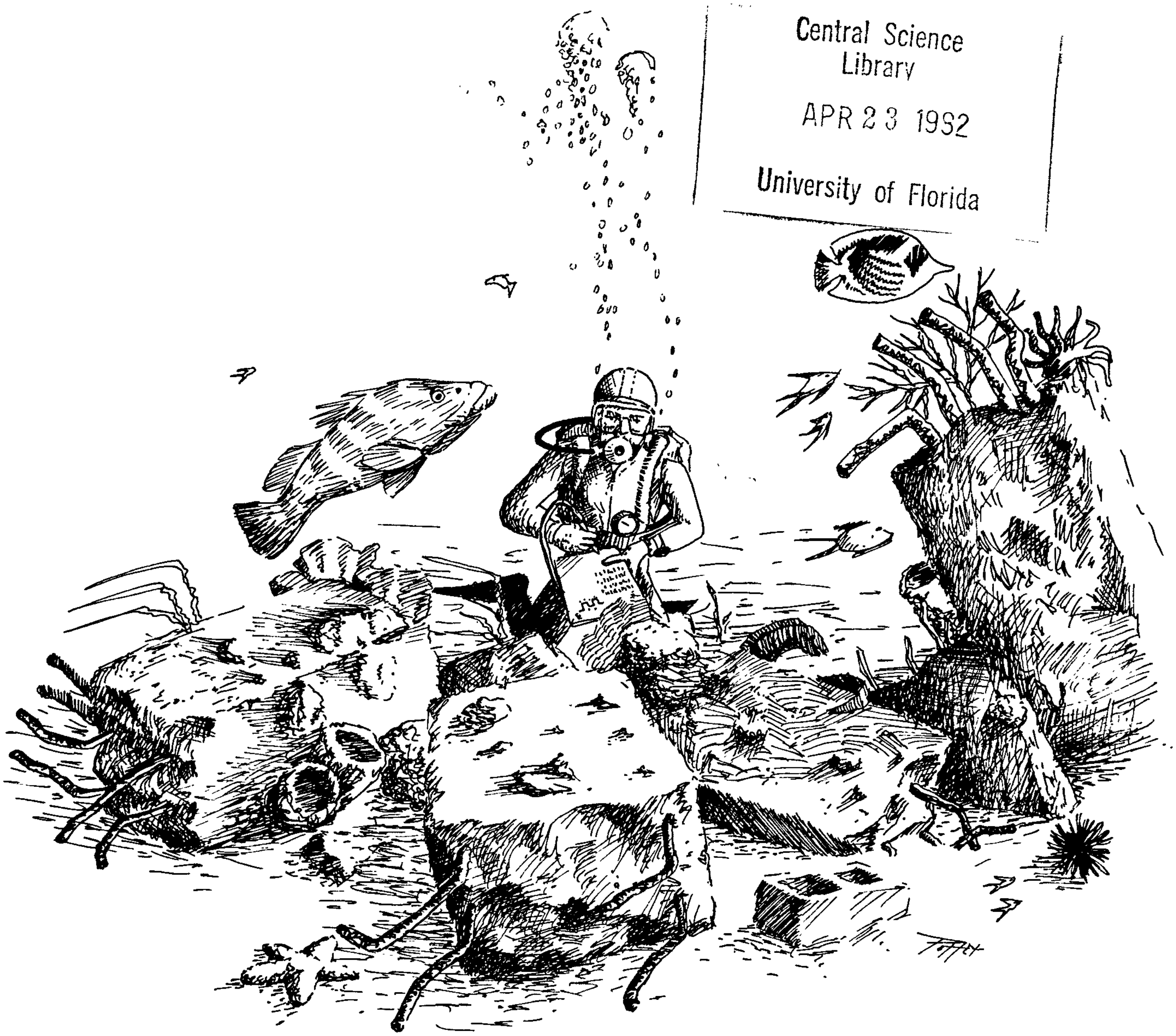
Artificial Reef Research

DIVER'S HANDBOOK



TP - 63

FLORIDA SEA GRANT COLLEGE PROGRAM
research, extension, and education for a better coastal environment

This handbook is dedicated to Edward A. Kalakauskis, a tireless reef research diver and sports fisherman "volunteer", who has been the common thread that helped make all this possible.

It is further dedicated to the memory of three "Artificial Reef Pioneers" whose work will long benefit fisherman and divers off the Northeast Florida coast:

Linden Heston - Jacksonville Offshore Sport Fishing Club

Richard "Dick" Longo - Daytona Beach Sport SCUBA Diver

Col. "C.M." McCormick - Ancient City Gamefish Association
St. Augustine, FL

Florida Sea Grant College is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number NA89AA-D-SG053, under provisions of the National Sea Grant College and Programs Act of 1966. This information is published by the Sea Grant Extension Program which functions as a component of the Florida Cooperative Extension Service John T. Woeste, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914. The Florida Sea Grant College is an Equal Employment Opportunity-Affirmative Action employer authorized to provide research, educational information, and other services only to individuals and institutions that function without regard to race, color, sex, age, handcap, or national origin.

Artificial Reef Research

DIVER'S HANDBOOK

Principal Editor
Joseph G. Halusky
Florida Sea Grant Extension Agent
Marine Education Center at Marineland
St. Augustine, Florida

FLORIDA SEA GRANT
COLLEGE PROGRAM

Florida Sea Grant College Program
PO Box 110409
University of Florida
Gainesville, FL 32611-0409
Technical Paper TP-63
$5.00

Contents

SECTION TWO

Underwater Research Methods Summaries & Equipment Descriptions

LIST OF AUTHORS

James Bohnsack
Southeast Fisheries Center
National Marine Fisheries Service
75 Virginia Beach Drive
Miami, FL 33149.

Steven A. Bortone
Biology Department
University of West Florida
Pensacola, FL 32514.

Scott R. Braunsroth
1424 Fruit Cove Rd. N.
Jacksonville, FL 32223.

Shawn Brayton
Archivist
Jacksonville Scubanauts Reef Research Team
10881 Great Southern Drive
Jacksonville, FL 32223.

Joseph G. Halusky
North East Florida Sea Grant Extension Agent
233 Marine Center Drive
St. Augustine, FL 32086.

Robert L. Jenkins
Director of Operations and Husbandry
National Aquarium in Baltimore
501 E. Pratt St.
Baltimore MD 21202.

Christopher P. Jones
Coastal Science and Engineering,
P.O. Box 8056
Columbia, SC 29202.

Gary Kirkland
1811 Indian Wood
Neptune Beach, FL 32233.

Thomas M. Leahy
Former Director
Florida Sea Grant Communications
and Publications
Editorial Dept.
University of Florida
Gainesville, FL 32611.

Heyward Mathews
Professor of Oceanography
St. Petersburg Jr. College
Clearwater Campus
2465 Drew St.
Clearwater, FL 33575.

J. Walter Milon,
Deptartment of Food and Resource Economics
IFAS
University of Florida
Gainesville, FL 32611.

Ronald L. Schmied
National Marine Fisheries Service
9450 Koger Blvd.
St. Petersburg, FL 33702.

Dennis Short
Jacksonville Scubanauts Reef Reserch Team

Gregg R. Stanton
Research Diving Coordinator
Academic Diving Program
Florida State University
Rm. 10 Montgomery Bldg.
Tallahassee, FL 32306.

A. Quinton White
Department of Biology and Marine Science
Jacksonville University
Jacksonville, FL 32211.

Preface

Artificial reef construction in Florida is largely a result of volunteer efforts. Historically, volunteer reef builders have had difficulty evaluating the success of their efforts since divers were usually not called upon to observe the reef material after placement. If divers were available, they generally had little or no training in objective underwater data gathering and documentation methods. Properly trained sport divers can assist reef builders by providing feedback information and documentation. Volunteer reef research divers can provide a valuable public service, not otherwise available from state or academic institutions, by establishing their own reef research, monitoring and documentation projects and storing this information in a publicly accessible reef data archive.

The purpose of this Artificial Reef Research Divers Handbook is to provide background information and guidelines for sport divers:

1) to gather information about their community's artificial reefs;

2) to document and store this information in a way that can be retrieved and understood by the reef builders, government agencies, the research community, other interested volunteer organizations and the public;

3) to communicate their observations in a credible fashion.

The handbook is organized into two primary sections. **Section I** consists of thirteen chapters which discuss the theoretical and practical aspects of physical and biological data collection underwater, project planning, training, public relations, setting up an archive and organizational structure of a reef research team. **Section II** is what might be called the "recipe" section or "Underwater Research Methods Summaries". It, like any recipe book, provides step by step guidelines for various underwater data gathering methods.

Scientific Diving to gather information (Data) underwater is NOT merely jumping in the ocean, looking around and reporting back to the surface what the diver "thinks" is going on "down there". It is the establishment and use of SYSTEMATIC and STANDARDIZED procedures for gathering OBJECTIVE information which is added to the DIVE LOG and the data ARCHIVE. It may include the collection and preservation of specimens for a REFERENCE COLLECTION, as well as the making of detailed REEF SCATTER MAPS and systematic MARINE ORGANISM POPULATION SURVEYS. It may include MONITORING, through documented photographs, video surveys and systematic photo transect surveys over long periods of time to capture changes which otherwise might remain unobserved. LEADERSHIP, PLANNING and COMMUNICATIONS is at the heart of a successful underwater research program, whether if its done by professional scientific divers or volunteers.

This handbook will not make the reader a research scientist! Professional academic degrees and training are needed to conduct credible marine science. Becoming a marine scientist requires the completion of degree work at a college and university. This cannot be achieved in a single extension course, handbook or dive shop training program.

This is NOT a handbook on diving technology. No attempt is made to discuss methods of diving, diving theory, new life support equipment or technique. There is no discussion about rescue or emergency procedures, except to say that such procedures should be established on any dive. There are many "Dive Manuals" available to fulfill these needs.

There is considerable discussion about safety procedures which might be different from those practiced in sport diving, and APPENDIX A is a reference to the Scientific Dive Standards adopted by the American Academy of Underwater Sciences. Any research diving activity should seriously consider the adoption of these standards to their underwater research activities.

There is discussion about the need for the scientific dive teams to establish organizational procedures to safely conduct a research dive operation and insure the data is preserved. Chapter 11 on "Project Management" provides a thorough discussion about how to organize a research dive expedition, to include logistics and descriptions of specific job assignments. Chapter 12 discusses how to establish an "Archives and Reference Collection" to preserve the data and Chapter 13 discusses how to organize a "Reef Research Team."

The underwater research methods included should not be construed as the "only" or even the "best" method for gathering the type of data discussed. Good science methodology depends on the nature of the question that is being asked, the technology available to get the data and the situation it is to be collected in. Often, the questions will change as new information is made available; as the technology changes and the situation in the field changes. The intent of this "Section II - Underwater Research Methods Section" is merely to provide ideas as a basis for deciding what data gathering strategies might be used in a reef research project. Each "Method" should be adjusted to meet the users situation.

Section II should continue to grow. I encourage the reader(s) to develop, field test and write their own Underwater Research Methods Summaries and share them with others through the Florida Sea Grant Extension Program. This can be accomplished by copying the blank Underwater Research Methods Summary form, found at the beginning of Section II, filling it in and mailing it to:

Florida Sea Grant Extension Program

Building 803

University of Florida,

Gainesville, FL 32611.

The **Appendix** of this handbook is a collection of supporting materials that should help the readers to start their own reef research program. It, like the "Methods Summaries", should be used as a guide only, and modified to suit the users needs.

The "Artificial Reef Research Divers Handbook" should help volunteers to take the first step in the scientific method - MAKE AN OBSERVATION about their communities' artificial reefs and DOCUMENT IT. It is specific in that it focuses on underwater data collection methods with basic SCUBA equipment normally used by sport divers. It uses simplified methodology found in a number of science disciplines. It is unique in that it concentrates on teaching volunteers how to design, lead and store information for THEIR OWN artificial reef documentation projects. Its practical end is aimed at improved reef monitoring and construction programs through volunteerism.

The Florida Sea Grant Extension Programs, Artificial Reef Research Divers Training Program and this Handbook, would not be possible were it not for the many volunteer scientists, sport divers, fishermen, citizens and agency people who willingly gave their time and energy to this effort. The workshops held since 1980 was dependent on those individuals who freely gave their weekends, boat time and equipment in support of this activity. To all of you volunteers who helped, too numerous to list here, we offer this "Thank You!" We owe a special thanks to the original students who graduated from this training, for in many respects, you were the "Guinea Pigs" in this grand experiment. The program would have failed without your patience and dedicated spirit.

In any program, a few individuals always stand out for their extra dedication to the project. Foremost, is Ed Kalakauskis, to whom this Handbook is dedicated. Ed, a graduate of the first workshop in Daytona, has continued to be deeply involved with all the training programs since, and is the connecting strand between the reef builders and reef research divers. He continues to freely give volunteer time to all reef activities throughout the North East Florida region, serving as an inspiration to all.

I would also like to recognize and thank Dr. Quinton White, Jacksonville University, who, without compensation, freely gave his time and talents to this program, from the very beginning. He has kept a sincere interest in the projects of its graduates and serves as their academic advisor. He has provided additional extension training in Invertebrate Biology for the Jacksonville Scubanauts Research Team.

Others who deserve special thanks for supporting the training and keeping the program growing include: Don Serbousek, Thiele Wetzel, Dan O'Brien, Pete Heebner, H.C. "Hap" Jones, Dick Starke, Halifax Sport Fishing Club and Ormond Anchor Chasers Dive Club from the Daytona Beach area; Jim Netherton, Larry Mahn, George Miller, Rick Holmlund, Gene Burns, Kevin McElroy, Bill Kerr, Ancient City Gamefish Association, N.E. Florida Marlin Association, Camachee Cove Marina, Sea Hunt Enterprises Dive Shop from St. Augustine; and Aquifer Dive center of Jacksonville. Some individuals willingly provided leadership during the early stages of this program and include: Bob & Joy Engel, Dennis & Wendy Short, Larry Tipping, Don Landis, John Hammond, Marilyn Halusky, Jim Powell, Beth Strawbridge, Mark & Kim Ullman, Gideon Carpenter, Gary Kirkland, Jacksonville Offshore Sports Fishing Club, Jacksonville Scubanauts Dive Club, Aquifer Dive Center from the Jacksonville area; Leon Dufresne from Brevard County and Mike Mcallister from Nassau County. I apologize for any omissions from this list and regret that I cannot list all the volunteers who have helped make this program the success that it is. To all I offer my warmest "THANKS" !

A special thanks goes to Ms. Ginger Layton Pophel and Ms. Janice Hoskins, for their tireless and patient labors in assembling this manuscript.

There are a few "Artificial Reef Pioneers" who are no longer with us. They each deserve special recognition for much of their thinking is found in this handbook. Perhaps, their pioneering work will live on through this publication. We will never forget them. They include:

Dick Longo

Assistant Divemaster

1980 Daytona Beach Artificial Reef

Research Diver Training.

Col. C. M. McCormick

President

Ancient City Gamefish Association

past Chairman of the Reef Committee.

Linden Heston

Jacksonville Offshore Sportsfishing Club

Reef Committee and one of the early reef

builders in Jacksonville

We, the authors, wish continued progress and success for all who are involved and concerned with the wise management of our marine habitat resources.

Joe G. Halusky

September, 1991

SECTION ONE

Chapter 1

Introduction To Artificial Reef Research Diving: Theory And Practice

By Joseph G. Halusky

Artificial Reef Research Diving has its roots in Scientific Diving and Diving Technology which have evolved since the invention of self contained underwater breathing apparatus (SCUBA) in the early 1940's. Early explorers of the undersea made use of SCUBA technology to observe and document new discoveries that were reported in scientific publications, movies, the media and popular literature. In the 1950's, SCUBA equipment was first introduced to the scientific community in the United States, through the efforts of researchers at the Scripps Institute of Oceanography. Since then, the use of SCUBA and surface supplied diving technology has evolved to become as indispensible as the microscope, as a tool for scientific data gathering.

