed to surrounding fishing grounds by oceanographic processes. Depending on larval behavior and currents, some individuals may disperse only short distances and resupply reserves, while others may disperse more widely to supply more distant fishing grounds and the wider ecosystem.

Marine reserves also provide indirect fishery benefits, including the protection of the genetic quality of exploited stocks from detrimental selective effects of fishing; reducing annual production variability, buffering populations from recruitment failures. Spatial refuges make overfishing more difficult, protect critical habitat from fishing damage, and can accelerate rebuilding stocks in fishing grounds in case of collapse from overfishing. Reserves also provide reference sites for determining fishery impacts on marine ecosystems; monitoring sites for distinguishing natural versus anthropogenic influences on stocks; and minimally disturbed experimental sites for fishery investigations on behavior, environmental factors, species interactions, and natural mortality. Finally, compared to other regulations, NTRs may be easier to enforce because violations are easy to detect at sea and limited enforcement assets can be concentrated more effectively in limited areas.

The possibility of using artificial reefs as marine reserves has great potential for enhancing diving and tourism by creating high densities of fishes in small areas. This approach has appeal because artificial reefs can be deployed on "unproductive habitat" without disturbing traditional fishing. No-take artificial reefs also can potentially increase public understanding and appreciation of marine ecosystems and their management. Proposed uses of artificial reefs as marine reserves for increasing total fishery yields are much less promising, however, because huge areas would have to be covered by artificial reefs and the total cost would be prohibitive. All the artificial reefs built so far in the U.S. are still only a drop in the ocean compared to the amount of natural habitat. Artificial reefs can, however, be used as alternative fishing sites to mitigate areas lost to fishing by creating marine reserves. A limitation of artificial reefs is that they only benefit reef-associated species, while marine reserves can be applied to a wider range of species and habitats.

In conclusion, both artificial reefs and marine reserves are two tools that can be used in comprehensive marine ecosystem-based management program to achieve sustainable fisheries, provide ecosystem protection, and enhance human activities. Both artificial reefs and reserves complement traditional fishery management approaches that rely on regulating size of capture and controlling total fishing effort. Neither, however, are a panacea or substitute for other forms of management. They will not protect all species, may not be effective for all ecosystems, and on their own will not treat regional problems of pollution, coastal development, human population growth, or global climate change. They must be used in addition to other fishery and resource management measures to obtain high sustainable fishery production. The goal is for marine ecosystems to survive

intact and to maintain unimpaired services. Ultimately, human extractive activities must be within sustainable limits determined by marine ecosystems.

LITERATURE CITED

Bohnsack, J.A. 1996. Maintenance and recovery of fishery productivity. Chapter 11. Pages 283-313 in N.V.C. Polunin and C.M. Roberts (eds). Tropical Reef Fisheries. Fish and Fisheries Series 20. Chapman and Hall. London. 477 pp.

REEF FISH SURVEYS AND APPLICATIONS OF DATA

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The Reef Environmental Education Foundation (REEF) is a non-profit organization of divers and snorkelers committed to protecting and preserving the marine environment. One of REEF's most successful programs has been the ongoing Fish Survey Project, enabling many thousands of divers to gather fish diversity and abundance data on their recreational dives. To date, REEF's fish survey project has gathered over 37,000 surveys from around Florida, the Caribbean, coastal North America, Hawaii and the Gulf of California. The standardized data collection method and central REEF managed database are providing a valuable resource for scientists, marine park managers and interested members of the general public. Data collected as part of the REEF program has many applications and can be useful in documenting species and abundances on artificial and natural reef areas. Following is a brief description of the REEF Fish Survey Project and examples of data applications.

REEF's data collection protocol follows the Roving Diver Technique (RDT) (Schmitt and Sullivan, 1996), allowing divers free range of a defined dive area no greater than 100m in radius. All fish species positively identified during the dive are recorded on underwater checklists, then assigned to log10 abundance categories. Following the dive, data are transferred to computer readable scantrom forms and submitted to REEF headquarters. Once received, survey forms undergo initial QC/QA checks for clerical errors and suspect sightings. Data are then scanned at the University of Miami testing center and processed through additional QC/QA custom computer programs. Once data are clean, they are uploaded to REEF's Fish Survey database and made publicly accessible on the web at www.reef.org.

Data on the web are separated by experience level of the volunteer and displayed as summary reports. These reports include species lists, sighting frequencies and density indexes by geographic area, sighting report location for individual species, site comparisons by date and member life-list reports. Custom reports and full data access is also available to researchers on request.

Once entered into the REEF database the fish survey data have many applications. Spatial and temporal analysis of fish assemblages can be undertaken beyond the basic reporting available on the web. REEF data from the Caribbean island of Bonaire has been used to document differences between dive sites. Analysis of 2,014 surveys, (1,557 of which were conducted by expert observers) representing 1,937 hours of survey time at 58 sites showed distinct differences between mainland island sites and those on Klein Bonaire less than 800 meters away. (Pattengill-Semmens, 1998) (Figure. 1). Similar

analysis could be utilized to help determine differences among artificial reefs sites or between artificial reefs and nearby natural reefs.

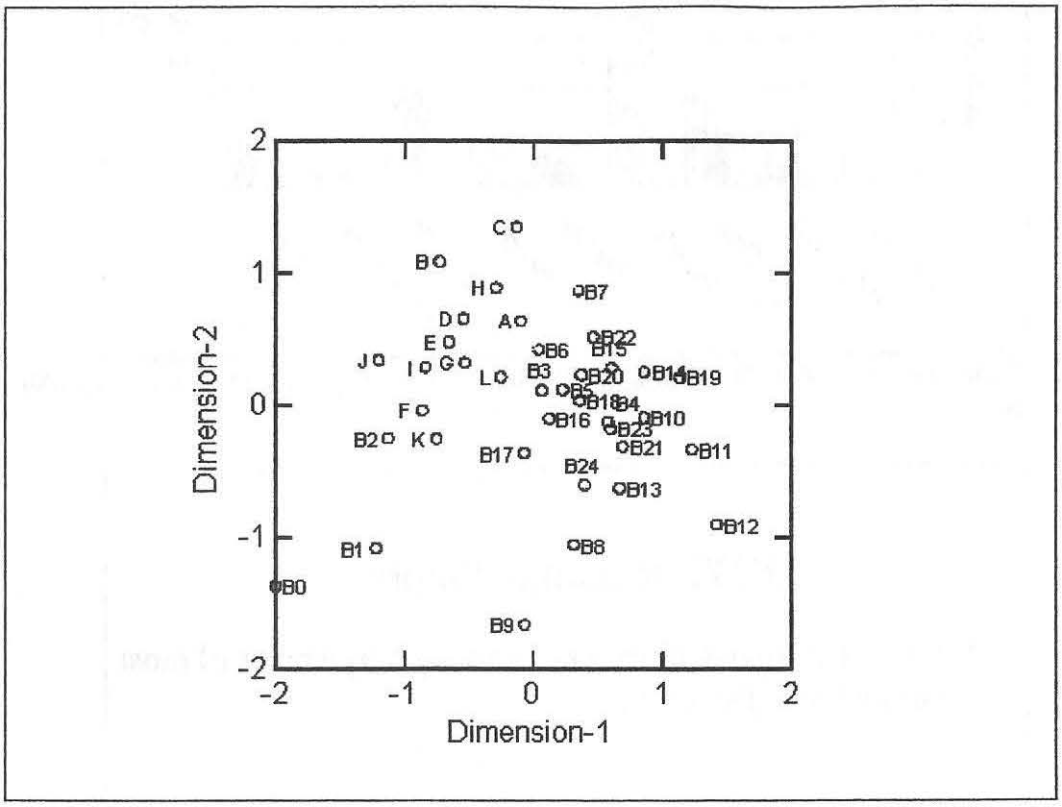


Figure 1. Cluster diagram of site similarity based on rank species abundance. Main island sites are alphanumeric (B0-B23), Klein sites are represented by letters (A – L).

Data collected from the Cayman Islands in the Western Caribbean have also shown utility of the Roving Diver technique. Information collected as part of the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol has shown distinct differences among methods especially for targeted species such as grouper. (Pattengill-Semmens and Semmens, in press). Data gathered using transect surveys (Figure 2) showed no statistical difference in density of grouper between sites in Grand Cayman and Little Cayman, while data collected from the same sites using the RDT (Figure 3.) showed very large differences in sighting frequency of several grouper species. Clearly, each method has its utility, however, for targeted species that may be leery of human presence, the RDT may provide a better measure of presence.

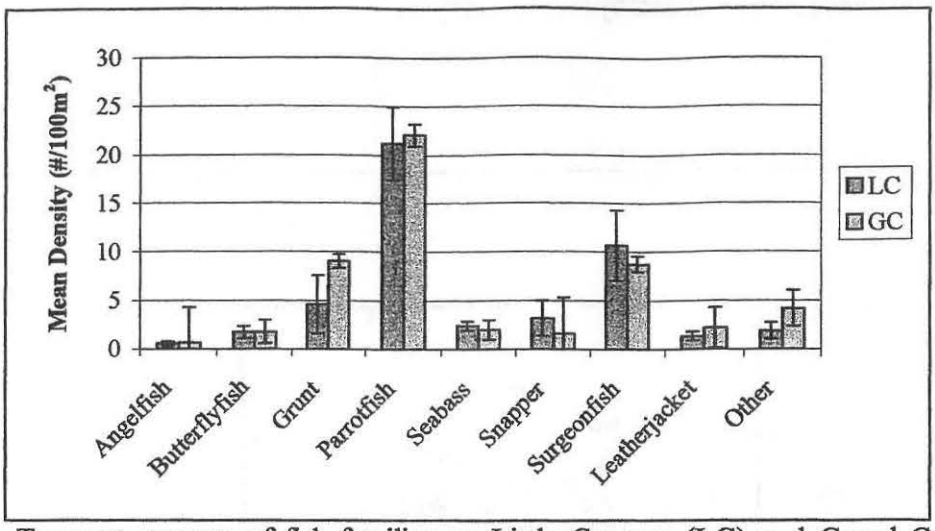


Figure 2. Transect surveys of fish families on Little Cayman (LC) and Grand Cayman (GC) islands

RDT Results- Fishes

- According to roving diver data, sighting frequencies of most species were higher on LC.

Sea Basses	Serranidae	GC	LC
Black Grouper	*Mycteroperca bonaci*	3%	7%
Nassau Grouper	*Epinephelus striatus*	9%	69%
Red Hind	*Epinephelus guttatus*	21%	44%
Tiger Grouper	*Mycteroperca tigris*	12%	50%
Yellowfin Grouper	*Mycteroperca venenosa*	0%	22%
Yellowmouth Grouper	*Mycteroperca interstitialis*	3%	6%

Values are %SF.

Figure 3. Summary of REEF Roving Diver surveys of Grouper species on Grand Cayman (GC) and Little Cayman (LC) islands.

Some of the most encouraging work with the REEF data has come from a partnership with NOAA's Biogeography Unit in Washington, DC. Working with the large amount of REEF data from the Florida Keys National Marine Sanctuary, initial work has focused on combining fish survey data with GIS benthic habitat maps (Jeffrey, et al. 2001) (See Figure 4). The REEF fish survey data provides a layer of spatial information on fish

assemblages at different reef sites in the sanctuary. This data can include proportional make-up of fish community structure by family as well as provide a quick reference for multiple sites and for comparison to benthic characteristics. The information can be easily and quickly understood by managers and policy makers and provide the basis for more detailed study. Future plans in data analysis include helping to define the relationship between fish assemblages and benthic habitat at the site level as well as developing predictive models for determining fish community structure at sites throughout the Keys, particularly in relation to recently implemented no-take marine reserve zones and corresponding reference sites.

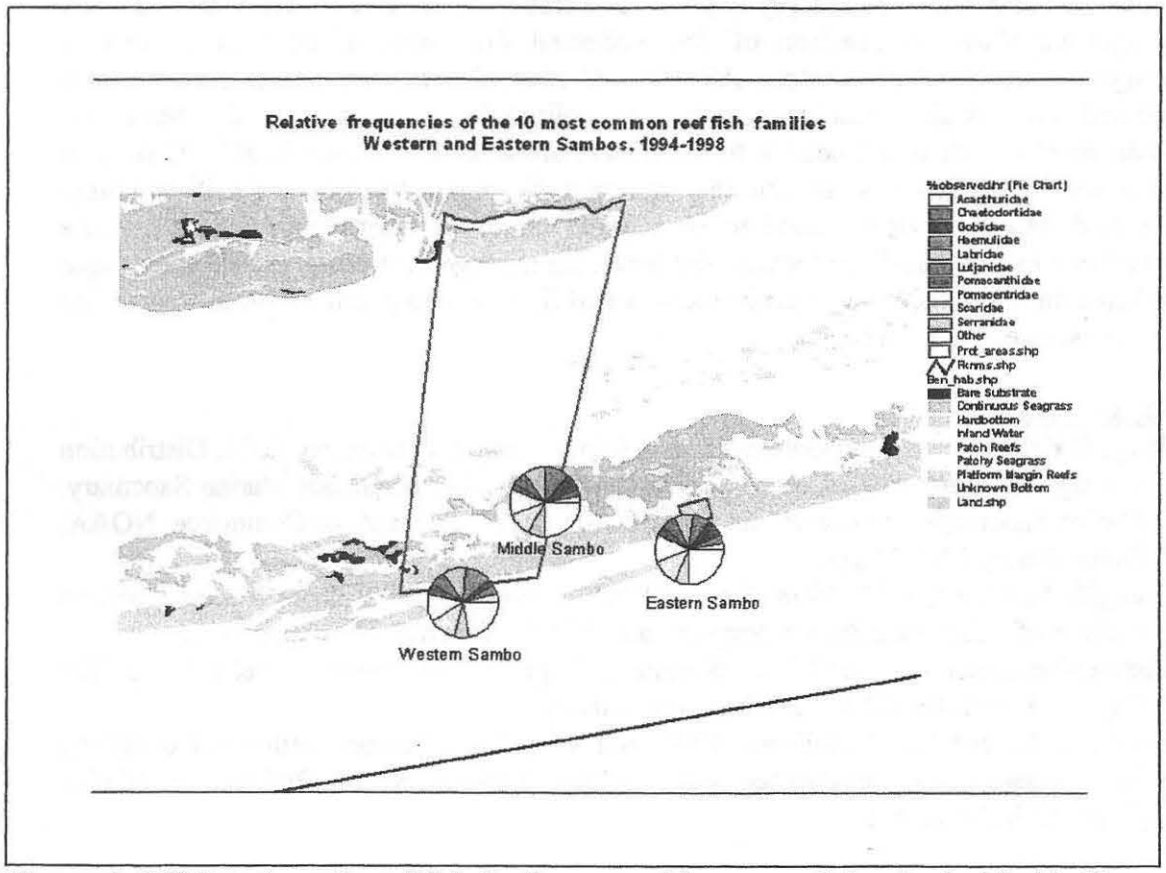


Figure 4. GIS based overlay of fish family composition on reef sites in the Florida Keys National Marine Sanctuary, relative to benthic habitats.

REEF has also worked closely with the Florida Fish and Wildlife Conservation Commission to aid in the standardization of data collection and management by county teams. As part of a contract with FWCC (then DEP), REEF conducted 5 regional training seminars throughout the State in 1999 and 2000. Participants were trained in identification of local fish species as well as how to conduct and complete REEF fish surveys. Local volunteer teams were encouraged to utilize REEF surveys and to submit survey forms for inclusion into the REEF data management system.

Upcoming projects with the FWCC include a two-year project to relocate, map and conduct fish surveys and benthic assessments on sixteen permitted artificial reef sites in the Keys. Many of these sites were placed in the 1980s and have not been revisited since. Coordinates for these sites is also not well known as the loran navigation system was in place during their placement and numerous storms have passed over the sites since their placement. REEF volunteers and fish surveyors from county teams are encouraged to contact REEF if they are interested in taking part in these surveys over the next two years.

In summary, REEF's goal is to provide training assistance, materials for data collection, data management services and high-level assessments of fish assemblages in a wide variety of locations throughout our survey regions. The standardized data collection protocol and management allows comparison of data collected from around the State as well as throughout the Tropical Western Atlantic. It also allows comparisons between data collected on artificial structures with that collected on natural reefs. Numerous standardized reports and feedback to volunteers are available via the REEF website and higher level statistical analysis are also emerging from the dataset. REEF volunteer generated data have been found to have great utility in determining fish assemblage information in a standardized format with little data management costs. REEF encourages participation in the fish survey project and would like to engage any volunteer teams that need assistance.