Scientific Diving & Diving Technology

Scientific Diving and Diving Technology are not the same research effort. Scientific Diving is the conduct of underwater operations by divers with the expressed purpose of gathering information in any basic or applied scientific discipline. These include such disciplines as archeology, biology, engineering, physical oceanography, geology, etc. It is diving FOR science, where diving is merely a research tool. Diving Technology, on the other hand, is the science OF diving, where the subject of the research is diving. It is applied research which is focused on increasing man's ability to function safely underwater. It includes such research disciplines as human physiology, hyperbaric medicine, human engineering and life support equipment design etc. It is important to recognize the difference between the two.

Artificial reef research diving follows Scientific Diving methodology that is focused on safely gathering meaningful and objective data about artificial reefs. It is not Diving Technology research unless it is focused on improving the divers ability to gather artificial reef data.

Scientific Diving Safety

Safety is of paramount importance in Scientific Diving research and never should be compromised for data. In Diving Technology research, however, their may by times when researchers go beyond the commonly accepted limits of safety to test a new diving concept or to extend human capabilities underwater.

Recognizing the difference between scientific diving and diving technology has implications for planning, safety and the establishment of standards which apply to their respective underwater research procedures. Diving Technology research, for example, could require testing new life support equipment, or new gas mixtures at exceptional exposures. These procedures may require the diver to be a test subject to work outside the limitations of "traditional" safety standards. In Scientific Diving, however, exceeding traditional safety standards is rarely acceptable. Scientific Diving procedures are limited by the current level of Diving Technology that is available to the diving scientist.

There are also implications for proper dive planning, organizational procedures and the establishment of special safety standards for Scientific Diving, when compared to sport diving. In sport diving, for example, the objective is recreation. In a sport dive plan, bottom time is maximized, and all precautions are made to minimize stress and work, maximize enjoyment, comfort and safety. Abrupt changes in the environment, as limited visibility, thermoclines or heavy seas may be sufficient reason to abort a recreational dive, without hesitation.

The word safety in Scientific Diving takes on new implications beyond that of sport diver safety. Since the mission of the scientific diver is to gather data, safety implies the safe return of the diver with the data. The job of gathering data places a burden beyond what the sport diver may normally be accustomed to when underwater. Not only is the scientific diver concerned with the safety of the dive team, but is also concerned about diver performance. They must concentrate on the task(s) of gathering quality information, objectively. Stress and distractions imposed by the environment, a limited air supply and increased hazards (compared to a safe laboratory), severely limits the amount and quality of information which can be gathered underwater. Procedures for simplifying data gathering tasks and securing it must be considered in the scientific dive plan. A scientific dive plan may require diving under less than desireable (uncomfortable but safe) conditions if the project's objective is aimed at the study of the effects of these conditions on marine life, or the opportunity for getting the data is rare.

Simply stated, ALL dive plans for scientific diving missions must first maximize diver comfort, and minimize stress, work loads, time pressure and the number of tasks each diver must perform. A comfortable diver will produce high quality data. If he is distracted by an unnecessary concern for survival he simply will not give adequate attention to his assigned task, and the quality of the data will suffer.

Special safety standards for scientific divers have been developed by the American Academy of Underwater Sciences (AAUS). They have been accepted by the federal office of Occupational Health and Safety Administration (OHSA). See Appendix A for AAUS Scientific Diving Safety Standards. Divers engaged in underwater research activities should adopt the AAUS standards for their organization to insure compliance with OSHA's minimum requirements for scientific divers.

Scientific Diving Limitations

A diving scientists mission is to collect precise, accurate (see Chapter 2) and objective information underwater. Any impairment to his cognitive abilities, whether from environmental stressors, limitations of life support equipment or safety requirements will limit the precision, accuracy and objectivity of the data collected. In some cases, if the diver is severely stressed, or task loaded, the data actually may need to be discarded because of its questionable reliability.

Leadership & Scientific Diving

The conduct of undersea research using SCUBA as a primary tool has many limitations which require careful planning and adherence to the "Buddy System". Adoption of a "buddy system" automatically implies that two or more individuals are involved with the project, therefore a structure for leadership emerges.

In sport diving, leadership may consist of an agreement "You follow me !" and the team swims away. In a scientific dive, the task of collecting information adds a significant level of complexity to the leader-follower relationship. For example, someone must decide: What data will be collected? How it is to be collected? Who is going to write it down and transcribe it to paper after the dive? Who is going to carry any instrumentation that may be required? Who will operate it? Who is going to monitor dive time and issue warnings as bottom time runs out or some hazardous marine life intrudes in the study area? This increase in complexity demands that divers communicate and coordinate long before the actual dive and agree to lead and/or follow where appropriate.

A research team of more than two persons is likely to be the rule on most research projects. Some scientific dive programs use a three person dive team. Two divers engage in the collection of the data, and the third one serves as the team leader and safety monitor. This enables the data collectors to concentrate on the research task(s) at hand. Frequently, a project will require more than one team. Underwater mapping, usually requires two or more teams to complete the data gathering task. As the number of persons involved increases, so does the need for leadership, communication and coordination.

The chief scientist and the divemaster for any research project must apply their best leadership qualities to prepare their dive teams. Procedures for gathering data underwater are typically established by the chief scientist. This is the person who has determined what data needs to be collected that will fulfill the research projects requirements. Most often, the divers do not have the same level of expertise that the chief scientist has in the research being conducted. For example, a fish biologist may want the divers to observe a certain species of cryptic fish. Divers unfamiliar with that species, may at first, have difficulty finding the fish, even though it may be quite prevalent on the reef. The chief scientist must, in this case, extend his leadership role to include training the divers to an acceptable level of competency needed to produce the desired quality of data.

In any at-sea operation, all diving activities which are conducted from a boat, must also have a surface crew and additional rescue equipment, such as a chase boat. The need for coordination and communication with this crew increases the level of complexity of the operation. The need for firm leadership and communication becomes even more apparent.

The obvious conclusion is that the quality and amount of data collected during an underwater expedition will directly depend on the amount and quality of leadership and organization put into it. Expedition planning, leadership and risk management strategies are at the heart of successful reef research projects. Chapter 11 "Underwater Research Project Management" provides a more comprehensive discussion of this subject.

Scientific Diving Tasks & Data Collection

Properly trained and well equipped scientific divers are capable of performing a wide variety of tasks underwater. Great discretion must be used however, regarding how much the individual diver is expected to do in the limited bottom time available to him. Task loading (assigning the diver too much to do) will result in poor quality data if the diver becomes stressed by even the simplest changes in the environment. Good scientific dive planning will limit the tasks a diver must perform and will establish a standard of acceptable performance. Complicated tasks may require two or even three dive teams to accomplish, especially if data gathering instruments must be deployed.

Great care must be given to break each task down into its simplest steps and individual action patterns. Then a step by step analysis of each action should be considered in the dive plan. For example, the task of taking temperature using a glass thermometer seems simple enough at first. When broken into its action patterns, it takes on a new meaning:

"1) Remove thermometer from protective case when at the desired depth; 2) Read temperature after mercury has stabilized; 3) Return thermometer to protective case; 4) Write temperature, depth, time and date on underwater slate; 5) Proceed to next data recording station or task. Note: record any "unusual" temperature changes and the depths where observed."

These five steps each carry additional implications for the dive plan. The thermometer needs a case that won't get lost when the thermometer is removed from it, so it should be on a lanyard. The diver will need a watch, and a slate with a sharp pencil on a lanyard, to record the data. The diver will need to know where and when to actually take the temperature, and be aware of any unanticipated changes. He will also need to know if the temperature is to be read to the nearest degree, one-half degree or two degrees of accuracy, or is it to be taken three times at each station and averaged. What appeared to be a simple taking temperature has now become a formidable task, unless the procedure has been carefully thought through and STANDARDIZED by agreement before the dive.

Generalized Tasks of Diving Scientists

The following list is organized according to the level of complexity from the most simple to the most complex of generalized tasks that scientific divers can perform.

SEARCH - simple preliminary examination of the study area to assess what is there.

OBSERVE - looking, listening, or otherwise perceiving organisms or physical conditions to include the documenting of the information in some fashion.

COLLECT - capturing or taking of living or non-living specimens for later analysis. Includes photography and sound recording as well as use of environmental instrumentation.

MEASURE - collecting numeric information regarding spatial relationships, horizontal/vertical distances, sizes and relative positions between study subjects. Mapping.

COUNT - numerically quantifying the occurrence of events, organisms or behavioral activities.

SURVEY - careful examination and re-examination of selected areas for the occurrence of certain events, or for comparisons.

MONITOR - regular collection of certain data parameters of the same environment over long time periods to document physical and/or biotic changes.

EXPERIMENT - replicated manipulation of variables to document their effects and determine causal relationships. In a field setting, all variables cannot be controlled.Underwater research projects commonly employ the use of combinationsof these generalized tasks. For example, a fish population study may require searching, collecting, and counting to document fish occurrence at a single site. Comparing sites may require additional surveying or counting and even monitoring.

The procedures for gathering data underwater will largely be determined by the original purpose for the research project and the task level needed to fulfill that purpose. If the purpose of the project is to describe what invertebrates are covering a reef structure, then there is no need to survey, monitor or use experimental procedures. A simple collection may be enough. If, however, the project is to determine what and how many invertebrates are on a reef, then the more elaborate surveying or counting methods may be needed.

Collecting Data

Data is simply information. It may be a written or voice description of something or some activity or phenomena observed. It may be a number or count of something that is recognized according to a category, such as number of Barracuda or Sharks observed. Data may consist of measurements of something such as temperatures, depths or distances between things as for maps. It may be actual specimens, videos or photographs, properly labeled and catalogued.

Raw & Reduced Data

Data can exist in two forms, raw data or reduced data. Raw data is the actual information as it was gathered when the observation was being taken. It might appear on standardized "Data

Sheets", as written or photocopied notes from a slate, dive log page or as an original photo, slide or unedited video or movie film. Reduced data is raw data which has been summarized or edited in some fashion. Information may be taken from the raw data sheets and listed in a table or portrayed on a graph. It may be reduced further through some mathematical procedure or placed on a map using symbols. Each time the data is reduced, some information may be lost or ignored, or worse yet, erroneously transcribed. Obviously, it is imperative that the original raw data sheets are preserved, along with the reduced data sheets.

Data Collecting & Preservation Guidelines

The collection and preservation of the raw and reduced data from underwater projects requires adherence to a few basic guidelines listed below:

- Create a standardized basic raw data sheet. This should be simple and easy to understand (fail safe). Be consistent and avoid frequent changes to the sheet.
- If there is a change (from the standard) in data collection procedures, it must be noted on the raw data sheet.
- Data must be intelligible to any reader. Avoid complex coding symbols. If they-must be used, make sure a code key is on the data sheet.
- Dive log is part of the data.
- Put the Complete Date, Location, and Name Of Observer on Every raw data sheet, to include year, month and day.
- Use pencil or indelible ink --- no felt tip pens, unless they are waterproof.
- Remember, "0" is a real number. It means you looked for something and did not find or observe it. If you made no observation at all, you should enter a dash (-) or a "Not Applicable" (N/A) symbol on the data sheet.
- Make backup copies of all raw data sheets and store them in a separate location, as soon as possible.
- Make sure original or authenticated copies of raw and reduced data gets into the archives (see Chapter 12).

Summary

Underwater research as it applies to volunteers involved with artificial reef research is the special adaptation of sport diving technology to scientific diving. It does not require the use of sophisticated methods or equipment that may only be available to the scientific community.

There are a few considerations applicable to all underwater research projects which are fundamental to credible scientific research. This "Introduction" and following chapters deal with those things considered by the authors to be fundamental to artificial reef research. Perhaps the best review of these fundamental principles can be summarized through a list of basic concepts presented in this handbook.

Artificial Reef Research Divers Basic Concepts Summary

1) Artificial reef research diving follows Scientific Diving methodology. Scientific Diving is the conduct of underwater operations by divers with the expressed purpose of gathering information in any basic or applied scientific discipline. It is diving FOR science and is limited by diving technology. The chief scientist is responsible for the science methods used on a project.

2) Safety is of paramount importance in Scientific Diving research and never should be compromised for data. Since the mission of the scientific diver is to gather data, safety implies the safe return of the diver WITH the data. The project divemaster is responsible for safety.

3) Never should the chief scientist and divemaster be the same person.

4) ALL dive plans for scientific diving missions must maximize diver comfort, and minimize stress, time pressure and the number of tasks each diver must perform. A comfortable diver will produce high quality data.

5) The quality and amount of data collected during an underwater project will directly depend on the quality of leadership and organization put into it. Expedition planning, leadership and risk management strategies are fundamental to successful underwater research. The leadership must establish a standard of safe and acceptable performance.

6) The procedures for gathering data underwater will largely be determined by the original purpose for the research project and the task level needed to fulfill that purpose. Procedures must be carefully thought through and standardized by agreement before the dive.

7) It is imperative that the original or authenticated copies of raw data sheets, along with the reduced data sheets are preserved in the archives. If the data never gets into the archives, then all prior efforts are a waste of time.

Chapter 2

The Science And Technology Of Artificial Reefs

by Robert L. Jenkins

Sport divers' lives and activities have been greatly affected by both science and technology. Science has identified the natural laws which affect what happens to our body underwater and technology has applied science to design the life support equipment we use in diving. How do we define just what science and technology are? Knowing the distinction is important for the beginning scientific diver. Science, in essence, systematically explores the universe, using strict research procedures, to determine how natural laws function, and to learn how to use them. Technology is the application of the findings of science to man's advantage. It is beyond the scope of our work to go much beyond these rather simple working definitions, however, they will be sufficient for our discussion.

The purpose of this chapter is to familiarize you with what science, research, and technology are, and provide some examples of their implications to artificial reef research. In its essence, this chapter will not be telling you how to do research on an artificial reef; rather, its purpose is to tell you what science and research are about in a philosophical, and yet practical sense. We will be concerned about the "whys" of science and not so much with the methods and the means of science and technology as they are applied to artificial reefs. Those will be the subjects of the following chapters. It is the reasoning behind the "whys" that will be discussed here.

Science: A Definition

Science is a human endeavor that believes that the real or natural world is described by what it terms NATURAL LAWS.

The goal and practice of science is to discover and describe these NATURAL LAWS. In other words, science is an objective, systematic and logical discipline to examine, describe, analyze, and test the real world of natural phenomena. The resulting descriptions that are discovered through science become the natural laws we are seeking. SCIENCE IS SIMPLY A LANGUAGE used to describe a highly integrated form of knowledge about the real or natural world, with the knowledge being described by its natural laws.

Now the term natural "laws" can be misleading, for it does not imply anything that is unalterable, concrete or non-changing. A NATURAL LAW is our best overall description of a natural (phenomena) which can be understood from the best accumulated facts we have at that moment in time. As facts accumulate, our description of the natural law may change. Put simply, science describes our world by developing a specialized language for doing so. Because we are now openly refuting one of the more frequently misunderstood aspects of science (being that it is unalterable or unchanging), it is important to recognize and highlight several of the more crucial aspects of just what science is. Among these are:

1. Science is a human invention and endeavor. As such, it must deal with all the human weaknesses that any other human endeavor must cope with. It attempts to restrict the impact of these influences through highly disciplined practices and standardized procedures that are repeatable by others.

2. Science is objective and not conjectural. Facts are only those things which can be detected, observed, proven, and generally accepted. Science is always open to continual scrutiny, evaluation and re-evaluation if deemed necessary.

3. Science is not just the documentation of events and instances in the natural world. Rather, science is the language that we use to describe those instances through the descriptions known as natural laws.

4. Science approximates the truth, rather than attempting to define the truth absolutely. Old interpretations of "truth" can change and be altered as new facts are discovered (this is one of the more exciting aspects of science as it continually documents new knowledge).

It is this fourth aspect of science with which the beginning scientist/technician often has the most difficulty. We approximate the truth in science simply because in forming our descriptions (natural laws), we can never know or be able to describe all of the facts and variables which support any truth. Science is an endeavor that consistently and constantly seeks truth by the gathering, describing, and examination of all facts under all conditions. Consequently, as we become aware of new facts, our "truths" must be re-examined and often re-defined, even to the point of being discarded. This process will have particularly important meaning in our work on artificial reefs, simply because there is so much that has yet to be learned.

It is at this point that the terms "hard science" and "soft science" come into play. There are "hard sciences" and there are "soft sciences". These terms describe the relative strength of the facts that support the natural laws of each scientific discipline, and not the degree of difficulty of understanding them.