REFERENCES

Jeffrey, C.F.G., C. Pattengill-Semmens, S. Gittings, and M.E. Monaco. 2001. Distribution and sighting frequency of reef fishes in the Florida Keys National Marine Sanctuary. Marine Sanctuaries Conservation Series MSD-01-1. US Dept. of Commerce, NOAA, Silver Spring, MD. 51 pp.

Pattengill- Semmens, C.V. 1998. The reef fish assemblage of Bonaire Marine Park: an analysis of REEF Fish Survey Project data. 52nd Gulf Carrib. Fish. Inst. Proc.

Pattengill-Semmens, C.V. and B.X. Semmens. in press. The status of reef fishes in The Cayman Islands (B.V.I.). Atol Research Bulletin.

Schmitt, E. F., and K. M. Sullivan. 1996. Analysis of a volunteer method for collecting fish presence and abundance data in the Florida Keys. Bulletin of Marine Science.59(2):404-416.

Fish Assemblages of Exploited and Unexploited Artificial Reefs Offshore of Sebastian Inlet, Florida: Phase I – Experimental Design and Baseline Censusing

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Introduction

As typically managed, the ability of artificial reefs to increase production of reef fishes has long been questioned (Polovina 1991, Grossman et al. 1997). The biological production that does occur on artificial reefs may not be sufficient to offset the increases in fishing mortality due to easy access and high catch rates on artificial reefs (Lindberg and Lofton 1999). Controlled studies of the effects of fishing pressure on the fish communities of artificial reefs are important both in artificial reef management and demonstrating the potential role of artificial reefs as marine reserves. Marine reserves, where no take of marine resources is allowed, are proposed in fishery management to serve as replenishment sources to repopulate adjacent exploited areas (Bohnsack 1994, 1996). These reserves may function by protecting spawning populations, thereby increasing potential larval recruitment, or by the movement of adult fishes from reserves to exploited areas (Russ and Alcala 1996, Johnson et al. 1999). This study is intended to assess fishing effects on reef fish assemblages on a small manageable scale and demonstrate the potential benefits to the fishery of using artificial reefs as marine reserves.

This project off Sebastian Inlet, Florida, is intended to evaluate the effects of public fishing pressure on fish abundance and fish community structure on offshore artificial reefs of the Florida Atlantic coast. A similar study is underway in South Carolina in the same depth range, conducted by the South Carolina Department of Natural Resources. The South Carolina project, and studies on the Florida gulf coast (Lindberg and Lofton 1998, 1999), will allow for comparison of results in a variety of habitats.

It is anticipated that the results from this study may provide a tool for evaluating the potential benefits of Marine Protected Areas (MPAs), by demonstrating that artificial reefs can serve as manageably sized, replicable sampling units for assessing the effects of the elimination of fishing pressure on reef fish populations. Properly designed, sited, and managed artificial reefs may also be useful as a component of the MPAs themselves.

Materials and Methods

In the summer of 2000, four artificial reefs were constructed 12-14 miles offshore of Sebastian Inlet in approximately 70 feet of water. Each reef consists of 570 tons of concrete railroad ties deployed in a single pile. All four reefs were allowed to recruit for

one year in the absence of fishing pressure, as the locations were not made public. In the spring and summer of 2001, baseline fish census data were collected. Resident fishes were censused by a diver-operated video camera, along permanent line transects established on each reef. A variation of transect sampling methods known as the Discrete Group Census was used (Greene and Alevizon 1989, Greene and Shenker 1993). In this method, the resident fish species were grouped into separate guilds based on habitat use (i.e. water column schooling species, reef associated schooling species, cryptic species) and censused in separate runs. This allows the census takers to better focus their attention, rather than attempting to census all species in a single run.

Following the baseline censusing, two reefs were designated as treatment reefs and two reefs as controls. The locations of the treatment reefs were publicized and marked with buoys, while the locations of the control reefs remained undisclosed.

The experimental design for the study includes continued censusing every six months for two years to delineate differences in fish assemblages between the exploited and unexploited reefs, and mail-in as well as web-based angler catch and effort surveys on the treatment reefs.

RESULTS

The study is presently in the preliminary stages, with only baseline data having been collected. The baseline census data indicate an abundant and diverse fish community on all four of the study reefs, with a total of 49 species belonging to 21 families.

DISCUSSION

We expect the results of this study to be of direct benefit to artificial reef management by demonstrating and quantifying the effects of fishing pressure on the resident fish community of an artificial reef. We also expect the results of this study to demonstrate the potential response of a reef fish community to the elimination of fishing pressure. As such, it may serve as a model to predict what benefits, if any, can be expected from the establishment of a Marine Protected Area in this habitat type. Each area to be considered as a potential MPA has a unique recruitment environment to draw from and a unique historical pattern of exploitation. The undertaking of studies such as this one on reefs located in each potential MPA may be able to serve a small scale model of what sort of population or community response might be expected from a reduction or elimination of fishing effort in that specific habitat.

REFERENCES

Bohnsack, J.A. 1994. How marine fishery reserves can improve reef fisheriesProceedings Gulf and Caribbean Fisheries Institute 43: 217-241.

Bohnsack, J.A. 1996. Marine reserves, zoning, and the future of fisheries Management. Fisheries 21 (9): 14-16.

Greene, L.E. and W.S. Alevizon. 1989. Comparative accuracy of visual assessment methods for coral reef fishes. Bull. Mar. Sci. 44 (2): 889-912

Greene, L.E. and J.M. Shenker. 1993. The effects of human activity on the temporal variability of coral reef fish assemblages in the Key Largo National Marine Sanctuary. Aquatic Conservation: Marine and Freshwater Ecosystems 3: 85.1-85.17.

Grossman, G.D., G.P. Jones, and W.J. Seaman, Jr. 1997. Do artificial reefs increase regional fish production? A review of existing data.Fisheries 22 (4): 17-23.

Johnson, D.R., N.A. Funicelli, and J.A. Bohnsack. 1999. Effectiveness of anexisting esturine no take fish sanctuary within the Kennedy Space Center, Florida. N. Am. J. Fisheries Management: 19; 436-453.

Lindberg, W.J. and J.L. Lofton. 1998. Effects of artificial reef characteristicsand fishing mortality on gag (*Mycteroperca microlepis*) productivityand reef fish community structure. Final Report, Grant MR-073.Florida Fish and Wildlife Conservation Commission, Division ofMarine Resources.

Lindberg, W.J. and J.L. Lofton. 1999. Suwannee regional reef monitoring for thesecond summer of public fishing. Final report, grant OFMAS-135.Florida Department of Environmental Protection.

Polovina, J.J. 1991. Fisheries applications and biological impacts of artificial habitats. Pages 154-176 *in* W.Seaman, Jr. and L.M. Sprague, eds.Artificial habitats for marine and freshwater fisheries. Academic Press,New York.

Russ, G.R. and A.C. Alcala. 1996. Do marine reserves export adult fish biomass? Evidence from Apo Island, Central Philippines. Mar. Ecol. Prog. Ser. 132:1-9.

EVALUATING FLORIDA'S ARTIFICIAL REEFS FOR FISHES AND MACROINVERTEBRATES: SOME POINTS TO PONDER

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INTRODUCTION

Artificial reefs are usually deployed in the context of creating new or additional habitat to attract and/or sustain fish (e.g., snapper and grouper) and macroinvertebrate (e.g., larger invertebrates such as crabs, shrimp, clams, and lobsters) species that are the preferred targets of both recreational and commercial fishers. It is assumed by the general public that, for the most part, artificial reefs meet these intended motives. Missing however, are the data and analyses that permit the scientific community to objectively assess these assumptions. It is also important to note that while artificial reefs have been deployed for centuries, their careful and purposeful scientific evaluation to elucidate the specific features or factors (both environmental and reef-based) are understood at a level that makes their design, construction, and deployment configurations only slightly more technical than 'guesswork'. Needed therefore, is a large body of accurately gathered data on the fisheries associated with a reef, measured details on reef features, and an evaluation of the environmental conditions surrounding the reef. These data are essential if we are to begin the enormous and difficult task of gaining some edge on predicting the outcome of a reef project with any certainty. The remainder of this paper will address some issues that should be considered in the process of designing a study to evaluate the fisheries associated with artificial reefs. If done appropriately, we will be able to use these data to fully assess the functional designs and deployment conditions necessary to enhance Florida's nearshore and coastal fisheries.

THE ASSESSMENT CONCEPT

Seaman and Jensen (2000) prepared a flow chart of the necessary steps that should be taken to develop an artificial reef assessment study. The first step is to establish a set of goals or general objectives for building the reef. In a fisheries program, for example, these might be to increase the standing biomass of a particular grouper species, or to raise the average size of red snapper in the area. After the goals and general objectives are established, the specific objectives should be put forth (Lindberg and Relini 2000). These should consist of testable hypotheses that are specific in nature. An example of this would be: construction of a reef having X dimensions and composed of Y materials when placed in area Z that will increase the size of grouper by 4 inches and snapper by 2 inches. This provides the project with objective levels of success criteria that are measurable. The 'assessment concept' provides a pathway for the remainder of the project design that includes a determination of the level of assessment needed, the formulation of a study design and analysis plan, data collection, management and analysis program, and a synthesis of the information and evaluation of the objectives (Seaman and Jensen 2000).

FUNDAMENTALS FOR UNDERSTANDING ARTIFICIAL REEFS

An artificial reef is an added (i.e., extra) substrate or habitat that becomes a part of the naturally functioning aquatic ecosystem. The ecosystem specifics vary from place to place but generally they include trophic (i.e., food) linkages that begin with sunlight acting with nutrients in the water (Miller and Falace 2000). In the water column this results in the production of phytoplankton (free floating, minute plants). Phytoplankton are consumed by zooplankton (free swimming, minute animals), both of these are fed on by small filter feeding invertebrates such as shrimp and clams or fishes such as anchovies. These are fed on by birds and larger fishes, and these by the largest predators that include sharks, whales and humans (Bortone et al. 2000). A similar food-web linkage takes place on the bottom except that attached plants and filter-feeding organisms such as sea squirts and oysters help establish a benthic community. This all too brief summary of the 'life in the sea' is important to understand as it summaries the basic web of life that occurs in the assemblage that is associated with an artificial reef. Influences at any level (e.g., reduced water clarity can reduce available light that lowers phytoplankton productivity that lowers the amount of food available for filter feeders, etc.) can have profound effects on the biota associated with the reef (Miller and Falace 2000).

THE IMPORTANCE OF GOOD TAXONOMY

Accurate species identifications are fundamental to the utility of any artificial reef database used in an assessment. Whether the assessment is a comparison over time or a status report on the standing biomass on a reef, the number of species and their proportional importance in an assemblage (i.e., either number or size) are crucial to understanding biotic interactions on a reef. Identification guides to the various species are available but assessors should be mindful that getting help from professionals should not be thought of as a humiliating experience. Its something any professional does to assure the accuracy of their data. It is important to realize that inaccurate species identifications can nullify the results of the most carefully designed research study. For example, one can assume that the number of individuals of a species recorded is an estimate with some associated statistical sampling error attached to it. Repetitive sampling gives us some idea as to the actual number present. However, no amount of repetitive sampling can correct for a misidentification, especially when the observers refuse to believe they might be wrong!

LEVELS OF ASSESSMENT

In planning a reef assessment study it is important to appreciate levels of study design complexity (Portier et al. 2000). For example, to obtain a 'picture' or description of a reef on a one-time basis for purposes of verification, it may only be necessary to make a few simple measurements, take some pictures, record a few estimates of fish species abundance and call it a day. This is referred to as a Level 1 assessment and is generally useful for descriptive studies. In another example, it may be important to compare the fish assemblage on a reef when it was initially deployed and at some time in the future. These comparative studies are more complex than the descriptive studies and are referred to as Level 2 assessments. Level 2 assessments can also include comparisons between places or comparisons over time and include a series of places over several time intervals. The

most complex studies, Level 3 assessments, are more involved and require data that allow the evaluation of the influence of one or several independent variables on one or several dependent, response variables. These are associative/predictive studies that eventually permit an ability to predict the outcome of some change to the system (i.e., adding another reef module, transplanting fish from one reef to another, etc.).

TYPES OF VARIABLES

In designing an artificial reef assessment study it is important to identify the variables or factors to be measured and recorded. These variables can be classified into two major types: independent and dependent. Independent variables are usually those factors that we suspect as having an influence on the reef components. It is often useful to divide the independent variables into two groups. First are the reef-attribute variables such as size, shape, location, and composition of the reef that are controlled in the reef design process. The second group includes the environmental-condition variables such as weather and sea conditions. The importance of separating independent variables into these to two groups helps us to identify those variables we can control (reef attributes) and those we cannot control (environmental conditions). We usually wish to use the values of the independent variables to help predict the dependent variables. Dependent variables are usually those biotic features of a reef that are likely to be affected by the independent variables. Dependent variables, therefore, can be most often thought of as the types of things we want from a reef such as target species biomass, number of species, number of individuals, size of individuals, and species diversity, etc.

METHODS USED TO MEASURE VARIABLES

There are host of 'standard methods' books available that will help determine the best methods for measuring the independent variables identified as environmental conditions. Thermometers, refractometers (used to estimate salinity), depth gauges, etc. are examples of equipment used to make these measures. Accurate latitude and longitude measures of reef location should be taken with a GPS or, preferably, with a DGPS (differentially corrected global positioning system). These variables should be measured on site, during the actual sampling. Care should also be taken to record time of day and date of the sample event as well. Many reef measures are most accurately measured before the reef is actually deployed. In practice, however, this not often done as the reef is already in place when the study begins. Reef unit configuration measures (distance between reefs, height of a pile of units, etc.) are more reliably measured in the water as the actual deployment configuration often differs significantly from what was planned.

Dependent variables can be measured from two different perspectives: fishery dependent and fishery independent – depending on the study objective. For example, if the objective for building a reef is to improve the catch per unit effort (CPUE) of a particular species, then obtaining estimates of CPUE based on the actual fishery methods used by the fishery participants is essential. Thus we would employ the actual sampling methods (number of hooks, size of nets, etc.) used by the fishery. If our objectives were to improve non-fishery related variables such as species diversity or species richness (number of species)

then we may want to use a fishery independent means to gather the data. By way of example, these methods could include nets with a mesh not used in the fishery.

Another way to categorize the sampling methods is to classify them as being either destructive or non-destructive. Generally, fishery dependent methods are destructive – they remove fish from the assemblage. Many fishery independent methods can be considered destructive as well. An example would be the use of an ichthyocide toxin, such as rotenone, to kill fish. In Florida, the use of poisons is not a standard fishery dependent technique (although they are used by fishers in some parts of the world!).

The most common non-destructive, fishery independent sampling techniques used to assess artificial reefs for dependent variables are visually based. Visual census techniques are preferred under many circumstances. They are easily adaptable to a variety of assessment objectives, they are relatively inexpensive and, if operators consistently use clearly defined protocols, they can provide valuable and useful data on fishes and macroinvertebrates. Oppositely, because most visual techniques are 'diver operated' they suffer from any circumstance that leads to diminished vision underwater. Storms, darkness, and algal blooms are just some of the circumstances that can lead to reduced visibility. Diver-operated visual censes are also physiologically limited because of the restrictions depth and amount of bottom time impart on diver safety.

There are three general methods that have been successfully used to conduct visual assessments for fishes and macroinvertebrates on artificial reefs (Bortone et al. 2000). The first of these is the line-transect in which two divers, swim pairwise along a preset line or compass heading and count and estimate sizes of fish by species within a prescribed space and time limit. This method has the advantage of putting divers in closer proximity to the fish as they move along the transect. The method, however, requires recording data while swimming and this can be difficult under some conditions. More important is the fact that most artificial reefs are generally not of sufficient length to warrant a transect survey; therefore, transects have been most often used on natural reefs that are generally more extensive. A second method, called point-count, is often used in artificial reef surveys. With this method, a diver/observer takes a position on or near the reef and enumerates all fishes within a circle (actually a cone because the vertical distance must also be defined) having a specified radius. The observer slowly turns at the center of the circle and conducts the survey for a specified amount of time.

The advantage of this technique is that it is site specific (and therefore easily used on even the smallest artificial reef) and facilitates the diver's ability to record observations. The disadvantage is that when water has low visibility (less than 3 m or about 10 feet), this technique is not particularly useful as smaller fishes at the outer edge of the circumference are often difficult to see or identify. A third general technique is called the random-swim technique in which a diver swims 'randomly' (actually haphazardly!) over the study area and lists species in the order in which they are first seen. The observer continues listing species for a period of 50 minutes (less time in low diversity areas) and indicates 10 min intervals on the list. Later, the species are weighted for relative

abundance by scoring a 5 for species seen in the first 10-minute interval, 4 in the next 10-minute interval...etc. The principle here is that abundant species are seen first and rare species are difficult to find and are likely to be seen last. Because variance in the dataset is high, it is necessary to repeat the procedure at least 8 times and sum the scores. The resulting dataset is a list of species with abundance scores that reflect their relative abundance in the assemblage. This method allows observers sufficient time to make positive identifications and often yields datasets with large numbers of species. The disadvantage of this method is that only relative scores of abundance are obtained and it is very time consuming. Variations and combinations of each of these methods have been used. More important than using any particular method is making sure the protocols of dimension and observation time are kept consistent within any study. Voiding these two methodological features will result in data that are incomparable.