Going from the harder to the softer sciences, they run from: mathematics - physics -chemistry - biology - anthropology-sociology - psychology, etc.

Mathematics is the hardest of the sciences because its facts are precisely defined and built on strict numerical logic. Psychology is one of the softest sciences since its facts about human behavior are subject to the scientist himself who cannot objectively remove himself from the behaviors he describes. The science of artificial reefs, while mostly based in the relatively stronger sciences of physics, chemistry, biology, engineering and geology, is presently on the softer side of these disciplines. It should be our goal to make the science of artificial reefs "harder" than it presently is. That is: based more on strict (mathematical) objective logic, than on the more subjective personal interpretations of observed events.

This also brings us to yet another very important aspect of science: that science is a self-correcting discipline. Science has, as one of its most fundamental rules, the maxim that it can, and must, be alterable. We merely approximate the truth in our natural laws, and therefore, we must always be ready to discard a natural law or truth when the facts show it to be no longer valid. This aspect is the one people and even scientists most often forget. Any truth or natural law is only our best description at any one moment in time. It should always be open for re-examination and evaluation as our knowledge increases. Our science of artificial reefs will be no exception to this tenant. The option to re-examine and re-evaluate what we know about artificial reefs based upon an ever increasing knowledge base must always be open.

How then, do we obtain the facts on artificial reefs so that we may define and describe the truths or natural laws that govern them? And, how may we employ this knowledge to build successful artificial reefs? We will do so through both scientific research and the development of technology.

Scientific Research & Technology

Scientific documentation methods and technology applications are two basic disciplines you will use in your work on artificial reefs.

Scientific research is essentially an endeavor whose motive is the search for truth. Technology is the application and re-application of research results to defined goals which usually benefit someone or something. The typical development of an artificial reef is to benefit fishermen through increased populations of certain select species of aquatic organisms (more edible fish!). This usual goal should be based on sound, scientifically based artificial reef technology developed through artificial reef scientific research.

An example research project may discover that benthic reef organisms will grow on weathered concrete, but not (perhaps due to some toxic problem), grow on raw, or uncured concrete. Technology then would use this natural law discovery (a truth, discovered and described through research) so that weathered concrete, and not raw concrete, is used to construct artificial reefs. Then, in order to improve the overall efficiency of our technology, further research would be done to find out just how weathered the concrete had to be before it could be used for artificial reefs. Findings of that type of research would further refine the construction of artificial reefs.

A research finding may show that complete ships, having decks and holes in the hull, make better (by attracting more game fish) artificial reefs than do plain, bare ship hulls. Again, technology would use this knowledge so that only ship hulls with holes and decks are used to build artificial reefs. In this example, further scientific research on reef technology would attempt to determine the ratio of holes and hole size to the size of the ship's hull that optimize the desired effect.

During our work with artificial reefs, both scientific research and technology may be ongoing at the same time. It is most important to remember that we must first have sound scientific research from which to build a sound artificial reef technology. We then further strengthen that technology through continuous applied research.

Well, just what exactly is sound scientific research, and just how do we do it?

Artificial Reef Research

Scientific research falls into two essential types: BASIC and APPLIED. Basic research is commonly known as "pure" research, which merely seeks knowledge. It has no directed goal or motive other than pure discovery as its driving force. It has no focus on a real application. It pursues knowledge for knowledge's sake.

Applied research has a specific goal or aim which is focused on solving a problem or meeting some specified goal by searching for new information. Technological research is used to REFINE an already existing knowledge. In its essence, artificial reef research is applied research, for we are engaging in it to increase knowledge for specific goals. However, it will also require some technological research to refine how we may build a more efficient reef that produces a desired product(s).

To illustrate, a study to determine the numbers and seasonal changes of fish around a shipwreck is a basic or pure research effort. Doing this same study to measure the success of a wreck with respect to attracting a desired species of fish would be an applied research project. Undertaking this same study to determine how one should alter the wreck to increase the numbers of fish on the wreck would be engaging in technological research. In fact, all three types of research could be going on at one and the same time in any given project. The distinction between basic, applied, and technological research is primarily based upon the goals and objectives for the research in the first place. This research then serves as the basis for building an artificial reef technology which will then require further technological research to fine tune it to the specific geographic location where it is found.

It is important for artificial reef researchers to develop clear and well-defined goals for the research before actually starting it. While it may seem that a motive for reef research automatically exists, it is often surprising that so many do not really know the direction or reason for doing the work. It is simply just not enough to want to do artificial reef research. One must know <u>why</u> he or she is doing it and what specific question(s) is/are to be answered. Such a direction or goal may range from the general (what is there?) to the specific (how does concrete compare with rubber as reef substrate?), and from the simple to the complex. But, it still remains imperative that clear goals be identified for the research effort.

After the research goal or direction has been defined, a project outline should identify how that goal may, or may not, be reached, what data parameters would be needed, and if it is within the researcher's capability. It should also identify what the project can not do as well. Once a goal has been defined, we need a method to attain that goal. It is at this point that "the scientific method" comes into play.

The Scientific Method Or Process

The scientific method is a chain of activities similar to the Deductive Process Outline found in Figure 2.1. The researcher takes existing knowledge, makes and documents an observation(s), and forms an idea or explanation called the hypothesis. He then designs and conducts experiments (tests) to see if the hypothesis is true or false. The experimenter attempts to directly control all but one factor (variable) in the situation to observe how it influences the data. Closely examining this variable and its effects determines the truthfulness of the hypothesis. One should not regard the experiment as being solely found in the laboratory, where all variables can be carefully controlled. Experiments can also include observations, behavior, and other similar subjects in a field setting.

Once the experimental phase has been completed, the facts are accumulated, correlated, and the new scientific law or discovery is described. The new or "discovered" law may then be used as a base to develop a new hypothesis and the process can then repeat itself. The knowledge accumulates and more laws are either formulated or discarded. At some point, when the discovered laws reveal a broader pattern, a more general explanation or description may be offered. This broader description is called the THEORY.

Deductive Method

The foregoing process in science is known as DEDUCTION. It takes existing knowledge and builds on it to increase the number of facts and laws to become a generalized theory see Figure 2.1). Deduction was virtually the only identifiable scientific method used until the turn of the century, which partly accounts for its popularity as the scientific method. However, there is another scientific process.

Inductive Method

A researcher may gather knowledge available to him on what he is studying, and by developing a thorough understanding of that knowledge, make a rather large leap directly to a new law or theory. This method is called INDUCTION. Induction takes existing knowledge and, without experiments or other fact finding, infers the existence of a new natural law through a purely mental process. In essence, it predicts the formulation of a natural law or theory. The new law or theory is then offered as being tentative until such time that experimental facts can be found to support or prove it (see Figure 2.1). Often the researcher who makes such a leap forward in knowledge will outline the experiments that would be needed to confirm the inferred law or theory. If such experimental proof can be found and confirmed, the new law or theory is accepted; if not, then it is cast aside or a search undertaken to explain why it was not found to be true. **(See Figure 2.1)**

Both induction and deduction are useful scientific methods. It is important to remember, however, that deduction needs only a small amount of knowledge from which to begin. Induction, to the contrary, requires a much larger and more diverse base of knowledge and a typically longer time for the researcher to assimilate that knowledge before it can be fully used. The deductive and inductive methods are generally combined in the real world of scientific research. For example, Darwin's Theory of Evolution was built from the accumulation of an immense base of knowledge and facts or deduction, and was also developed from a purely mental process using available theories and observation, or induction. This was a case where both the deductive and inductive processes have created a theory at nearly the same time. The Special and General Theories of Relativity were built from isolated facts of existing knowledge and Einstein's own inductive mental processes. The two theories on relativity were later confirmed by other researchers' experiments suggested by Einstein, and are good examples of the inductive scientific process being confirmed by deduction later on.

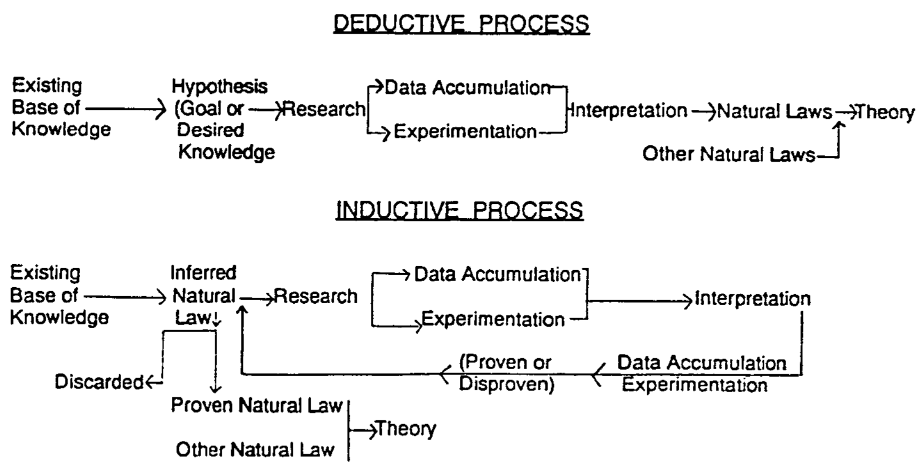
How does this apply to artificial reef research? If we use the example of the bare ship hulls versus those with decks and holes in them, the deductive process would prove the natural law: "that decks and holes attract fish" through the accumulation of data reflecting less fish being found in the bare hull reef and more fish being found in the reef made of hulls with decks and holes. Deduction would allow us to develop the natural law describing this and we would apply this knowledge to develop a technology that builds reefs from ships with decks and holes in the hull. The inductive process would start from the knowledge that fish on natural reefs prefer areas where numerous nooks and crannies are present. We would then infer that fish would prefer ship hulls with decks and holes over those that were bare. Experimental proof of our induction would then come from observations once both types of hulls were made into artificial reefs.

Artificial reef research diver technicians will use the deductive process almost exclusively. The current small body of knowledge about artificial reefs prevents highly reliable inductive reasoning methods. Particular concern should be on accumulating field observations that are well documented. The discovery of the natural laws through this accumulation of facts (data), requires standardization in how that data will be accumulated. It is the "what", "where", and "when" of data accumulation that must be carefully considered, outlined, and maintained from the start of any research project, as well as what kind of data is to be accumulated. What then is data?

Data & Its Successful Accumulation

Data is information in just about any form. A datum (singular; data is plural) is really nothing more than an event in time that is observed and recorded. Data can be the total number of fish observed on a certain dive, the weather conditions, the water or bottom conditions, a photo or video of the event, or any other parameter set by the persons conducting the research. All data recorded

Figure 2.1



The Deduction Process as Compared to the Inductive Process must include the date it was taken and the name of the observer to properly account for the information and its credibility.

In any research project, the kind of data to be collected must be defined before it is gathered. Data accumulation has basically two important aspects that must always be considered and planned for. The first is that the data is recorded in some permanent, sharable, understandable and retrievable form. Data can be written on paper, stored in a computer or any other method defined by the person conducting the research. The actual method is unimportant as long as it is RECORDED, SHARABLE, RETRIEVABLE AND UNDERSTANDABLE. Data which is tucked away inside someone's head or recorded in a code known only to the observer, does no one any good and may actually be lost should the person leave, forget or die.

The second aspect of good data accumulation is that the data is relevant to the research goal. This is determined during the outlining of the research project where the "how, "what," "why," and "when" of data collection is decided. The accumulation of data is a lengthy and costly affair. This is especially true for artificial reef research due to the costs and time necessary to get to the study site, the limited time spent there, the time returning, preparing, and all the logistics that are needed to dive on an artificial reef. Therefore, it is very important to decide beforehand what data is needed and what data is to be ignored. The researcher must realize from the beginning that it is physically impossible to record all possible data encountered during any study.

Data Gathering Methods

Since everything that can be observed around an artificial reef can be recorded as data, great care must be given to decide what and how data needs to be recorded and by what method. This depends on the question being asked and the limitations imposed on the observer by the environment or experimental design. Occasionally, the data, or its gathering method, may need to be altered during the course of the project as new knowledge is gained, important information gaps are found or changes in the situation are encountered. Normally, this is not recommended for it makes comparisons difficult. Any changes to the type or method of data gathering must be carefully described in the records to account for differences which may be found in its interpretation later on. Unrecorded changes in data collecting methods half way through an experiment or an observation series could lead to wrong conclusions. This can even apply to changes in the observers themselves or the instruments they were using.

Quality of Data

The quality of the data is just as important as the definition of the data that is being recorded. Data is typically ordered in a series of facts or observations that may relate to each other in some meaningful way. They must be consistently gathered and retain high quality from the beginning to the end of the observational period or experiment if the relationship is to have any meaningful substance. This may appear to be self evident; but it is surprising how often a research project becomes worthless simply because good quality data was not taken consistently. Inexperienced or uncomfortable divers are most likely to be inconsistent data gathers.

Since data is focused by the project's goals, it is the responsibility of the research project leaders (chief scientists) to define the limits to its precision and accuracy. For example, data that records the numbers of non-edible fish present on an artificial reef may be useless if the study is solely concerned with the numbers of food fish present. If, on the other hand, a study is undertaken that compares the relative numbers of non-edible fish to the food fish on the reef, then that data taken before becomes both relevant and worthwhile. Just what is, and is not, good or relevant data must be defined by the project leaders before the project begins and must be continually reviewed during the course of its accumulation.

It must be stressed that high technology is not necessarily needed to accumulate high quality data. In fact, underwater, the most reliable data is often collected by the simplest means. For example, exceptionally good data can be collected with only a pencil, paper, or plastic slate, and a good set of eyes!

Measurements

Many types of data can be collected by the artificial reef research diver. Measurements and simple observations are probably the two most used types of data which are often combined. Some distinction between the two should be made.

Observational data is the accurate description or representation of some detectable phenomena. Measurement is the comparison of some phenomenon or happening in the real world against a pre-defined standard or scale. Common standards of comparison from everyday life are the inch, the yard, and the Fahrenheit degree. Metric standards commonly used in science would be the centimeter, the meter, and the Celsius degree. Whatever the standard is, it is really nothing more than the measurement taken and adhered to, throughout the experiment. Doing so provides continuity throughout the research project. Often such measurement standards are already established through long use in a particular field of study, such as measuring the temperature of water in degrees Celsius. Other times, when no formal standard exists, some form of comparison, geared to the project's needs, may have to be developed by the research leader. Therefore it is important to standardize the limits needed by the study. Occasionally, it may prove necessary to change the standard for a certain measurement after entering into a research project. This may be done only if there exists the means by which the now older form of measurement may be converted with reasonable accuracy into the newer standard, such as changing inches to centimeters, etc. Establishing the defined standard by which any measurement is to be undertaken BEFORE the project is started will also help provide consistent and high quality data throughout the project

Accuracy & Precision

It is important to define and outline the standard by which any measurement is to be taken. It is also important to define the parameters which will govern the type of measurement undertaken. The two parameters that govern any measurement are accuracy and precision. In common usage, these are often mistaken as being one and the same. In scientific research, they are quite distinct, yet equally important, aspects of any measurement.

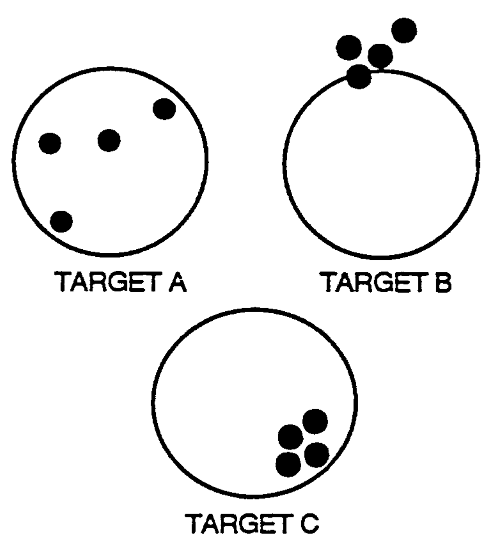
Accuracy is the evaluation of how close one comes to the set standard by which something is being measured. Stated another way, accuracy is a measurement of how well one's individual measurements compare to the selected standard. For example, if the length of an artificial reef site is measured in meters, the measurement would be accurate to a one-meter standard if the reef site is measured to the nearest meter. If, on the other hand, one is unable to measure to the nearest meter, but may only measure to the nearest 10 meters, then we would have less accuracy, based upon the one-meter standard.