OTHER THINGS TO CONSIDER

Estimating number of individuals requires some practice. Be aware that most divers over estimate the abundance of rare fish and underestimate the number of abundant fish. When encountering large schools of fish, it is sometimes helpful to estimate the number of groups of individuals. For example, an observer gets an idea as to about what a group of 100 looks like and then estimates how many groups of 100. This will be handy when one encounters a school of several thousand anchovies! When enumerating a mixed species school, it is often best to estimate the proportion that each species makes to the total and then estimate the total number of fish in the school.

Size estimates of fish, in total length, can be done underwater with enough accuracy to provide useful information during a reef assessment. Size estimates help determine the population structure present on the reef and can also be converted, by way of a mathematical equation, to biomass. Some divers prefer to estimate size according to terms such as small, medium, and large. This is permissible as long as the terms are clearly defined (e.g., small = 0-10 inches, medium = 11-20 inches, and large = 21-30 inches). Estimating actual size is not that difficult, it just requires practice like everything else. Having a rule marked on a slate helps estimate size. Divers should be aware that despite the magnification feature of water (i.e., objects appear 25% larger or closer underwater) observers have tended to underestimate the size of fish in the water (Mille and Van Tassell 1994).

Recording data underwater requires some attention. Although there are waterproof papers available, most reef assessors find using a pencil to record data on a plastic slate, roughened with sandpaper, to be the most practical and least expensive option. Experiments with underwater video cameras have potential in recording assessment data. Video provides a permanent record and species identifications can be verified by others. Coupling underwater video with the ability to record information audibly underwater appears to be the best alternative to date. This requires a full-face mask as well as a video camera in a waterproof housing but prices are reasonable enough to allow purchase by most programs.

A Summary of Important Points to Consider

1. Use the Assessment Concept
2. Clearly define the goals and objectives for an assessment that reflect the purpose for deploying the reef
3. Identify the independent and dependent variables that will be necessary to address the objectives
4. Establish appropriate and clearly defined methods to measure these variables
5. Be consistent in the application of methods
6. Continually practice faunal size and number estimation skills
7. Verify species identifications by obtaining voucher specimens and advice

Literature Cited

Bortone, S.A., M.A. Samoilys, and P. Francour. 2000. Fish and macroinvertebrate evaluation methods. Pages 127-164. In: Seaman, W., Jr. (ed.). 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, Florida.

Lindberg, W.J. and G. Relini. 2000. Integrating evaluation into reef project planning. Pages 195-235. In: Seaman, W., Jr. 2000. Purposes and practices of artificial reef evaluation. Pages 1-19. In: Seaman, W., Jr. (ed.). 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, Florida.

Mille, K. and J. Van Tassell. 1994. Diver accuracy in estimating lengths of the parrotfish,*Sparisoma cretense*, in situ. Northeast Gulf Science 13(2):149-155.

Miller, M.A. and A. Falace. 2000. Evaluation methods for trophic resource factors – nutrients, primary production, and associated assemblages. Pages 95-126. In: Seaman, W., Jr. (ed.). 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, Florida.

Portier, K.M., G. Fabi, and P.H. Darius. 2000. Study design and data analysis issues. Pages 21-50. In: Seaman, W., Jr. (ed.). 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, Florida.

Seaman, W., Jr. and A.C. Jensen. 2000. Purposes and practices of artificial reef evaluation. Pages 1-19. In: Seaman, W., Jr. (ed.). 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, Florida.

THE PALM BEACH COUNTY REEF RESEARCH TEAM WHAT DO WE DO?

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Palm Beach County Reef Research Team

OVERVIEW

The Palm Beach County Reef Research Team which is a group of volunteer divers, was formed 10 years ago to monitor the County's artificial reefs under the auspices of the Florida Oceanographic Society. The Team has been gathering data under State monitoring grants awarded to the County's Environmental Resources Management Department since 1996. The goal of the Team is to provide quality biological and physical data for use by the County and the State.

TRAINING

To provide quality data, training the Team members is an important part of the Team's operation. The Team is fortunate in that long-standing, experienced members knowledgeable in their field of monitoring can provide all the training. Each new diver must complete the initial Research Diver Orientation which is about 16 hours of classes including an in-water session. During the orientation, the following topics are covered: identification of 50 frequently-seen fish species including the methods for fish counting; introduction to monitoring of the invertebrate assemblages; introduction to photography and videography methods to collect data; mapping; physical data collection; safety; and diving skills as they pertain to Team activities.

After this initial training, new members are "apprenticed" with experienced Team members to practice skills in their chosen area of interest. Team members are encouraged to become proficient in multiple areas. On-going training includes regular sessions at the Team meetings and a comprehensive set of quizzes for fish identification on the Team web page. Advanced classes provided for further training are: fish identification; invertebrate assemblage identification and methodology; and photography/videography data collection and camera care. To become a "fish counter", a member must pass a 50-fish test with a 90% or better accuracy and also pass a retest each year.

For the current Florida Fish & Wildlife Conservation Commission monitoring grant, the Team monitors 8 artificial reef sites. The site structures vary from a ship, concrete bridge pieces, and limerock boulders in the 85+ ft. depths to Jersey barrier ledges, limerock boulders, and prefabricated modules in the 20 to 25 ft. depths in the marine and also estuarine environments. The reef ages vary from brand new (concrete bridge pieces) to older established reefs (Princess Anne-8 yrs. and Habitat Corridors-7 yrs.). These established sites are monitored annually; whereas the other reefs which have undergone additions or are relatively new are monitored quarterly. During each monitoring event, fish assemblages are counted, photographs are taken for invertebrate assemblage

analyses, physical data is collected, a video of the reef is made, and mapping is done according to what is needed.

DATA COLLECTION

Each reef is mapped with permanent benchmarks installed. This information is converted to a CADD map. Fish and invertebrate stations are referenced to the benchmarks. To assist in these tasks, a Team member developed a method to collect GPS points at our deeper reefs. We have been unable to gather this information at our deeper sites (85+ ft.) because they generally have strong currents which precludes taking GPS points from the boat. This method uses a handheld GPS unit in a waterproof container attached to a dive flag. The GPS/flag assemblage has a known-length tether line and by noting how much line is let out, the depth at the location in question, a compass heading for the tether line, and the time (to compare with the timed points taken by the GPS unit), and with mathematical calculations, we derive GPS points. Data from this method (which we have dubbed, "Wade-O-Meter" after its inventor) has been verified by comparisons with differential GPS points taken at our shallow sites and with existing maps, and the GPS points were found to be accurate.

On each monitoring dive, fish are counted at a minimum of 6 fixed stations for 10 minutes, recording species, numbers, sizes, and age class (juvenile or adult) on a waterproof form. At the end of the 10 minutes, the fish counter then roves the rest of the artificial reef gathering additional fish data on species and numbers. A photographer takes pictures at designated locations perpendicular to, and 2-3 ft. from the substrate for invertebrate assemblage analyses. Physical data is collected (water/air temperature, visibility, current, etc.), and a video pattern is taped. Mapping measurements are taken where needed.

Once on land, the mapping information is added to update the CADD maps; the video tape is watched and a log is created; and the physical and fish data are entered into the Team database. Fish data is also entered onto REEF's scanforms and sent to REEF. The invertebrate data slides are developed and each slide is projected onto a grid. The primary organism in the grid square is identified to lowest taxonomic level for 25 data points that were generated by a random number generator. Originally 100 points/slide were taken, but a comparison of the data generated from 25 versus 100 data points showed minimal difference in data proportions but maximal difference in volunteer time and effort in getting the data.

Handling the resultant data by the Team has undergone several evolutionary changes over the years. Originally a laptop computer was used to enter all data into a database in dBase by one person. This method required that individual to collect and interpret all data sheets from all divers. Originally the diver's data was handwritten on a slate and transcribed to a form at the dock. Multiple transcriptions led to a lot more errors, and burnout on the part of the one person was a problem. Next, more people became involved, but it necessitated passing the laptop around. This was an improvement from the one-person data entry, but it was not quicker or safer for the Team database.

Next, to increase safety/security for the database, the Team looked to the web and found a free storage site. Free storage web sites only store files, sometimes up to 50 mb. The database was set up on a free site. To enter data, someone had to download the whole database to their PC and then leave a message on the web site that they had done so. (This prevented others from downloading different versions of the database.) After entering data, the database was then uploaded and the message removed. This worked less than moderately well as it required the user to have a copy of the database software on their PC, in this case MS Access 97, and to be moderately computer-savy. As this was not a very intuitive method and in a volunteer group computer savy varies, almost nobody did it error free.

The next step was to try a commercial internet service provider. One was chosen that supported MS Access. The database was uploaded to the site and entry/query forms were created in HTML. The lesson we learned here is that it places a tremendous load on the server to be running your queries against an Access database rather than a simple text file. When we tried to check the data that had been entered by querying the database, we got timeouts from the server before more than a few records were loaded into the user's browser. Also, a knowledge of HTML restricted who on a volunteer team could do this programming, and this need could place a very heavy load on a single individual(s) who has the appropriate knowledge.

To get away from the HTML programming need, we next tried a commercial application service provider. These providers are of fairly recent origin, and they allow you to construct an application, such as a database system, on their server. The user constructs the necessary forms and tables within the application. The first web site of this type we tried was Bitlocker®. It was an excellent service but went out of business almost immediately after we were set up. We switched to Quickbase®, which is provided by Intuit, the company that makes Quicken®, so we assume they will be around a while longer. Data entry forms were created for use. Whenever possible "dropdown" lists were created which helps the data entry effort but also helps to reduce error.

DATA HANDLING:

Each diver enters data into the database from his/her data sheet at home. Invertebrate data from slides are recorded on data sheets by the person analyzing the slide, and this data is also entered from one's home. The Fish/Invertebrate group leaders then take charge to ensure that data is entered timely and to notify the database manager when the data is complete from a dive. The database manager or other computer literate person then downloads the data as a text file. It is then cleaned (a problem we are still working on) and converted to the formats to generate the tables, charts, and (fish) biomass calculations for the reports.

The Team's methods for fish data have the advantage of providing biomass information by species and by family as well as age-class (juvenile versus adult) use of the artificial reefs. Species and numbers information can also be added to REEF's statewide database. By keeping the data in a web-based database format, anybody can enter their data from

any computer and any type of output is possible. This format easily would lend itself to statewide use. Fish data could perhaps be modified to taking the detailed size data for biomass calculations for the grouper-snapper complex only. Age-class information is very important for artificial reef designing to learn what is really working for what age class. A statewide database on a web location would enable all groups to enter their data in a standard format and the data could be readily available for teams providing the data and to potential users of the data for research, reef design, etc.

JACKSONVILLE REEF RESEARCH TEAM BUNNY'S WEB ARTIFICIAL REEF/REEF BALL STUDY MONITORING GRANT WORK FOR 2001

LEX WATERS AND JOHN PERKNER
Jacksonville Reef Research Team (JaxRRT)

INTRODUCTION

For the past two years, the Jacksonville Reef Research Team (JaxRRT) has been focusing its monitoring efforts on a site off Ponte Vedra Beach called Bunny's Web (BW). The site is almost directly between the Mayport and St. Augustine inlets in Northeast Florida. It is about 14.7 nm on a heading of 163 degrees from the Mayport jetties and lies in 50 to 55 feet of water. The site is approximately 5.6 nm directly east off the beach from Mickler's Landing in Ponte Vedra Beach. The bottom is characteristic hard sand/shell bottom with little variation across the site.

REEF SITE SPECIFICS

The Bunny's Web site is composed of three primary deployments with all placements within ½ mile of each other. The oldest deployment was concrete bridge rubble placed in 1992. In 1998 a large deployment of concrete culverts was also placed here. Most recently, a reef made exclusively of 530 Reef Balls™ was deployed on June 5, 2000.

This reef, called the Kirbo Memorial Reef Ball™ Reef, lies within ½ mile of the other two older concrete placements. It is made up of a variety of Reef Balls™ varying in size from 2 feet in diameter up to 6 feet in diameter with the balls ranging in weight from 90 lbs. up to 3,800 lbs.

They include 100 ultra, 175 pallet, 155 Bay, 25 Lo-pro , 25 oyster and 50 mini Reef Balls™. The Reef Balls™ were constructed during the winter/spring of 2000 and placed here in June 2000. An attempted was made to place in them in a grid/cluster by crane, however most Reef Balls™ randomly dropped and 10-20% broke on impact with the bottom or other modules. The Reef Balls™ are not uniformly distributed and are mostly in clusters 50-100 feet from each other.

METHODS

As part of our current monitoring grant requirements, all three sites were carefully mapped over the past year by our "underwater methods certified" Reef Research Team Dive members (methods as defined in Artificial Reef Research Divers Handbook, Florida Sea Grant College, J. Halusky, October 1991). Besides the mapping that has been completed, we have also completed numerous fish counting events directly related to the monitoring grant at all three deployments from the April through September 2001 time frame.

The fish counting data collection efforts (which actually started prior to the monitoring grant work) began shortly after the deployment in June of 2000. This has allowed us to monitor the Reef Ball™ placement (over time) since its initial introduction into the BW deployment area.

The fish counting method utilized was the "*relative abundance/SOCA*" method (also defined in the Artificial Reef Research Dive Handbook cited above). Although it was not part of the monitoring grant work there was a significant amount of additional information gathered around the evolution of the Reef Ball™ placement (in terms of invertebrate growth and encrustation of the modules and information about the "size" of fish species on the reef). Unfortunately, the Relative Abundance method as currently defined does not capture species size. However, it was noted in numerous fish count logs that many of the species counted were either juveniles and/or much smaller adult fish compared to similar species on the surrounding older artificial reef placements.

RESULTS

Species richness increased at the Reef Ball™ site through the survey period while it remained consistent at other sites in same time frame. The number of fish counted increased at the Reef Ball™ site and at other sites through survey period. The "Similarity Index" increased through survey period. Table 1 below shows the data from two survey efforts.

Table 1 Example of Data Collected:

Findings/Date	**5/20/01**	**(N= 8)***	**9/08/01**	**(N=12)***
	Site 1	RB Site	Site 1	RB Site
# of Different Species	26	16	28	23
# of Fish Counted				
S = 1	8	4	7	5
O = 1-9	6	3	6	2
C = 10-99	9	4	8	6
A = 100+	3	5	5	10
Similarity Index	.42		.53	
Visibility	15 ft	15 ft	20 ft	20 ft

* 6 divers were the same on both events

Since we were able to look at all of these artificial reefs in a relatively contained deployment area over time we were able to do "similarity indices" for all combined data collection events and for individual events that occurred on the same day at the various placements. This provided some excellent insight as to how different fish populations

(from both an attraction and abundance perspective) might relate to the type of reef placement and the maturation of a placement (specifically the Reef Ball™ placement). For example, one key finding was that red snapper were almost always observed in the "common" abundance category (11 to 100 fish) on the older placements, while they were almost non-existent on the Reef Balls™.

SUBJECTIVE FINDINGS

More small fish and juveniles were seen on the Reef Balls™, particularly black sea bass and Atlantic spadefish, as compared to the other sites. A few very large fish such as Goliath grouper and black drum were observed on the Reef Balls™, but not on the other sites.

Multiple sightings of octopus were documented on almost every dive event at the Reef Balls™ site, however none spotted at other sites. It was also interesting to note that although the Reef Balls™ seem to attract primarily "smaller" fish, that two of the largest fish ever counted in our monitoring events were spotted on the Reef Balls™. Our first officially "counted" Goliath grouper (a single one) was identified at the Reef Ball™ placement on September 8, 2001 and measured 4-5 feet in length (estimated). Also numerous large black drum have also been counted at the Reef Ball™ site during the late August and September fish counting events and were usually counted as "occasional" abundance category (2 to 10 fish).

Overall, we feel our study of the Reef Balls™ and surrounding reef structures and placements have provided a good deal of data about how this type of structure can support certain types of fish species and populations. We feel that with enhanced methods definition and with further data collection (more fish counting events, over time as the reef further matures), we can learn even more about the attraction/abundance opportunities that these structures provide.