Accuracy is the means by which one gauges how closely one comes to the measuring standard for any single measurement. The relative degree of accuracy (the standard), then must be determined before the measurement is taken. It will do an artificial reef research project, or for that matter any research project, absolutely no good to undertake a measurement and then later find it is not accurate enough for the needs of the project. The degree of accuracy needed must be gauged by the goals of the project. If, for example, one wishes to measure the temperature of the water around an artificial reef site, one must determine, just how accurate one wishes the temperature measurement to be. One may decide his measurements need only be accurate to the nearest one degree Celsius. Using an instrument that measures to the nearest 1/5 of a degree, or one that measures to the nearest five degrees, will result in data that is either too costly to get or too inaccurate for the project needs. Accuracy is determined by the needs of the project; the intended use of the measurement and not the relative sophistication of the available instrumentation. Thus, a careful consideration of the accuracy needed in any measurement will help determine how the measurement is to be taken and the device by which it is to be done.

Precision is an evaluation of how often any particular measurement or series of measurements is accurate. Simply put, accuracy tells how close it is possible for us to get to the reality we want to measure, and precision tells how often we can get there using methodology and instrumentation. If one has a measurement that is accurate to the needs of the project, precision will allow the determination of how often such a measurement meets those needs. In any measurement it is very important to ask, "How often is this accurate measurement accurate?" The answer to this question will give the relative precision of that measurement. By now it should be readily apparent that a measurement may be a mixture of both accuracy and precision, as well as being either. Figure 2.2 illustrates the interrelationship of accuracy and precision.

In this figure, four darts have been thrown at three similar targets. In target A, the darts have

Figure 2.2



Target A--accurate but not precise
Target B--precise but not accurate
Target C--accurate and precise

landed in a way that is accurate but is not precise. They have hit the target but are scattered over the entire surface of the target. In target B, the thrown darts are now precise, but they are not accurate; they are close to one another, but are not in the intended target itself. In target C, the thrown darts are both accurate and precise. They are grouped both in the target and in proximity to each other (See Table 2.1).

Table 2.1

DIVER	COL. A	COL. B	COL. C
A	15.5	13.2	18.5
B	21.4	13.0	18.7
C	25.3	12.8	19.0
D	18.2	13.1	18.8
Date Taken:	1/24/84	2/16/84	5/30/84

The results shown in Table 2.1 are measurements of the water temperature that were made by four different divers on the same artificial reef at the same time of day on three successive days. By reading the available literature on sea temperatures for this area, an anticipated yearly range of 15 to 25 degrees Celsius for this area of the ocean was found. The first set of measurements, Column A, shows accurate results that are not precise. These measurements cover almost the entire expected range and show little comparative value to each other (i.e., is the temperature 15.5 or 25.3 degrees?) In the second set of measurements, Column B, all four measurements are precise, but they do not appear to be accurate, as they are out of the anticipated range. The reasons for both of these problems can be varied: inaccurate thermometer; poor choice of expected range, or the temperatures may indeed be this, and the day on which they were taken was an anomaly. Whatever the reason, the results indicate that something is not right and deserves to be checked out. Column C, the third set of measurements, gives both accurate and precise results. They are at once accurate, for they are in our expected range, and are precise since they are close to one another.

It is interesting to note several features of measurement and how they are affected by accuracy and precision.

1) Both accuracy and precision are largely determined by the standard of measurement that is set before the measurement is undertaken. Our choice of how and by what instrument a measurement is taken will affect how accurate and precise that measurement is.

2) The precision of any measurement can be simplified simply by narrowing the accuracy range of that measurement. By closing the gap between both ends of the measurement range, one can force oneself into highly precise measurements. For example, you may decide your reef maps need to be accurate to within 10 meters for every 100 meters actually measured. By changing the acceptable accuracy range to five meters for every 100 meters measured, you have increased the precision of the resulting maps. Of course, the price of this improvement is an increase in time and instrumentation needed to achieve this level of accuracy.

3) Accuracy of a measuring device, such as depth gauge using an analog needle, requires an estimate be made between a series of similar measurements. A single measurement can be accurate but it can never be precise. A more precise method would be to measure the depth from the same gauge five times, and average the readings. Of course, to verify the accuracy of the instrument it should be calibrated against a known measurement.

4) Measurements that are accurate and precise do not have to correspond exactly to one another. They merely have to be relatively comparable, as expressed in Column C of Table 1. This is where the science of statistics comes into play.

Statistics and its methods have been developed to measure measurements in relation to each other and thus determine their meaning relative to each other. The relative importance of both accuracy and precision is therefore set in the beginning of the project. Surprisingly enough, observational data also fits these descriptions of accuracy and precision for measurements.

Observation

Like any other data method, observation is a way in which to gather perceived and recorded phenomenon or events in time. It is normally conducted with any of the five senses: seeing, tasting, hearing, feeling, and smelling. Any scientific instrument can be used as an extension of any one of these senses. Essentially, an observer must be objective and not subjective in his/her observations. Objective in this sense means that the observer records accurately what is observed and does not impart any of their own ideas, desires, or interpretations into the observation. For example, one could document from a single observation, that a certain species of grouper is present on an artificial reef. However, one could not determine if the grouper somehow affected other fish on the reef until a series of observations were made to document the Grouper's effect. This interpretation could not have been made based solely on the first and only observation.

Observations are, therefore, objective recordings of sensed phenomena from the real world. This is not to say, however, that observations can not be intuitively based. They can certainly be intuitive, particularly when one is engaged in the inductive process of scientific investigation. To pursue the example above, one may observe the grouper on the reef and intuitively sense, based upon previous experience with the reef, that it is having a negative impact on the reef. One could then formulate and conduct an objective study to determine if this is indeed true.

Observations not only need to be accurate, they should use the most descriptive terms possible. They need to be precise in that they should be repeatable under the same circumstances. The point at which observations can trick one is that they are made by the person conducting the research. It is well known that we often observe things as reflections of our own inherent experience, prejudices, and desires. We tend to change (bias) our descriptions based on prior experiences. This is why we must maintain every possible effort to be totally objective when making observations. As artificial reef research divers, we must always be aware of our biases and how they may affect the work being done. For example, if a diver does not believe that non-edible fish have any impact on an artificial reef, he could choose to ignore them, and thus, never be able to measure the real impact that they may have on the total reef system. True objectivity in science is not arbitrarily "turning-off" of one's self. Rather, it is the knowing of one's own inherent biases and how they may affect the data.

Time & Data

The final aspect to be considered in data accumulation is the element of time. It takes, as mentioned earlier, a great deal of time (and thus money) to collect and record data. This is of great importance in artificial reef research, since so much time is consumed in just getting to and from the research site. Time is, therefore, one of the most precious commodities in artificial reef research. This is where all the careful planning and goal outlining mentioned earlier will have its greatest impact. Spending time planning the research while bouncing on the boat over the research site is just plain wasted. Planning is best done on shore before the dive. This includes planning for safety and maximizing research time at the study site.

Science is largely a repetitive endeavor, and it takes a great deal of time and many observations to build up the data base to make the research meaningful in the first place. It is important to realize that good reef research will not result from a single dive on any artificial reef. It will be the repetitive, sometimes seemingly monotonous work built up over extended periods of time, even over many years that will yield the most worthwhile results. Once again, caution must be used not to change data collecting methods because of their monotony. Time must always be taken into consideration when planning and outlining the final research project. Furthermore, time also has impact on the final step in conducting the research; the interpretation of all the data and experimentation that has been going on up until now. One must constantly take the time (between data collections) to evaluate what one has done in order to direct one's future work on artificial reefs.

Interpretation & Organization

Science, as outlined in the foregoing pages, is the overall method by which one discovers the natural laws which are the language used to describe the real world. It is the means by which, the artificial reef research diver will discover the world of the artificial reef. Observation, experimentation, and research are the methods of finding and describing the facts upon which this language will be based. Since we are conducting science, it now becomes necessary for us to explain this work so that others may know and make use of it. The step in which one formulates his explanation of the meaning of his work is known as INTERPRETATION. Interpretation is the analysis of the research findings from which the natural law and ultimately the theories, is developed into some communicable form. The interpretation can also be called the conclusion, or summary, of the work which conveys the discovered knowledge. Of all the steps involved in research and the scientific process, this will be the most difficult, the trickiest, and the one that requires the most experience to do properly. This is where the non-scientist must seek the advice of professionally trained scientists.

The principle reason that the interpretation or conclusion process is so difficult is that it is extremely easy to reach quick and often wrong conclusions before enough facts have been accumulated. As artificial reef research divers, our hardest task will be to keep from jumping ahead to the end of the research process and prematurely formulating an interpretation about the research results before the project is complete. In doing this work it will always be tempting to take some single observation or other small aspect of this work and build it into a rather grand fact. This is understandable, for the hardest thing any researcher or scientist must learn is that he or she must be patient and wait for the build-up and accumulation of data that will either prove or disprove any given hypothesis. The scientific literature, and indeed the popular literature through the media, is already scattered with the remains of research interpretations which were based on either too little data or on the premature interpretations of that data. For the artificial reef research diver, one of the most effective ways to avoid any premature interpretation is to have a full understanding of what his role and limitations are and how that role as a research diver (technician) is carried out. He should leave the interpretation in the hands of the professionally trained researcher.

Role of the Research Diver

In the past, research was usually carried out through the efforts of single, professionally trained individuals who did the observations and measurements, performed the experiments, accumulated the data and facts, and then did the interpretative work to formulate the laws and theories. During the past hundred years or so this has changed to more of a team approach. It is through this team approach that you will most likely be working as an artificial reef research diver. Because of the diverse nature of the disciplines involved in artificial reef work (i.e. population dynamics, invertebrate zoology, fisheries science, marine engineering, etc.), no single diver or set of diving partners can do all the work necessary to conduct research on artificial reefs. Therefore, the role of the artificial reef research diver is principally analogous to that of the laboratory technician in a modern day research laboratory. These technical people are responsible, by virtue of their training, to do the observations and data gathering pertinent to the research project and compile the data in a manner relevant to that project. It is the professional scientist who should interpret the data collected by the artificial reef research divers.

The modern research team usually has a primary researcher, called the Principle Investigator, who leads the research effort to meet the goals of the research project.This primary researcher may be a scientist or even a small team of scientists leading the research. It will usually be this principle investigator who will set the project's research goals, standards, evaluate the data, do the final interpretation and analysis of the data, and finally if applicable, publish the results. You, as the technical person, who collects the data, will play an integral and pivotal role in the research simply because so much depends on your diving and data gathering skills. The entire artificial reef research process depends on the accumulation of relevant, accurate, and precise data for its success. That is the reef research diver's function. A hypothesis will be supported or rejected on the basis of the data taken. The natural laws or theories that emerge will only be as good as the data that they are derived from. In no small sense, the success of any artificial reef research project will depend almost entirely upon the quality of its data; hence, the divers who are responsible for obtaining it.

Summary

Science is a series of steps used to discover natural laws. Scientific knowledge is built from data collected over time and the findings from past research and studies. In building our science of artificial reefs, we will be exploring new territory, discovering new facts, and expanding our knowledge of the real world. We can do so, however, only because we are basing our work in the beginning on the knowledge gained by those who went before us.

The advent of the volunteer, artificial reef research diver into the world of science is an exciting one. It is perhaps one of the first real opportunities in which a non-scientist can not only experience the fun and joy of doing science, but can also have direct and meaningful input into the world of scientific research without having to have the extensive training typical to most scientific disciplines.

References

Bolding, Kenneth E. 1980. Science, Our Common Heritage. SCIENCE, 207:4433, p 831-836.

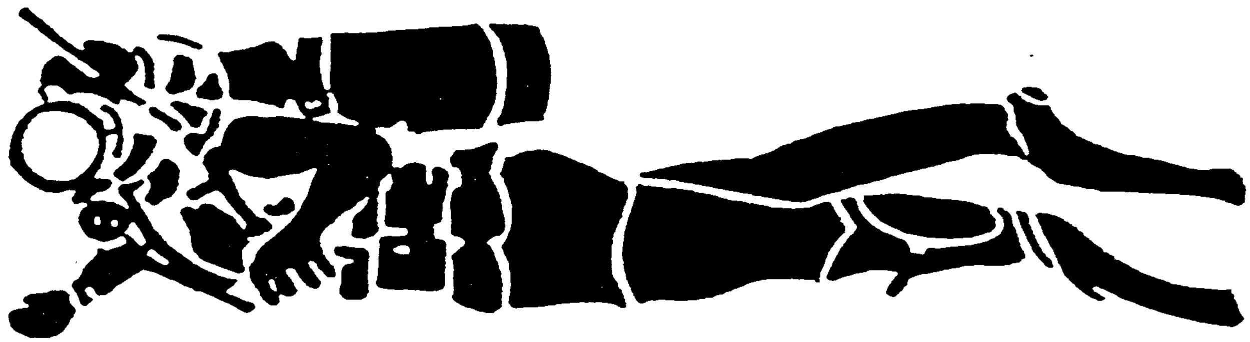
Bronowski, J. 1978. Magic, Science, and Civilization. Columbia University Press, New York.

Bronowski, Jacob. 1978. The Common Sense of Science. Harvard University Press, Cambridge, Massachusetts.

Goldstein, M. and F. Goldstein. 1978. How We Know. Plenum Publishing, New York.

Herrick, C. Judson. 1956. The Evolution of Human Nature. University of Texas Press, Austin, Texas.

Ziman, John. 1976. The Force of Knowledge. Cambridge University Press,Cambridge, England.



Chapter 3

Some Basic Considerations Of Underwater Scientific Photography

Joseph G. Halusky

Photography is a powerful tool for a diver/researcher. It enables the diver to return to the surface with a visual record of his subject as it was observed for moment in time. The camera-equipped diver can gather a large amount of data with a few snaps of the shutter, reducing the number of tasks he might need to get the same information manually. With proper accessory equipment and/or technique, the camera eye can capture phenomena invisible to the human eye by using infrared film or by stopping rapid motion.

Many "scientific" photos share characteristics common with "artistically" composed photographs, however, there are subtle differences. They vary in the value of the story they tell, in their eye appeal and in their composition. The "artistic" photos value is in its aesthetic eye appeal or unusual quality while scientific or documentary photos derive their value from the amount, quality, credibility and accuracy of the data (information) which they contain. Principally, the data photo is used to reconstruct and document some event and to capture qualitative and/or quantitative information about the subject. Often a series of data photos is taken to record the progress of a project or experiment or to show a progression of change over time, such as "before" and "after" photos. Of course, a good scientific photo can also have a high artistic value and vice-versa.

Basic Components of a Documentary Photo

Since the primary intent for a scientific photo is to record data, each photo should have certain key elements with it to make it acceptable as a scientific document. The key elements should appear <u>on</u> or <u>in</u> each photo. Information is placed <u>on</u> the photo after the film is processed and the print made. Information is placed <u>in</u> the photo at the time the picture is taken, and thus becomes part of the photograph itself.

Key Elements of a Scientific Photograph*

- 1. <u>Date</u> and <u>time</u> photo was made.*
- 2. <u>Location</u> where photo was taken (includes depth and precise geographic location).*
- 3. <u>Name of photographer</u>.*
- 4. <u>Scale</u> of photo. (The size of the subject should relate to some known object, such as a ruler, pencil or coin.)
- 5. <u>Orientation</u> of photo. (The subject of the photo should be related to some known benchmark such as distance and direction from a known point or experimental variable.)
- 6. <u>Exposure</u> information. (Film speed, shutter speed, f-stop and any special lighting and filters.)
- 7. <u>Project Identification</u> -- Name or code number.

* Indicates information which must accompany each photograph.

Basic Methods for Underwater Scientific Photography

Camera technique used by scientific photographers is generally no different from techniques used by amateur or professional photographers. All "tricks of the trade," therefore, can be applied and will not be discussed herein. Many suitable texts already exist on camera techniques and the reader can refer to them for further information.

The scientific photographer is faced with deciding between two photographic approaches to approach. It is the nature of the question being studied which determines the method used.