SUGGESTED MODIFICATION TO STUDY DESIGN

We should add a size component to the *"SOCA/Relative Abundance"* method, since it appeared to the divers that there was difference in fish size distributions s among the reefs. Also we need to attempt to do more monitoring events at multiple locations at same time/day allowing for similarity indices to be calculated with less variability due to time/condition factors.

CHARLOTTE MARINE RESEARCH TEAM

DR. JON HUBERTZ
Charlotte Marine Research Team (CMRT)

The Charlotte Marine Research Team (CMRT) is a non-profit corporation of volunteer divers and others interested in sustaining the marine environment in Charlotte County, Florida. CMRT was incorporated in February 1999. Working with the local Sea Grant agent, Mr. Richard Novak, CMRT permitted and began a new artificial reef site, the Palm Island Ferry (PIF) Reef, offshore Charlotte County in March and June of 1999. In anticipation of monitoring the new reef, a scientific diver's course was developed. Dr. Alex Brylski assisted CMRT in developing and presenting the course that introduced scientific and survey methods and fish identification to the first group of volunteer divers. The course was presented in the summer of 1999 and graduated 11 divers in August 1999. Monitoring supported by CMRT began while the CMRT applied to the Florida Fish and Wildlife Conservation Commission (FFWCC) for a monitoring grant in March of 2000. The grant was approved and FFWCC supported monitoring began in October 2000.

Presently, the team is 12 months into an 18-month contract to monitor species and abundance at three artificial reef sites. Two of the sites are close to the county line in neighboring Lee County to the south, Figure1.

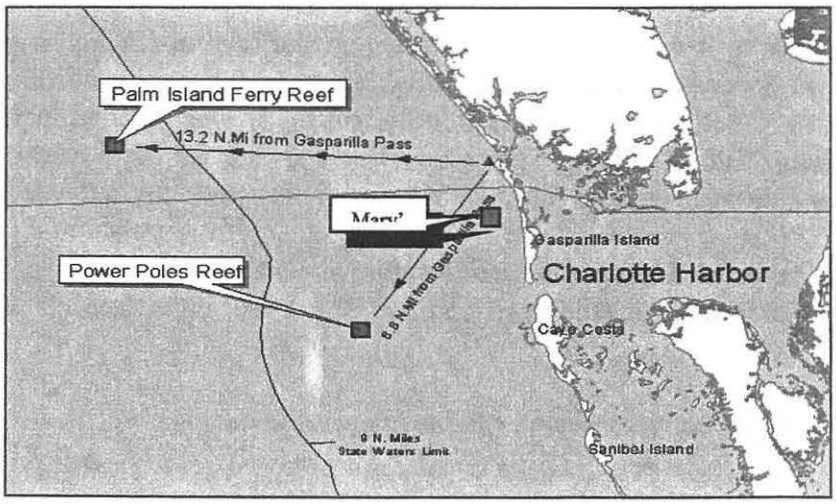


Figure 1. Location of reefs CMRT is monitoring, 2000-2002, (courtesy of Bill Horn FWCC.)

Mary's Reef and the Power Pole Reef are older sites, 12 and 9 years, respectively. The PIF reef is presently about 2.5 years old and consists of a car ferry (60x20x5 feet), a barge (70x23x8 feet), concrete culvert (30 pieces), and junction boxes (2 pieces) in a depth of 50 feet.

The objective in constructing this reef was to sink these two structures relatively close (150 feet) to each other and modify access to the habitat by the size of holes cut into the sides and top. Figure 2 shows the relative location of the two structures.

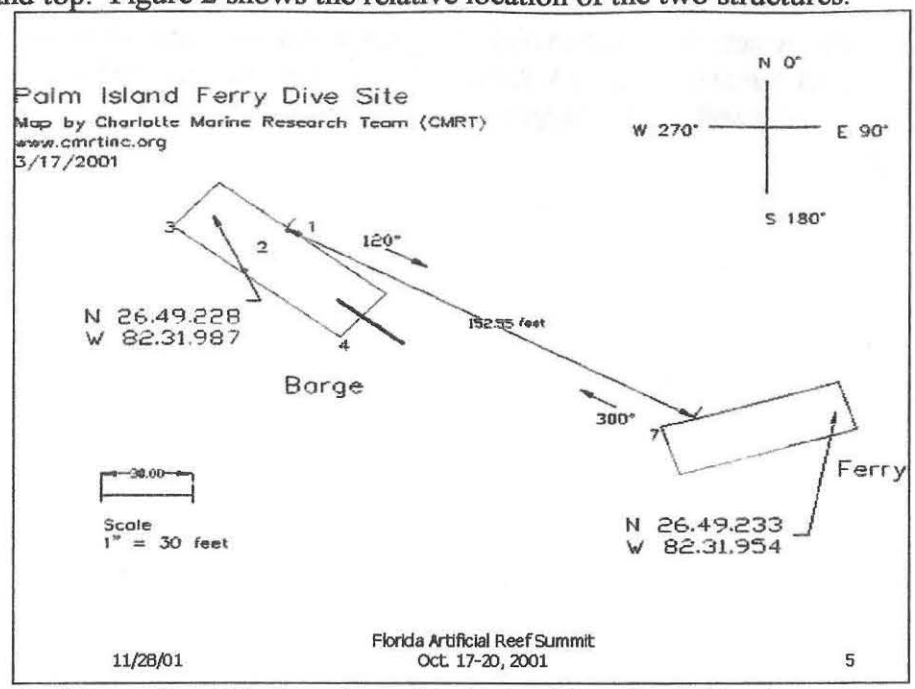


Figure 2. Schematic of the location of the Palm Island Ferry Reef structures.

The ferry was sunk so it would land upside down on the bottom resting on the extended car ramp and two concrete junction boxes. Six 18 x 24-inch holes were made in the deck and multiple 2 to 3-inch holes were made in the sides. It was planned that this habitat would shelter small fish. The barge was planned as a habitat for large fish so two 3-foot square holes per side were cut and four 4-foot square holes were cut in the deck.

Both structures have remained in the same location as when they were sunk. Some slight movement was noted after the passage of Category 1 hurricane Gordon in September 2000.

Monitoring of the reef complex since its deployment indicates:

(1) The ferry with fewer and smaller holes is good habitat for baitfish.
(2) The barge with more and larger holes is good habitat for large fish, namely Goliath grouper.
(3) There are a variety of fish sizes observed indicating possible production of biomass.
(4) There are many species present. The most common are tomtate (abundant >100) and Goliath grouper (many 11-100).

During the remainder of our monitoring contract, we will do separate fish species and abundance counts on the ferry and barge site to detail the populations of the two structures.

The CMRT is a relatively new organization and we appreciate the invitation to present our work at the 2001 Reef Summit. We look forward to a continuing relationship with the FWC and expansion of scientifically designed artificial reefs in Charlotte County and Southwest Florida.

THE ORGANIZATION FOR ARTIFICIAL REEFS' RESEARCH DIVE TEAM

SCOTT VASCAVAGE
Organization for Artificial Reefs

INTRODUCTION

The Organization for Artificial Reefs' (OAR) Research Dive Team (RDT) was formed in 1989 to aid OAR in the placement and monitoring of manmade reefs. This team of dedicated experienced divers has undergone special training in underwater survey, mapping, marine biomass and diversity assessment. The primary goal of the RDT is to perform all underwater tasks necessary in the development of permanent public artificial reefs, OAR's central objective. RDT is the primary tool that OAR uses to locate suitable sites for the construction of new reefs.

ORGANIZATION FOR ARTIFICIAL REEFS (OAR)

The Organization for Artificial Reefs, Inc. is a private, 501c(3) nonprofit group of marine enthusiasts and artificial reef advocates based in Tallahassee, Florida. Founded in 1985, OAR serves the recreational saltwater fishing industry of Florida's Big Bend Gulf Coast by promoting the professional development of public artificial reefs. OAR is committed to responsibly designing and deploying artificial reefs as a means of protecting and enhancing a variety of marine life for the sake of both biodiversity and for promoting the enjoyment of the saltwater environment by the sport fishing and sport diving communities. OAR uses only the best science and technologies available in pursuing its goals.

Primarily relying on volunteers, OAR is made up of a dues-paying membership base that is called upon to carry out its various duties. A non-paid coordinator and an 11-member, non-paid board of directors, which holds monthly meetings open to all members, govern the organization. OAR thus strives to operate at every level as a professional organization, as opposed to a club, with highly cultivated ties to key organizations in Florida and leaders in state government and in the local community.