Single-Event Photo Method

- Definition: In this method, the data needed is contained in a single photograph. It is a photo of a subject or phenomenon as it occurs. eg., photo of a fish, or a fish behavior; pictures of scenes, activities, etc.
- Method: Single photo using still camera.
- Application: Used to:
  - document "it happened";
  - illustrate the "who, what, where, when and how" of some event;
  - record patterns (as fish markings, distribution on reefs);
  - record angular relationships, colors, interactions between individuals (as hermit crabs and their shells or cleaning behavior of fish at a cleaning station);
  - show relationships with their environment;
  - document experimental procedure, methods and progress.
  - can easily be made available for publication.
- Disadvantages:
  - cannot document relationships over great distances;
  - is inaccurate for comparing individuals not in the same photo or for survey information;
  - cannot show elements of change over time (however, single-event photos can be analyzed when made part of a series);
  - as a single photo, it cannot be used for assembling quantitative data or making population estimates.

Systematic Photo Series

- Definition: In this method, the data is obtained by comparing a series of photos which were taken so that each photo is related to others in space and/or time. Example: series of photos taken to make a strip map or a movie film. A movie is a group of still photos taken in time series.
- Method:

  a) Series in relation to a benchmark -- Photos taken in order, at regular intervals from a known benchmark. (Bottom survey of invertebrates along a transect line from a permanent benchmark.)

  b) Series in relation to time -- Photos taken at regular intervals of time of the same subject to show change. Movie or time-lapse. (Growth of the same coral colony.)

  c) Series in some pattern -- Photos taken along a randomly placed transect using a predetermined pattern, not necessarily related to a benchmark or regular time interval. (Used in population surveys of a variety of reefs.)

Note: Generally it is best to include photo identification information (see Key Elements) in the photograph series rather than on the photo after processing.

- Application: Series of photos can be used to:
  - survey an environment to obtain numerical data, such as a strip census or to measure distribution of organisms in relation to identified parameters or benchmarks;
  - make maps;
  - measure relationships between individuals such as in fish schools (Slow motion movies);
  - measure animal behavior action patterns;
  - measure growth rates or otherwise unperceivable changes as with time lapse photography of slow moving organisms on reefs.
- Disadvantages: The series of photos:
  - takes more preparation and more space than the single event photo, and may require special viewing equipment. (Loss of one photo could destroy value of the series);
  - not as useful for organism identification since the photo series is not oriented to just one subject, but instead oriented in space and time. (A fish may not stay within the limits of your survey area when the photo is being taken);
  - may be costly, depending on the measurement and orientation equipment needed to get the series;
  - usually requires more than two divers and more coordination and time to obtain the series;
  - may be difficult to analyze since the data exists in more than one photograph.

Storage and Retrieval of Scientific Photos

Taking the photo or photo series is only a small portion of the work surrounding scientific photography. A photograph is like any other "specimen" or "data sheet" that should be safeguarded and filed for later use. Project photographers should consult with the archivist to insure their work is entered into the archives properly. Careful consideration should be given to purchasing cabinets and film holding devices since photos, video tapes, movie film and negatives may have special handling and storage requirements. Like any specimen, each photo and negative should be labeled with the minimum information on it to include: date photo taken; location and photographers name.

Organizing the photos for later retrieval can be the greatest challenge. This requires a cataloging system and some procedure for loaning out the photos for those needing to use them. Library techniques for assigning topic headings for various photos would be useful for organizing the photo archives. One excellent publication titled "Organizing Your Photographs" by Robl (1986) offers many good suggestions for filing the photos and even computerizing information about them for quick retrieval. Photos should be cross indexed with the original data and dive log sheets stored in the reef data archives. One good way of achieving this is to store a photo log sheet in the specific reef site files, or project file.

Summary

The diver/scientist/photographer has at his disposal a powerful, time-saving tool for documenting underwater phenomena. He must, early in his prtoject design, select the appropriate camera technique and method (single event or systematic photo series) by which to gather his data. When considering photography as a tool for data gathering, careful consideration must be given to: limitations of the equipment, lighting and film; environmental parameters which affect photography; length and cost of the study; the nature of the question being asked; and the need for accurate photo record documentation.

Suggested References

Andrewartha, H.G. (1961). Introduction to the Study of Animal Populations, The University of Chicago Press. 281 pp.

Bass, George (1966). Archeology Underwater, Penguin Books.183 pp.

Church, Jim and Church, Cathy (1972). Beginning Underwater Photography, 2nd Ed., Pischel Inc., Pasco, WA. 56 pp.

Church, Jim & Church, Cathy. (1986). The Nikonos Handbook, Herff Jones Yearbooks, PO Box 3288, Logan, UT 84321

Church, Ron (1971). Beginner's Guide to Photography Underwater, Ron Church Publications, La Jolla, CA. 64 pp.

Frey, H. and P. Tzimoulis (1963). Camera Below, Association Press, New York. 224 pp.

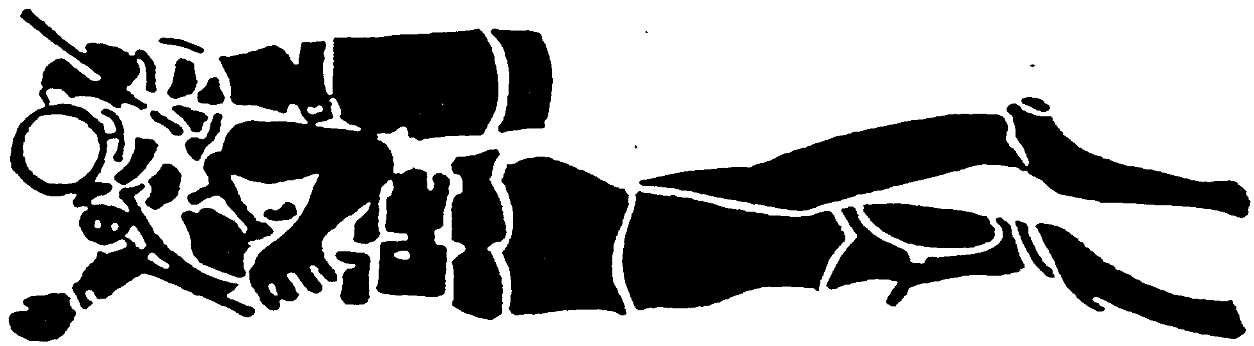
Hedgecoe, John (1979). The Photographer's Handbook, A.A. Knopf, New York. 352 pp.

Kinne, Russ (1962). The Complete Book of Nature Photography, A.S. Barnes & Co. Inc., New York 191 pp.

Kodak, Eastman (1972). Bibliography on Underwater Photography and Photogrammetry. P-124, E. Kodak Co. 30 pp.

Meyers, L.S. and N.E. Grossen (1974). Behavioral Research: Theory, Procedure, and Design, W.H. Freeman & Co., San Francisco, CA. 353 pp.

Robl, Ernest H.(1986). Organizing Your Photographs. Amphoto or Watson- Guptill Publications, 1515 Broadway, New York, NY. 10036. 191 pp.



Chapter 4

Oceanographic Data Collection And Reef Mapping

Christopher P. Jones

The collection of oceanographic data by divers is an important part of any artificial reef program. The data are needed for: site selection, assessment of physical changes to the reef over time and assessment of biological productivity. While some physical site selection data can usually be gathered during a single dive, assessments of biological productivity and reef stability requires many dives over an extended period of time.

The data are not the only consideration. Just as important are such things as measurement techniques, documentation of time and location of measurements, storage and retrieval of data (See Chapter 12: "Archives"). Unless the measurement techniques are standardized, and unless the time and location of the measurements are known, the data will be of no value. Standardized techniques for data gathering can help the diver make the most efficient use of bottom time and get maximum use out of the data. Reef maps can provide one of the best ways to handle data and to document changes to the reef structure over time. The type of map to be used (and the oceanographic data to be measured) will depend upon the goal of the data collection program.

The important thing to remember is that the reason for collecting data and noting artificial reef changes is to increase our understanding of reef behavior under certain oceanographic conditions and to improve siting and construction techniques. Unfortunately our present understanding of hydrodynamic forces on reef elements and submarine soil mechanics does not allow for accurate prediction of reef stability. Furthermore, expensive data collection programs using sophisticated equipment are required to make even approximate predictions. Since most artificial reef projects have minimal funding, data collection programs must be simplified; siting and construction decisions must be based on limited information and carefully researched principles. Divers will play an important role in collecting data and monitoring reefs so that these principles can be refined and improved. Oceanographic data as used in this chapter will include such parameters as: current direction and magnitude; direction, height and period of surface waves; bottom sediment characteristics; water temperature, salinity, turbidity and dissolved oxygen; and water depth.

There are only a few references dealing specifically with the stability of artificial reefs (Kim, et al., 1981; Aska, 1981). However, there are numerous references dealing with submarine soil mechanics and hydrodynamic forces related to pipelines and offshore construction; much of the information will be applicable to reefs (Grace, 1978; Chang and Ford, 1978; American Society of Civil Engineers, 1974; American Society for Testing and Materials, 1972; Schenck, 1975; Herbich, 1981).The NOAA Diving Manual (Miller, 1979) is also a good general reference for reef divers.

Reef Stability

Stability of an artificial reef can be defined as the ability of the reef to resist settlement displacement and deterioration. The long-term stability depends upon many things: reef material(s), water depth, waves and currents, bottom sediments, etc. A reef monitoring program should be designed to document any changes in reef structure and orientation, as well as material deterioration. The program should gather sufficient oceanographic data to correlate changes in the reef with these data. The reason for looking at reef stability is to note changes in the reef elevation, structure or materials that affect the biological productivity of the artificial reef. These changes can occur gradually over a long period of time or they can occur suddenly, particularly during severe storms. For these reasons, monitoring programs should include periodic dives at a reef site, and should allow for dives after storms as soon as conditions safely permit.

Important changes can be divided into five categories: settlement, siltation, collapse, disintegration and scattering. The first four all result in a loss of reef, while the fifth results in a dispersal of reef materials over a wide area.

Settlement and Siltation

Settlement occurs when the bearing capacity of the bottom sediment is not sufficient to support the reef elements or when the sediment liquifies during storm conditions -- the reef sinks into the bottom. Siltation occurs when waves and currents carry sediments into the reef area, where for one reason or another they settle out, slowly burying the reef elements.

Bottom characteristics should be investigated carefully as part of any artificial reef site selection process. This is to ensure that settlement will not occur, or if it does, that the expected settlement will not be a problem. Settlement of a reef can be monitored by driving one or more steel rods or pipes into the bottom at the reef site and measuring the elevation of the reef elements with respect to the tops of the rods. Siltation can be monitored by measuring the distance from the tops of the rods to the sediment. The rods can also be used as horizontal and vertical control points for mapping efforts.

Collapse and Scattering

Collapse is used to describe the movement of reef elements from their original configuration to one of a lower profile. Individual elements remain intact during this process.

Scattering occurs when reef elements spread out over the bottom (low density materials such as tires are susceptible).

Measurements of collapse and scattering will be more involved, due largely to the nature of reef materials subject to these changes - the elements are usually small and placed in large quantities (tires, appliances, culvert, rubble, etc.). In order to measure collapse and scatter accurately, the diver must have a complete and accurate post-construction map showing the locations and positions of the reef elements. He must then return to the site later to construct another map. Mapping can be accomplished with tape and compass, or with more sophisticated (and expensive) equipment. Raymond (1981) describes such a project, where side-scan sonar and underwater photographs were used to map a tire reef.

Ideally, differences between the maps should be due only to collapse or scatter, but this may not be the case. Poor conditions, limited visibility and errors in measurement will all be reflected in the differences between the maps. Divers should recognize that bottom time limitations and other constraints may not allow them to precisely locate individual reef elements, and that maps will therefore contain some errors. This is acceptable, provided that divers accurately map the boundaries of the reef, and the shape and height of its major features. These data will allow gross changes in reef structure to be documented. Remember, it will not be worth the effort to map large numbers of individual elements within a reef site, except during highly unusual circumstances.

Disintegration

Disintegration refers to the deterioration of reef materials. This occurs most commonly with automobiles, appliances and other elements made of thin sheet metal that corrode rapidly.

Disintegration may result in localized or total failure of a reef; it may occur slowly or rapidly, depending on the type of material used to construct the reef and the forces acting on it. Documenting deterioration will require that photographs and/or notes describing condition at the time of placement be compared with similar records from a later date.

In many cases, deterioration will be obvious (e.g., a broken hull or collapsed deck on a barge or boat). Divers should concentrate on documenting significant changes rather than the minor or not so obvious ones. They should look for such things as: changes in height, break up of large pieces into smaller ones, enlargement of major cracks and holes, corrosion and disappearance of metal sheets or wood planks, etc. It is helpful to mark a piece or part of a reef so that divers can return to the same place to follow movement of tagged materials to document change.

Oceanographic Data

Collecting oceanographic data is an important part of any site selection or reef monitoring program. Divers must collect the data systematically and record it carefully. Following the procedures outlined in this chapter will help divers to gather the most important data. Using a standardized data recording sheet (see Appendix B for examples), will ensure that the necessary oceanographic data area collected, and that other important information is also recorded. This additional information should include: surface position (latitude and longitude, or LORAN), date and time (be sure to note whether times are daylight savings or standard), a brief description of meteorological conditions (air temperature, wind speed and direction, cloud conditions, etc.) and the name of the person making these observations.

Even though divers will not be able to collect data during storms (when conditions will have the greatest impact on reef stability), they will be able to collect data during "normal" conditions or shortly after such events, which are probably more important biologically. The data can be analyzed in conjunction with fish counts and other biological observations to improve our understanding of artificial reefs. Some analysis has been done (Bortone and Van Orman, 1985a; 1985b) but more data needs to be collected.

Currents

Currents are one of the most important factors affecting reef stability. It is the flow of water past an artificial reef that creates hydrodynamic forces capable of shifting reef elements, scouring or depositing sediments, reducing the bearing capacity of the bottom and supporting the community of filter feeders.

Unfortunately, the strongest currents (and the greatest movement of reef elements) usually occur during severe storms - when divers cannot make observations. If a self-recording current meter can be installed at the reef site, measurements of storm currents can be obtained and correlated with observed displacements of reef elements. Even if a self-recording current meter cannot be installed, a post-storm dive on a reef as soon as conditions safely permit will yield valuable information.

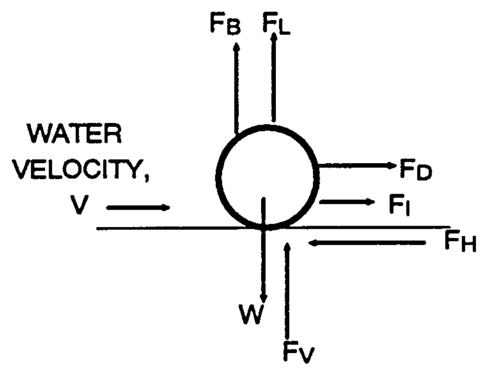
Currents at a particular location can be the result of several things: waves, tides, winds or large-scale current systems (eg. the Gulf Stream). Currents can move in one direction or they can be oscillators (divers often refer to oscillator bottom currents as "surge" or "wave surge"); they can change speed or direction rapidly or they can be slowly varying; they can be nearly uniform throughout the water column or they can change from surface to bottom. For these reasons, current measurement programs should be thought out carefully. Over time it will be possible to establish a current data base at a reef site, just as meteorologists have established climatological norms and extremes for sites on land.

This data base should include the following information: surface position; date and time of measurement; surface current speed and direction (note that current direction is specified as the direction in which the water is moving toward - this is opposite to the convention used for winds and waves, which are specified according to the direction from which they come); bottom current speed, direction and distance from the bottom to the point of measurement (since the velocity decreases as you get close to the bottom). Be sure that bottom current measurements are made "upstream" of any reef elements or obstructions (including other divers) that might distort the flow field. Note any rocking or movement of reef elements when the measurements are made.

Current measurement techniques need not be complicated. In fact, the simplest are sometimes the best. At the surface, measure the time it takes floating debris or foam to pass an anchored vessel. Dividing the vessel length by the measured time yields the current speed; a compass provides direction. Bottom currents can be measured in a similar fashion. Observe the time it takes fine sediment or other particles suspended in the water to travel a measured distance along the bottom. Dye pellets can be carried to the bottom in waterproof packages by divers and then opened; the dye will color the water and allow for speed and direction measurements to be made. These simple techniques have some advantages over the use of hand-held or other types of current meters. First, there is much less cost involved, and second, low velocities that are below the threshold for current meter operation can still be measured.

The most practical way for reef divers to improve our understanding of reef stability is by making systematic current measurements and observations of reef movement. Since it is difficult to predict accurately the effects of currents on artificial reef elements, simple correlations between currents and movement must be developed from the data collected. Nevertheless, it is useful to review the forces that will act on a reef element so that divers will have a basic understanding of them. **(See Figure 4.1, which illustrates the various forces acting on a single reef element in the presence of a current with velocity V.)**

Figure 4.1



The forces indicated in the figure are described below:

W = the weight of the reef element in air

F_B = the buoyant force acting upward on the element (note that the differences between the weight and buoyant force is the submerged wright)

F_V & F_H = the soil forces acting on the element that tends to resists settlement and lateral movement, respectively

F_D = the drag force acting in the direction of water movement

F_L = the lift force acting on the element in the vertical direction due to the flow around an asymmetrical element of to the alteration of the flow pattern around the element due to the presence of the bottom

F_I = an inertia force present only in accelerating (wave-induced) currents

Note that the hydrodynamic forces (F_D, F_L, F_I) depend upon the speed of the current and the area or volume of the reef element; if the speed increases then these forces will increase also. Likewise, if the size of the element subjected to the current increases then the forces will increase.

The magnitudes of the hydrodynamic forces also depend upon certain empirically determined coefficients. For example, the drag force can be described by the following equation:

$$F_D = pCDA\,V^2$$

Where p is the density of the water, A is the projected area normal to the current and CD is the drag coefficient. In general, CD will vary with the shape of the element, the roughness of the element and the speed of the current (i.e., CD is not constant, but a function of V).

It is difficult without detailed field and laboratory studies to calculate the drag force and other hydrodynamic forces on a reef element, particularly if it is of an odd shape or if it is surrounded by other elements which distort the flow field.

Surface Waves

Most waves are caused by wind. As the wind blows over the water surface energy is transmitted to the water and waves are formed. Wave characteristics depend on the wind speed, the distance over which it blows (the fetch) and the length of time that it blows. The sea surface at a particular location may be calm or very irregular, depending upon local winds and the presence of waves generated at far away locations; the surface may be composed of waves travelling in a single direction or of waves travelling in several directions.

Waves are classified according to the ratio of their length to the water depth as deep water waves, intermediate waves or shallow water waves. Deep water waves are those whose length is less than twice the water depth; shallow water waves are those whose length is one-half the water depth. Intermediate waves lie in between. This distinction is important since waves not only affect the sea surface, but also the water column below: waves generate oscillating currents that extend down into the water (see Figure 4.2). The water particles under a deep water wave tend to move in circular orbits, while those under intermediate and shallow water waves tend to follow elliptical paths.

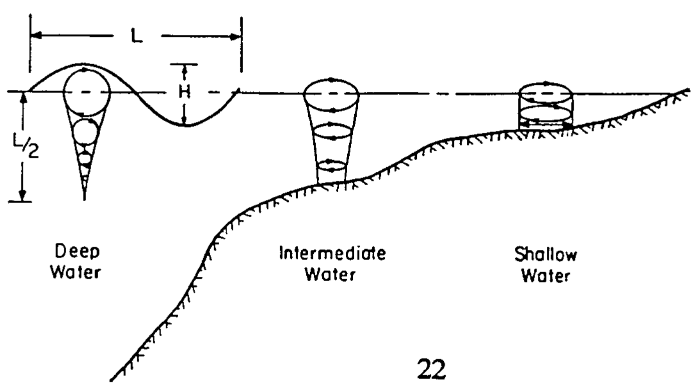
The magnitude of the water particle motion is greatest at the surface and decreases with increasing depth.There is little decrease in the case of shallow water waves - currents at the bottom are almost as strong as those at the surface. Deep water waves, on the other hand, only affect the water column down to a depth approximately equal to one-half the wave length.Thus, while a diver might find it impossible to work in 50 feet of water with surface waves greater than several hundred feet in length, he would not even be aware of waves shorter than 100 feet in length. The effects on reef stability would be analogous: deep water waves would affect reef elements while intermediate and shallow water waves might move the elements (and bottom sediments) easily.

Observing waves at the surface will involve three things: estimating wave height, wave period and wave direction. This will be relatively easy if only one wave train is present, but may be more difficult if two or more are present. Nevertheless, the same procedures apply - just try to observe individual wave trains separately. If the sea is too confused, estimate the characteristics of the dominant wave only.

Wave height, Figure 4.2, is the vertical distance between the top (crest) and the bottom (trough) of the wave. If waves are very regular, the height of each successive wave will be nearly identical. If wave heights vary, the "significant wave height" should be estimated - this is the average height of the hightest one-third of the waves. Estimate wave heights to the nearest foot.

Wave period is the time it takes successive wave crests to pass a fixed point. When wave period is measured, record the total time it takes *n* wave crests to pass, then divide by *n-1*, where *n* is large enough to average out variatons in period. Round the result to the nearest second. A convenient value of *n* is 11 since the total time is then divided by 10 - an easy calculation. Count only the passage of crests from the larger waves and neglect the smaller ones, if the surface is irregular.

Figure 4.2



Wave direction is the direction from which the waves are coming, not the direction in which they are moving. For example, waves approaching from the northeast would be recorded as 45°. Measure direction to the nearest 5°.

Water Temperature

The temperature of seawater tends to vary with season, location and depth. Seasonal temperatures can vary by 10 degrees centigrade, or more, depending on latitude. Regardless of season and location, there is usually a difference between surface and bottom temperatures of a few degrees (this may not occur in some cases where water depths are shallow and where the water column is well-mixed). This temperature drop may be gradual from surface to bottom or it may be sudden, occurring at an interface between two distinct layers of water called a thermocline. In some cases where water depths are great, there may be three (or more) layers and two (or more) thermoclines.

When water temperatures are measured as part of a reef siting or monitoring dive, the water temperature should be measured in situ, just under the surface, above and below a thermocline, and near the bottom. The depths at which the thermoclines lie should be noted.

Salinity

Salinity is a measure of the amount of dissolved solids in water. It is usually expressed in parts per thousand (ppt), with normal seawater having a salinity of 33 to 37 ppt. Salinity may be significantly less near fresh water sources such as river mouths, tidal inlets and offshore springs. There is a unique relationship between the density, temperature and salinity of seawater: knowing any two specifies the third. Appendix C illustrates

Unlike water temperature, salinity does not have to be measured in situ. It can be measured on board a ship or on land from water samples collected by divers. It can be measured by any number of ways, but probably the simplest is with a thermometer and a hydrometer. A more expensive but simpler refractometer uses a visual method to determine salinity by measuring the refractive index of the water. It is independent of temperature. Water samples should be collected on the reef, since that is where encrusting organisms and fish will be. There is no need to take water samples in the water column unless pelagic species are being investigated.

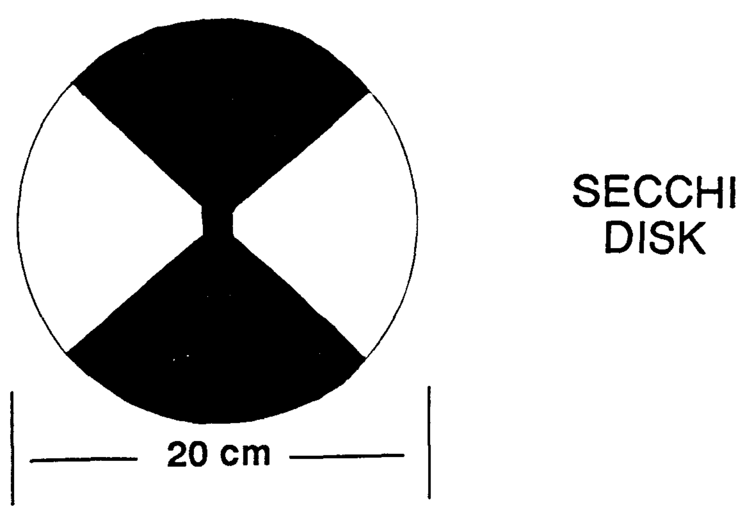
Transparency/Turbidity

Transparency and turbidity are two terms used to describe the clarity of water. Transparency is a measure of the avility of water to transmit light, while turbidity is a measure of the amount of particles suspended in the water: as turvidity increases transparency decreases. These measurements will vary with the number, size and type of particles suspended in the water, and with the nature and intensity of the illumination.

One of the simplest ways of measuring water clarity is with a secchi disk - a circular disk whose surface is divided into quadrants painted white or black. Oceanographers lower the disk into the water from a ship and record the depth at which the disk is no longer visible.

Divers can also emply a secchi disk, but in a slightly different way by measuring the horizontal distance along the bottom to a point when the disk in no longer visible (See Figure 4.3). Note that divers must be careful not to stir up bottom

Figure 4.3



sediments when this technique is used; if clarity is to be measured on a dive, this should be the first task performed so that diver activity during other tasks will not affect the results.

Dissolved Oxygen

Dissolved oxygen affects the health and distribution of finfish, shellfish and other creatures inhabiting a reef. Unfortunately, it is difficult to measure accurately. Since it varies with temperature and pressure, water samples cannot be collected and brought to the surface for analysis unless special techniques are employed.These may be beyond the scope of routine reef monitoring. For those that are interested, section 8.8.3 of the "NOAA Diving Manual" (Miller, 1979) describes procedures that can be used to collect and transport water samples for later dissolved oxygen analysis.

Bottom Sediments

Bottom sediment characteristics are one of the most important factors controlling the stability of an artificial reef. If the bottom has a low bearing capacity or if it is susceptible to liquification during storms, reef elements will settle.

In general, it is very difficult to accurately estimate the bearing capacity of bottom sediments with either in situ or laboratory tests. This is due to the fact that the results depend upon the type of test performed and the degree to which the sediment sample is disturbed during sampling and testing. However, there are some basic correlations between the type of sediment, its resistance to penetration and its bearing capacity. These will be discussed later in this chapter.

First, it is necessary to adopt a sediment classification system (see Appendix D).Bottom sediments can be composed of a variety of types and sizes of particles. Clay, silt, sand, gravel, shell and rock are those most commonly encountered. The finer particles (clay and some silts) are cohesive - there are electrochemical forces between particles that account for most of the strength of the sediment. The coarser sediments (sand, shell and gravel) are cohesionless and rely solely upon friction between particles for strength.

Rock may occur in large formations or as fragments suspended on or in other sediments. It sometimes occurs as outcrops on the bottom, but is usually overlain by sediments a few inches to several feet in thickness. Rocks occurring offshore of Florida are sedimentary in origin, with sand and/or shell cemented together. These sedimentary rocks posssess varying strengths, and in some cases may fracture or wear readily.

Gravel is a term used to describe small pieces of rock ranging from many centimeters to a few millimeters in diameter.

Sand particles are smaller than gravel, but larger than silt. The division between sand and silt is from .05 - .074 mm, depending upon the classification system used. Most sand-sized particles occurring offshore are quartz particles or shell fragments.

Silt particles are smaller than sand but larger than .002 - .006 mm in size. Silts can display some cohesive properties, but this is due usually to the presence of small amounts of clay particles.

Clay particles are very fine (< .002 to .006 mm, depending upon the classification system used). The most common clay minerals are montmorillonite, kaolinite and illite. Clays can be very sensitive (losing much of their strength when disturbed).

Sediment Correlation

Since there is a fairly good correlation between sediment type (i.e., size) and strength, it is important that the reef diver be able to differentiate between them. This can be accomplished in two ways. First, sediments of various sizes can be obtained and kept in containers for visual comparison with sediment samples obtained from reef sites. This method is useful for distinguishing between gravels and coarse, medium and fine sands.

The second way of differentiating between sediment sizes is more useful for distinguishing between coarse-grained sediments, silts and clays. It involves placing a sediment sample in a jar of water, shaking it and letting the particles settle. The sand and coarse-grained sediments will settle out in less than 1 minute, the silt particles will settle in 10 minutes to 1 hour, while the clay particles may take several hours to settle (Bowles, 1977). By noting the thicknesses of the layers, one will have an idea of the proportions of different size sediments in the sample.

In general, fine-grained sediments such as silts and clays should be avoided when siting artificial reefs, unless rock lies close to the sediment surface. They are usually soft and reef materials placed on them will tend to settle. Sediments composed of sand, shell and gravel provide greater strength and are preferred. Even these sediments are subject to occasional settlement problems. This usually occurs during periods of high wave activity. The waves set up cyclic variations in the pressure of water contained in the pores between the sediment particles. When the pore water pressure equals the pressure exerted by the submerged sediment, the soil liquifies and loses its strength.

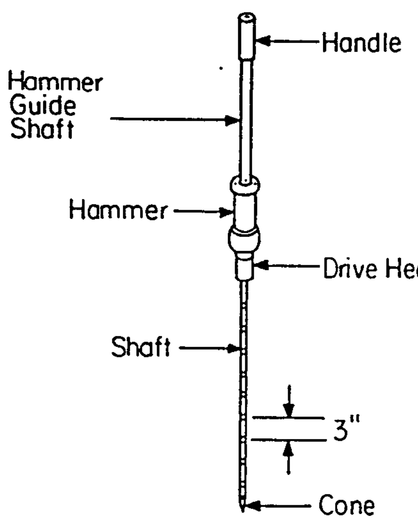
This may happen only briefly, but can allow reef elements to settle.

Coarse-grained sediments that have nearly equal proportions of various grain sizes are called "well graded" and are not normally subject to liquification. Poorly graded sediments (i.e., sediments composed almost entirely of a certain grain size) are called "well sorted" or "uniformly graded" and are more susceptible to liquefaction. Of these, fine sands tend to liquify more easily than coarse sands and gravels (Chang and Ford, 1983).

Those same sediments that tend to resist liquefaction (well graded sediments composed of sand, shell or gravel) also offer the greatest bearing capacity. While it is a difficult parameter to estimate accurately, reef divers can develop a feeling for the suitability of various sediments for reef construction with a simple tool called a penetrometer (see Appendix F). A penetrometer is a rod that is forced into the bottom a known distance by a load that is measured. A sediment with a high bearing capacity will require a greater load to push the penetrometer into the bottom a fixed distance than will a sediment with a low bearing capacity.

By using the penetrometer at several sites where artificial reefs have already been constructed and where varying degrees of settlement have been observed, reef divers can develop a correlation between measured penetration resistance and potential settlement. Of course, other factors such as water depth, type of reef material, etc. will have to be accounted for when the correlation is developed.

Figure 4.4



This figure from the Naval Civil Engineering Laboratory, 1985, shows one of several types of penetrometers that might be used. It is a good choice since it was developed specifically for use underwater.

Rock bottoms will provide a good foundation for artificial reefs, particularly when overlain by a few centimeters of sediment. The rock will limit the depth of settlement while the sediment will help stabilize the reef elements against movement caused by waves and currents.

Determining whether or not rock lies below loose sediment can be accomplished by pushing, driving or jetting a probe into the bottom until it will go no further. If rock is encountered, its depth below the bottom should be measured. Note that the reef diver is usually not interested in any more than the first meter of sediment. If rock lies deeper than that, it will be of little use in halting the settlement of a reef, unless the reef is constructed of very large elements.

Remember other factors besides bottom sediment characteristics must be considered when selecting a reef site. Water depth, the influence of currents and waves, and the type of reef materials will all affect the success of a reef. For example, steel fuel tanks with the ends removed (thus resembling pipe) were placed in 70 feet of water off Jacksonville on June 1, 1983. By June 30, 1983 some of the tanks had worked their way into a limestone bottom as much as 70 cm. The tanks were from 1 m - 2 m in diameter and 5 m - 8 m in length, with a wall thickness of about 6 mm. Concrete pipes of comparable diameters were placed at the same time, but settled only through a few centimeters of sand over the limestone. Calculations showed that the submerged weight of the concrete pipe (per m of length) was 2 to 3 times that of the steel tanks - a significant difference. Divers observed that the steel tanks rolled back and forth with only 1 - 2 foot waves at the surface, while the concrete pipes remained still. The movement of the steel tanks abraded the soft rock and the tanks worked their way into the bottom.

Sediment Sampling

Reef divers may be concerned with both the surface sediments and those below the surface, which can include unconsolidated sediments as well as consolidated sediments (rock).