Central to OAR's operations is the organization's Research Dive Team. They are a group of specially trained divers skilled in conducting the types of underwater work essential to the creation and monitoring of well-designed artificial reefs.

HISTORY

In 1989, several members of OAR attended a training session conducted by Joe Halusky from the Florida Sea Grant Extension Program in Marineland, FL. The members came away from the training with the necessary tools to create a research dive team. By the end of 1990, dive standards were developed and the first group of divers was trained.

Since then the training class has been offered annually, and over 80 divers have been trained in underwater data collection techniques and methods.

Since conception the team has been involved with various reef building and monitoring projects. In 1994, RDT subcontracted with Taylor County to conduct bottom surveys for 10 proposed sites. Once the reefs were constructed, RDT was contracted in 1996 and 1997 to perform three fish census events on each of the new reefs. The task itself was very challenging because the reefs are in five different counties.

In 1998, surveys were performed for the Florida Gas Transmission Reef and Two Dogs Reef site located off Franklin County, . After the completion of the Two Dogs Reef in 1999, RDT was awarded a grant from the FWC to perform monthly fish surveys. Along with the creation of the Two Dogs Reef in 1999, RDT also performed a bottom survey for the OAR2K reef. In 2000, along with the continuing monitoring of Two Dogs the team performed a bottom survey for the Rose City Reef, and assisted with the creation of Florida Gas Transmission and OAR2K reefs. Along with the new reef construction RDT also assisted with the enhancement of Marker 24 Barge Reef. The RDT continued it's monitoring of Two Dogs, and assisted with the enhancement of the One More Time and Yamaha Reefs in 2001.

CURRENT PROJECT

The Organization for Artificial Reefs (OAR) and the Research Dive Team (RDT) are currently conducting monthly monitoring on the Two Dogs Reef in Franklin County. This reef was constructed in June 1999, and consists of 2 equally sized patch reefs separated by about a ½ mile distance. One reef is constructed of fabricated reef balls ™ and the other concrete culverts. The team has been sampling each reef, and comparing fish species and populations.

FUTURE PROJECTS

RDT is starting a new monitoring project in April 2002. The project involves the monitoring of the Wakulla Big Bend Regional 2 (WBBR2) reef with the OAR-2K reef. WBBR2 was created in 1995 with the Lindberg cubes and contains 6 patches of 16 cubes with each patch 25 meters apart. OAR-2K was created in June 2000 and consists of 6 patches of 6 ft Fish Haven™ Pyramids, 25 meters apart. The purpose of the monitoring is a comparison of a well-established reef (WBBR2) with a newer reef (OAR-2K).

The team currently has 20 active divers. The current team leadership is as follows: Rob Buda, Coordinator; Scott Vascavage, Assistant Coordinator (Projects); and Chuck Blum, Assistant Coordinator (Training). More information about OAR and the RDT can be found on the web at http://www.oar-reefs.org or by calling the OAR office at (850) 656-2114.

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APPENDIX 2-Final Agenda

Florida Artificial Reef Summit 2001
October 17-20, 2001 ** Fort Lauderdale, Florida
Final Agenda

Wednesday, October 17, 2001- Welcome

7:00 to 10:00 pm Welcome Reception, NOVA Oceanographic Center, Dania Beach

Thursday, October 18, 2001- Welcome and Updates

8:00-9:00 am ***Registration***

Welcome

9:00- 9:15 Summit Overview and Welcome
Eric Myers - Broward County Department of Planning and Environmental Protection
Roy Crabtree - Florida Fish and Wildlife Conservation Commission (FWCC)
Dick Dodge - National Coral Reef Institute

9:15- 9:30 FWC Artificial Reef Program Activities - Jon Dodrill, FWCC

9:30- 9:45 Artificial Reefs: Habitat for Marine Resources-National Policy? - Ron Lukens, Gulf States Marine Fisheries Commission

9:45-10:00 Essential Fish Habitat Issues - Mike Johnson, National Marine Fisheries Service.

10:00-10:15 ***Break***

Government Agency Updates

10:15-10:30 Army Corps of Engineers - Clif Payne, Pensacola Regulatory Office

10:30-10:45 United States Coast Guard - Lt. Dan Gronski

10:45-11:00 Maritime Administration (MARAD) – Curt Michanczyk, Ship Disposal Program.

11:00-11:15 National Oceanic and Atmospheric Administration - Ken Forster (Charting)

11:15-11:30 Florida Department of Environmental Protection - Timothy Rach (Permitting)

11:30-11:45 FWC Florida Bureau of Marine Enforcement - Capt. Mike Lamphear

11:45-1:00 pm ***Lunch***

Artificial Reef Program Updates

1:00-1:15 Sea Grant Activity Update – Rich Novak , Sea Grant Program

Florida's County Programs -Regional Updates

1:15-1:30 Southeast Region - Brian Flynn, Miami-Dade County

1:30-1:45 Northeast Region - Joe Nolin, Volusia County

1:45-2:00 Southwest Region - Chris Koepfer, Lee County

2:00-2:15 Northwest Region - Robert Turpin, Escambia County

2:15-2:45 International Reef Activities - Bill Seaman, Sea Grant Program

2:45-3:00 pm ***Break***

Artificial Reef Monitoring Programs

3:00-3:30 FWC Monitoring Grants Program - Fish Census Database Bill Horn, FWCC

3:30-4:00 Artificial Reef Research off Alabama- Andy Strelcheck, FWCC

4:00 pm ***Close days sessions***

5:00-8:00 pm ***Workshop –Ships as artificial reefs (Military vessels and derelict ships)***

Moderator - Kurtis Gregg, Intergovermental Programs, FDEP
Speakers include:
Denis Rushworth, MSCL Inc. on the RAND Report
Tom Maher, MHI, Inc. on the progress of the two proposed vessels for the Florida Keys

Friday, October 19, 2001 - Technology

Artificial Reef Developments

8:30- 9:00	NOVA Southeastern University's Research Projects - Dr. Richard Spieler
9:00- 9:30	Comparisons of Five Reef Materials - Heyward Matthews, St. Petersburg College
9:30-10:00	Socio-Economic Study of Reef Resources in Southeast Florida and the Florida Keys - Grace Johns, Hazen and Sawyer, P.C.
10:00-10:15	***Break***
10:15-10:45	Overview of Artificial Reef Use and MPA's - James Bohnsack, National Marine Fisheries Service
10:45-11:15	Stability Analysis – Lee Harris, Florida Institute of Technology
11:15-11:45	GIS Data Management - Christopher Friel, GIS Solutions, Inc.
11:45-1:00 PM	***Lunch***

Artificial Reef Mitigation

1:00-1:30	Guidelines for Restoring Marine Epibenthic Habitats- Walt Jaap, Florida Marine Research Institute
1:30-2:00	Palm Beach County Mitigation Projects - Carmen Vare, Department of Environmental Resource Management
2:00-2:30	Broward County Mitigation Projects - Ken Banks, Department of Planning and Environmental Protection
2:30-2:45	***Break***

Artificial Reefs and Marine Protected Areas

2:45-3:15	Reef Environmental Education Foundation, Laddie Akins, Executive Director
3:15-3:45	Marine Protected Zones & Artificial Reefs - Mel Bell, South Carolina
3:45- 4:15	MPA's & Artificial Reefs - Jonathan Gorham, Indian River County
4:15- 4:45	Cedar Key Research Updates- Bill Lindberg, University of Florida
4:45	***Close session***

5:00-8:00 PM ***Poster and video Reception***

Saturday, October 20, 2001 - Monitoring

Artificial Reef Monitoring Programs

8:30-10:45 Artificial Monitoring Workshop, Florida Sea Grant
Bill Seaman, Moderator with presenters Steve Bortone, Bill Lindberg, Walter Milon, Margaret Miller and Peter Sheng

10:45-11:00 ***Break***

Regional Reef Research Teams - Monitoring Grant Project Updates

11:00-11:15 Palm Beach County Reef Research Team - Janet & Glenn Phipps
11:15-11:30 Jacksonville Reef Research Team - Lex Waters
11:30-11:45 Charlotte County Marine Research Team - Jon Hubertz
11:45-12:00 Organization for Artificial Reefs - Scott Vascavage

Reef Summit 2001 Overview

12:00-12:30 Workshop Summaries - Jon Dodrill, Fish and Wildlife Conservation Commission
12:30- 1:00 Summit Overview - Jon Dodrill, Fish and Wildlife Conservation Commission

1:00 PM ***Adjourn***

2:00 PM '☺'- Optional Local Dive Trip