The best way to sample unconsolidated sediments, both on the surface and beneath, is with a thin-walled core tube (usually clear plastic or PVC pipe, a few cm in diameter). The method (described in Methods Summary) provides a consistent way of sampling, while ensuring that all grain sizes present in the sediment are retained in the sample, and that there is minimal disturbance to the sample. A clear plastic pipe allows the reef scientist to examine any layers in the sediment and to perform grain size analyses on the sample. If a sediment sample is collected by hand and placed in a container, the finer particles can slip through the fingers or be suspended in the water and the sediment structure will be destroyed.

If a surface sample is all that is required, the core tube needs only to be about 6 inches long. Partially filling a longer tube is not good practice since this allows the sample to shift in the tube and the sediment structure to be altered during handling. The tube should be pushed fully into the bottom, capped at the top and then sealed at the bottom with a flat plate or the diver's hand. The tube is then removed, inverted and capped at the bottom. Be sure to mark the tube so that the location and time of sampling are known; make sure the top of the sample is marked as well. Procedures for obtaining longer cores are not much different, except it is usually necessary to drive the tube into the bottom. Simple impact corers have been devised to make this task simpler (Naval Civil Engineering Laboratory, 1985; Sanders, 1968).

An important consideration in obtaining samples of unconsolidated sediments is that the location from which they are obtained be representative of the area being investigated. Otherwise, the sample will not be useful in characterizing the sediments in the area: it will give reef scientists a false impression of what the bottom is like. Pooling multiple samples from the same site will be more representative than a single sample.

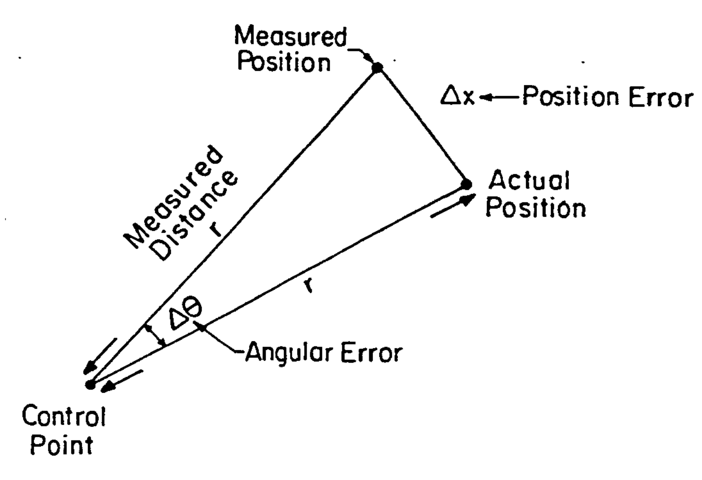
Mapping

Mapping is a crucial part of artificial reef research. Physical and biological measurements may be of little value if the locations of the measurements are not known, or if divers cannot return to the same points later to take additional measurements. Reef divers should become familiar with basic mapping techniques so they can use them during site surveys and monitoring surveys.

Divers should strive to make accurate, rather than precise, maps (see Chapter 1 for discussion of this). The desired degree of accuracy should be determined before any diver enters the water, based on the intended use of the data, bottom time limitations, etc. Remember, it will take much more time to make measurements accurate to one meter than it will to make measurements accurate to five meters or ten meters; in some cases the less accurate measurements may be sufficient.

Figure 4.5 and the following table will assist reef divers in determining the accuracy requirements for locating an object. Note that for a certain allowable position error, the allowable angular error decreases and the length of a measured distance increases. For example, if an object must be located within five meters of its actual position, the maximum allowable angular error over a distance of 50 meters is 5^0; the maximum allowable angular error over a distance of 100 meters is 2 $1/2^0$. In most cases, however short the measured distance, will an angular error greater than 10^0 be considered acceptable for mapping purposes.

Figure 4.5



Establishing Control Points

Whenever bottom features, reef elements or data collection stations must be located, a point (or points) of reference must be available; otherwise, there will be no way to accurately relocate them. These points of reference, called control points or bench marks, should be established around and/or through the reef site so that no object or feature is very far from a control point. This also insures that if a control point is disturbed or lost, another can be re-established easily.

Control points can be made of anything that is durable, that will remain in the same location and that can be easily located and uniquely identified, perhaps with its own tag or number. A good choice for many areas will be steel rods or pipes. They should be long enough so that the top will be two or three feet above the bottom, after the rod or pipe is driven into the bottom several feet. Both horizontal and vertical measurements can be referenced to the control points. Each point should be given a different name, number or letter to distinguish it from the others. It will be necessary to label the points underwater to avoid confusion during mapping.

Once control points are installed, distances (measured to the nearest meter) and azimuths[3] between the points should be measured so that their positions with respect to one another can be determined. An azimuth is an angle measured clockwise from north; azimuths will lie between 0° and 359°. The elevation at the top of each control point should also be determined (use a depth gauge to do this). Divers may wish to refer to any basic land surveying text for a discussion on how to check the accuracy with which control points have been mapped (look for discussion on traverse closure and adjustment).

Please note that the exact position of a control point (i.e., latitude and longitude or LORAN coordinates) need not be determined. Without very sophisticated (and expensive equipment, it will be impossible to perform this task. Instead, the approximate surface position corresponding to a control point should be determined so that the divers can repeatedly find the control point and make accurate measurements using it as a point of reference.

Locating Objects on the Bottom

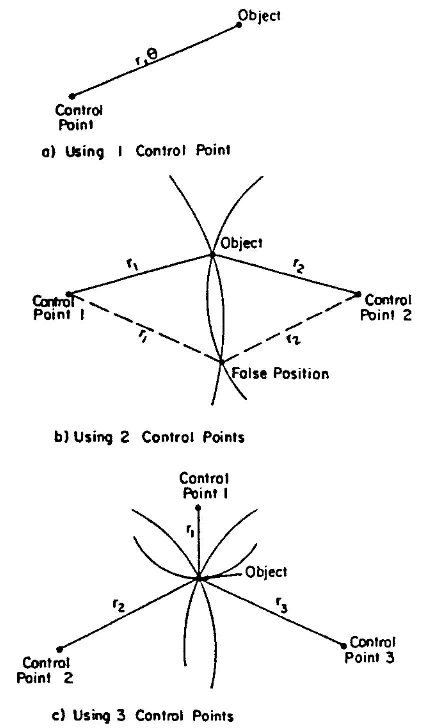
In order to locate an object (or data collection station), it is necessary to reference it to one or more control points. The horizontal position can be found given any one of the following:

- the distance and direction from a single control point or bench mark.
- the distances from two control points and an approximate direction from either control point.
- the distances from three control points.

These are illustrated in **Figure 4.6**. Note that in the case where an object is located using two control points, distance measurements alone will not suffice. For example, suppose an object is determined to be 25m radius from point one and another arc with a 35m radius from point two reveals that there are two intersections of the arcs. Thus, there are two possible locations of the object for the given distances. In order to determine which location is correct, an approximate direction from either control point to the object is required. If three control points are used, the arcs will intersect on only one point and directional information is not needed.

Divers should be careful when making measurements to pull the tape taught (gravity and currents may both cause the tape to sag or distort, causing measured distances to exceed actual distances). Divers should also be careful when measuring distances along a slope or from a point on the bottom to another point above the bottom. In such cases, the distance measured by the tape (the slope distance) will be greater that the true horizonal distance (**see Figure 4.7**). This error can be corrected, if a diver measures the depth at both ends of the tape with his depth gauge (be sure to

Figure 4.6



use a good quality, oil-filled gauge or electronic dive computer which measures depth and be sure to use the same gauge to measure at both ends). The true horizontal distance is related to the slope distance and the difference in depth (elevation) of the two points by the following equation:

$X = S2 - D^2$

X = true horizonal distance

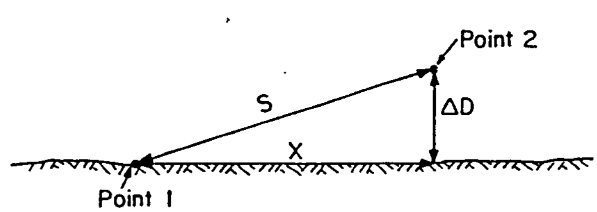
S = measured slope distance

D = difference in depth between the two points

Be sure to use consistent units, i.e., if X and S are measured in meters, make sure that D is measured in meters, not in feet.

Vertical distances can be measured as described above - by reading a pressure gauge at two locations and taking the difference between that two readings.

Figure 4.7



References

American Society of Civil Engineers, Pipelines in the Ocean, 1974, 110 pp.

American Society for Testing and Materials, "Underwater Soil Sampling, Testing and Construction Control", ASTM Special Technical Publication 501, 1972.

Aska, D.Y., ed., "Artificial Reefs: Conference Proceeding", Florida Sea Grant Report 41, 1981.

Bowles, J.E., Foundation Analysis and Design, McGraw-Hill, 1977, 750 pp.

Bortone, S.A. and Van Orman, D., "Biological Survey and Analysis of Florida

Artificial Reefs", Florida Sea Grant Technical Paper 34, 1985a.

Bortone, S.A., and Van Orman, D., "Data Base Information and Assessment of Biotic and Abiotic Parameters Associated with Artificial Reefs", Florida Sea Grant Technical Paper 35, 1985b.

Chang, H.H. and Ford, J., "Pipeline Shore Approach: Analysis and Design", ASCE Journal of Transportation Engineering, Vol. 109, No. 6, 1983.

Grace, R.A., Marine Outfall Systems: Planning, Design and Construction, Prentice Hall, Inc., Englewood Cliffs, NJ, 1978.

Herbich, John B., Offshore Pipeline Design Elements, Marcel Dekker, Inc., 1981, 233 pp.

Johnson, R.E. and Hilder, F.A., "Isopycnal Temperature-Salinity Diagrams", Old

Dominion University School of Oceanography, Technical Report 41, 1981.

Kim, T.I., Sollitt, C.K. and Hancock, D.R., "Wave Forces on Submerged Artificial Reefs Fabricated from Scrap Tires", Oregon State University Sea Grant Publication T-81-003, 1981.

Miller, James W., ed., NOAA Diving Manual, U.S. Department of Commerce, 1979.

Naval Civil Engineering Laboratory, "Determine Seafloor Soil Properties with Diver Operated Geotechnical Tools", NCEL Techdata Sheet 85-23, Port Hueneme, CA 1985.

Raymond, B., "Underwater Photogrammetic Survey of a Tire Reef", in Aska, D.Y., ed., Artificial Reefs: Conference Proceedings", Florida Sea Grant Report 41, 1981, pp. 211-218.

Sander, J.E., "Diver-Operated Simple Hand Tools for Coring Nearshore Sands", Journal of Sedimentary Petrology, Vol. 38, No. 2, 1968, pp. 1381-1386.

Schencek, H., Introduction to Ocean Engineering, McGraw Hill, 1975, 351 pp.

Chapter 5

Site Selection And Evaluation By Divers

By Heyward Mathews

The most critical phase of any artificial reef construction project is the selection of its site. A properly selected reef site will attract, for a long time, large numbers of fish to a location which is easily found by fishermen and divers. Improperly sited, the reef can become lost, or settle into bottom sediments, or attract only a minimal amount of fish. It also can become a hazard to navigation and bottom trawlers or even be found washed up on some beach. The research diver plays a vital role in the site selection process by providing first hand observations of the sea floor that cannot be provided by simple fathometer surveys.

Some General Considerations for Reef Sites

In most reef building projects, a general location for the reef site is usually selected, either by local officials, a fishing or diving club or civic organization. There is a tendency among anglers to select an existing favorite fishing spot to "sweeten it up" or make a "good bottom" even better. If the site has any type of natural reef or "live bottom" then the use of such a site for an artificial reef is discouraged by the permitting agency. Part of the reason for this is that there is insufficient research to determine what effects an artificial reef may have on the functioning of a natural reef system. In addition, the artificial reef materials may actually damage some of the existing natural bottom community, such as incrusting corals and sponges.

When an artificial reef is built in the middle of a flat, featureless bottom, it can serve as an oasis in a desert of sand. Divers have observed great concentrations of fish on new artificial reefs within a few days of placement in such areas. Most offshore areas which have such barren bottoms are usually well known to local divers and fishermen. Where possible, the nearest site to a sea buoy or inlet is preferable to save both time and fuel costs for the users traveling to and from the reef. The site should not be located in or adjacent to a heavily used shipping channel or fairway, because these areas will be in use day and night by small boats.

Another important consideration for the site selection is local commercial fishing operations, particularly those using nets or trawls. Often there are obstructions or snags in an area that is already avoided by net fishermen. The selection of such an area will avoid any conflict with existing fishing operations, and benefit the net fishermen by having a buoy in the area of the obstructions that will allow them to avoid it completely. An existing wreck can be an excellent starting point for an artificial reef, and the addition of materials can only increase the fisherman's choices around the wreck (see Appendix F for further information on site selection).

Role of Divers in Site Planning

Divers and diving clubs can make a very important contribution during the planning stages of a reef project by surveying local fishing spots and potential artificial reef sites. Often anglers have only a general picture of the bottom based on depth sounder tracings. They can seldom tell if the bottom has living corals, sponges, or other live bottom organisms, especially if they are low profile. The fathometer tracing will not show the supporting ability of the bottom, so the diver must test the substrate with his hand, some type of bottom probe, or retrieval of a bottom sample to determine if it will properly support the reef materials. Chapter 4 provides further discussions about testing and describing sediment for its ability to support reef materials.

Preliminary Surface Survey

Once a general area has been selected, the diver/biologist should make a systematic fathometer survey of the area unless it has already been surveyed and fished extensively in the past. If possible, a permanent record of this survey should be made by using a paper tracing or video of the fathometer readings. A series of transects using a good quality fathometer is the least costly and time consuming way to do this. In most areas the "live bottoms" are rock ledges or outcrops. Generally, these structures may have some lateral orientation with respect to the coastline. This occurs as the continental shelf slopes seaward where it intersects rock strata that form the ledges and outcrops which have become covered with benthic communities. Knowing that such structures run at some angle with respect to the shore-line, makes it easy to establish transect lines. They should be set up to run at right angles to these structures to reduce the chance of one being missed. Once the transect lines indicate an area devoid of any hard bottom communities, then the physical survey of the bottom can begin.

Underwater Site Survey

Before any reef site is finally chosen, there must be an underwater survey by divers to verify that there is no live bottom and make a physical and visual check of the bottom type and measure its supporting ability. Generally, the surveyors should swim a 50-meter radius around the potential site to verify there are no significant "live bottom" communities in the site area. Significant "live bottoms" would include any large rock ledges or outcroppings having an incrusting (attached) or fouling community. Even the bare sand bottoms have some marine life living in or on it, but cannot support a large community of incrusting invertebrates and fish. The divers should document fish and benthic organisms along a 50-meter transect line. It is best to count the organisms for a one to three meter width on either side of the transect line. Generally, a two-diver team is used and the lead diver swims in a constant direction from some starting point with a slate, and the second diver follows and plays out the measured transect line until the correct distance has been covered. If possible, replicate transects should be run in different parts of the site permit area to estimate the patchiness of the biological community. If a known point can be used for the transect line, then later runs along the same line after construction, it will provide excellent data as to the effectiveness of the reef building effort. If possible, a specimen of any organisms that cannot be identified by the divers should be collected and preserved for later identification by a qualified biologist. If collection is not possible, a photo should be made instead.

Surveys by a towed camera for hard bottom are inadequate, for they can sometimes be misleading. They may show a bottom that looks solid, but in fact may have a firm sand overlay on soft silt or clay sediment. While it is unusual, there are some locations where divers have observed a thin sand layer which has covered a much softer sediment which cannot support reef material. Only a diver using a long (at least a five-foot steel or fiberglass rod) sediment probe can check the sediment to prevent later loss of reef material by sinking.

In such instances, where there is evidence that soft sediment exists, reef materials should be selected that will provide profile and habitat even after some sinking has occurred. If, for example, the reef is to be built from bridge rubble, then a layer of small sized rubble could be placed first to provide a base, then the larger sections and pilings could be placed on top to provide maximum profile. It may be possible to use low-density materials such as tires, on soft bottom sites. However, great care must be taken when using low-density reef materials since these materials are prone to shifting during storms. Any reef that is in exposed waters (those receiving direct waves from the open sea) should be constructed of only high-density materials in depths of less than 80 to 90 feet. In many areas, the Army Corps has stopped permitting tire reefs in offshore waters because of the possibility of the materials shifting off the reef site and even ending up on the beach (see Appendix G for more information on reef materials and construction).

Biological Survey Report

Once the underwater survey is completed, a written initial biological report should be made (See Appendix H, pages 3 and 4 for example). This report is often required by the various permitting agencies as part of the original application. This report should include a careful description of the bottom material (sand, shell, mud, etc.) the degrees of firmness (as measured by sediment probe and core sample described in Chapter 4) and a description of the biological community present on the site. The exact position of the site should be determined by Loran C reading and several compass bearings to fixed points on land if it is in view.

This initial biological report is not only important for the permit application, but it is also important to provide a comparison of the site before and after the reef construction. In most instances of a reef failing to remain on site or its loss of effectiveness, the initial site survey, or the lack of such a survey was a major cause in the failure.

Post-Deployment Survey

Usually a post-deployment reef survey is required to verify placement and fulfill the terms of the construction contract with the barge and tug crew. Some serious problems have occurred in the past when the actual site placement was several hundred yards away from the site surveyed by the divers.If the site is near any live bottoms, be sure to have the dive team present before the first placement to make a final check. Often the use of a small marker buoy will insure that the materials are placed in the exact location selected. This marker buoy will also help prevent the materials from being scattered by the barge crew. The profile of the materials appears to be very important, so the maximum piling up of the materials is desired, and a small jug on the site will help greatly. A post deployment map and photographs should also be prepared to document the scatter and profile of materials immediately after the deployment. This will be useful for later comparisons to determine changes over time.

Divers play an essential role in reef site selection well before and even after a reef site is developed. They can insure that existing "live bottom" habitats will not be harmed, they can prevent loss of reef material in soft bottoms and they can document the scatter and profile of the reef materials after the reef is constructed. Feedback from trained diver-observers is essential for maximizing the effectiveness of reef site selection and construction efforts.

References

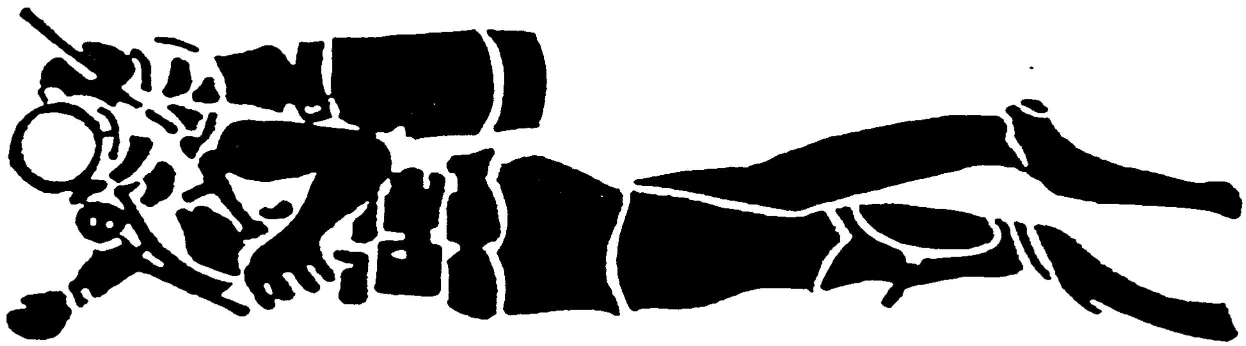
Mathews, Heyward H. Artificial Reef Site Selection and Evaluation. August 1979. Florida Sea Grant Publication # MAFS-20.

Mathews, Heyward H. Artificial Fishing Reefs, Materials and Construction. September 1983. Florida Sea Grant Publication # MAFS-29.

Mathews, Heyward H. Artificial Reefs:Permit Application Guidelines.October 1984. Florida Sea Grant Publication # SGEB-4.

Burchfield, Bill. Constructing an Artificial Reef Buoy. June 1979. Florida Sea Grant Publication # MAFS-9.

To receive these publications, write Florida Sea Grant College Program, Building 803, University of Florida, Gainesville, Florida 32611.



Chapter 6

Collecting Biological Data: Benthic & Planktonic Plants & Animals

by Quinton White

The presence of plankton and benthic organisms and plants are important reasons why many species of fish are attracted to an artificial reef. These organisms make up a living community which provides food and shelter and are the major living components of the artificial reef community.

The sampling necessary to look at the productivity of an artificial reef must include not only the fish, but the benthic (bottom living) and planktonic (free-floating) organisms which are associated with it. Biomass is the term used to define the total amount of living material in a given area. When the biomass is measured at a specific point and time, it is called the standing crop of the area. Standing crop differs from productivity in that it does not look at the change in biomass amount over the time, nor at the rate at which biomass is produced. Productivity is the change in biomass per unit time.

To understand how productivity on a reef changes, we can construct a food chain or food web. The food chain illustrates "who eats whom." It is based on photosynthesizing plant materials which are called the primary producers. This plant biomass, in turn, is consumed by herbivores (animals that eat plants), and then the herbivores are consumed by the carnivores (animals that eat animals). This can be illustrated by the food pyramid shown in Figure 6-1.

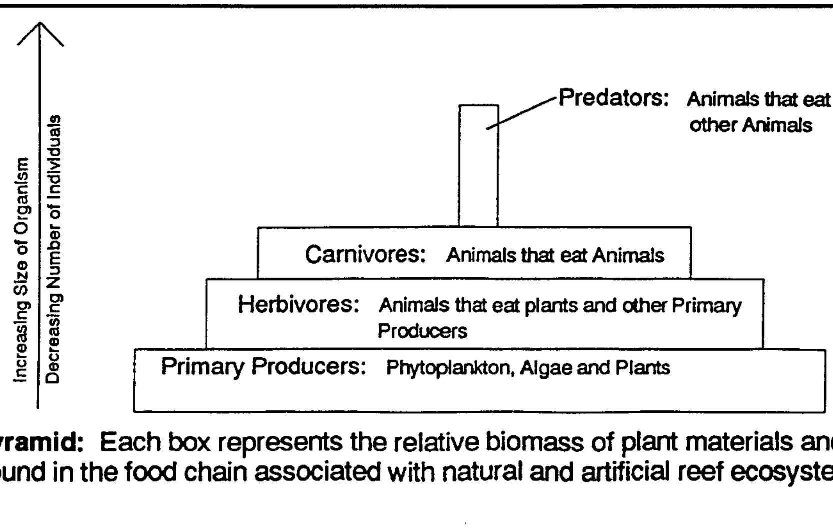
Why Sample Benthic & Planktonic Organisms?

To understand how a reef functions and to unravel the question of which fish are attracted to the reef and why; you must understand the reef's living components and interrelationships. Since the benthic and planktonic organisms associated with any reef comprise "food" for fish, it is an essential part of the puzzle that needs to be determined.

The Difficulties Sampling Benthic & Planktonic Organisms

The complexity, or at least the potential complexity, of the planktonic and benthic invertebrates and plants on an artificial reef structure is immense. Over time, different organisms become attached to a reef and compete with their neighbors for space. In some cases, one or two species will dominate, whereas in other cases a number of species will crowd together. It is impossible to inventory the entire reef structure, therefore we are forced to divide it into small subsections which can be studied in detail. This is sampling. Since we are not going to examine every square centimeter of the reef, it is important that the sampling be

Figure 6.1



Food Pyramid: Each box represents the relative biomass of plant materials and benthic invertebrates found in the food chain associated with natural and artificial reef ecosystems.

done systematically so that it may be repeated accurately on other similar structures for comparisons. It is essential that systematic sampling be done, using replicate efforts, so that meaningful comparisons can be made. Isolated observations are useful but not meaningful for making comparisons or determining causation, as is systematic quantification and sampling.

It is beyond the scope of this chapter to discuss the philosophy and statistics behind sampling theory. Be aware that a single observation is useful, but it gives you no information about change over time. The single observation merely shows that the event happened "once." To accurately follow the changes that may be occurring on a reef, it is necessary to use repetitive sampling techniques that are as nearly alike as possible. For example, Diver Dan makes a series of observations using a six-inch square area as his sample size. He takes a series of closeup photographs and scrapes this area and places the sample in a plastic bag to be analyzed. Scuba Sam makes a similar dive at a later date, but uses a square foot as his sample area. He photographs the area and also scrapes material into a plastic bag for future analysis. Later, Data Analyzer Debbie looks at the two samples. If she did not know that they came from different size sample sites, the analyses and her conclusions might be very misleading. Remember, it is important to be consistent in sampling methods. Once you have decided on a sampling method, stick with it. If you find it needs to be modified, take special care to record these changes in method on the data sheets.

Identification of Plants & Encrusting Organisms

Depending on the time of year and the general location of an artificial reef, the potential for finding variation in the plankton and benthic communities is tremendous. There are approximately 1,500,000 species of living things now described and named in the scientific literature. Luckily, 800,000 of these are non-marine insects, but that still leaves approximately 700,000 species. Perhaps you are beginning to get the idea that it is very difficult to know exactly what might be found where. Most organisms can be identified only after they have been properly sampled, preserved and returned to a laboratory. References listed at the end of this chapter are a partial bibliography of books and reference material for identifying invertebrates. Even when experienced scientists identify an organism down to the genus and species level, they will often send it to an independent authority for verification.

Scientists would like to identify organisms to the species level. This is where you see the genus name capitalized and underlined, and the species name just underlined without caps (for example Millepora alcicornis, Fire Coral). The genus and species names are underlined because they come from Greek or Latin derivatives and are foreign words in our print. We italicize the print in books for such names; but since we do not have that capability with typewriters, we normally underline them. This is also true in handwritten cases.

Planning & Preparation for Sampling

Standardize Everything

It is essential that regular and repetitive sampling be done in order to detect any trends or biological patterns that develop. Much care should be taken when deciding how much sampling can, or should be done. For example, it is better to take a number of small samples rather than one large sample. This is because you have a greater chance of getting more and different species in a number of small samples than you do in one large sample. You should therefore decide how many small samples you can take in a given research dive. Remember that each diver is limited by bottom time, experience, and sampling capability. The difficulty of working underwater compounds the sampling problems. Experience has shown that most divers are initially overly optimistic in their objectives. They think that they can gather more samples than is actually possible. However with experience, you will find that task loading from having to work safely underwater will limit how much you can accomplish. One general guideline is to think about what you can do and then try to do half of it; then be happy if you get at least half of that done.

In standardizing everything, be sure that the collecting routines and the information that is collected each time is consistent and repetitive. It does not do any good to have one set of divers recording salinity and turbidity, while the next set of divers is only observing temperature. Prioritize the information that is needed and make sure that it is obtained on each and every sampling event.

How Big is a Sample?

It is difficult to give an a priori (before the fact) desirable quantitative size for each benthic sample. What can be done will be partially based on the type of reef being studied and the nature of the question to be answered. Benthic communities are normally attached to the bottom or some substrate associated with the reef. A number of large pieces of concrete placed on the bottom as an artificial reef will be impossible to bring to the surface to examine. If the need to collect benthic samples is a possibility, place small, removable pieces on the reef that could be easily returned to the surface for analysis. Typically, on any one trip to a reef site, at least three samples should be taken. The number three is useful because it is an odd number of samples from which data can be extracted and better analyzed statistically.

Photographing

Whenever possible, a series of photographs should be used to document benthic growth. Some suggestions for successful scientific (data) photographs of benthic life are:

1) Include a scale or some known object for scale in the photograph;
2) Take the photograph at an oblique angle in order to show some degree of three-di mensional structure--hence, it is often best not to shoot straight down on a subject, but rather to shoot at an angle (note how ever, you would shoot straight down on a subject when accurate quantification is needed from the photograph;
3) Get close to the subject. Broad sweeping photographs are not good for species iden tification, but can be used to indicate the quantity of growth present in a given area;
4) Include a date and location tag in the photo series;
5) Make sure the photos are recorded in a photo log book.

Preserving

In general, collected specimens should be preserved as soon as possible after they are brought to the surface. This can be done in a 10 percent formalin solution then later transferred to a 40 percent isopropyl alcohol or 70 percent ethanol to make it easier (less irritating smell) on the person doing the identification. For plant specimens, initial as well as final preservation in alcohol is adequate as natural pigmentation will usually be lost using either technique.

How to Collect Samples

One of the most difficult things to tell a diver is how to collect specimen samples. What works for one diver will not always work for another. Divers often vary tremendously in the degree of comfort and efficiency they show underwater. It will be necessary for you to develop some of your own techniques by trial and error. Think through exactly what you want to accomplish and carefully plan how to best complete the task. Collecting most benthic (fouling) organisms, will usually require some scraping device and a container for the sample. Use of a simple putty knife and plastic zip lock bags often suffice. Fabrication of special scraping tools may be needed, especially if the sample is to be quantified.

Materials and Methods

Some thought should be given in advance regarding materials needed to handle the kinds of specimens brought back to the surface. A number of handy items include plastic bags and refrigerator containers in which to place your specimens, along with the necessary formalin for preservation. If the substrate to be sampled is large and immovable, then a small scraper, or hammer and chisel may be necessary to dislodge the specimens. During sampling, care should be taken not to disrupt the substrate surface, and to prevent the loss or escape of mobile organisms. The sampled specimens can usually be placed in a plastic bag or box, and returned easily to the boat. In planning your dive, it would be wise not to attempt to carry too many individual pieces back to the boat. This simply increases the chance that some might be lost. It also means that they may be confused or mixed up. Confused or jumbled data is worthless. Once on board the boat, the diver should preserve the samples quickly, or at least keep them cool in an ice chest until brought to shore. Immediate processing can be important as many organisms will die and deteriorate in the heat and low dissolved oxygen of the small sample bags or boxes.

Identifying

Ideally, it would be nice to identify by name all the specimens obtained using the scientific binomial nomenclature because these names are unique. In practice, however, for much of the work on artificial reefs, it will only be necessary to recognize the fact that a given organism is a different species and not that it be identified to the genus species level. A general biology textbook can be used as a source for the descriptions and classifications of animals into related taxonomic groups called Phyla, and plants into related taxonomic groups called Divisions. Appendix I is a generalized classification scheme. These species lists can also be used to suggest what species are generally present on these reefs. References can be used to identify species found along the Florida coast. This reference list is fairly extensive and serves as a good bibliography for invertebrate and marine plant identification.

Once a specimen has been identified, it is a good idea to save it for the reference collection. It can be used later to help with future identifications. The reference collection will serve as an invaluable tool for training future reef research divers as well. Much time can be saved by training new research divers to identify reef organisms from reference specimens, before they actually dive on the reef site.

Suggested References

* Available from commercial bookstores.

* Abbott, R. Tucker. 1968. Seashells of North America, Golden Press, New York. 280 p.

* Abbott, R. Tucker. 1974. American Seashells, Van Nostrand Reinhold Company, New York. 663 p.

* Amos, Stephen A. and William H. Amos. The Audubon Society Nature Guides. Atlantic and Gulf Coasts. Random House, New York. 670 p.

* Arnold, Augusta Foote. The Sea-Beach at Ebb-Tide, Dover Publications Inc., New York. 490 p.

Brattegard, Torleiv. 1970. Mysidacea from Shallow Water in the Bahamas and Southern Florida. Part 2 Sarsia 41: 35P.

Cain, Thomas D. 1972. Additional Epifauna of a Reef off North Carolina. The Journal of the Mitchell Society. 79-82.

Calder, Dale R. and Morris L. Brehmre. 1967. Seasonal Occurrence of Epifauna on Test Panels in Hampton Roads, Virginia. International Journal of Oceanology and Limndogy 1 (3): 149-164.

Calder, Dale R. 1977. Guide to the Common Jellyfishes of South Carolina. South Carolina Sea Grant Marine Advisory Bulletin 11. 13p.

Calgren, O. and J.W. Actiniaria, Zoantharia and Ceriantharia from Shallow Water in the Northwestern Gulf of Mexico. Published by the Institute of Marine Science, University of Texas 2 (2): 141-172.

Chace, Fenner A. 1972. The Shrimps of the Smithsonian-Bredin Caribbean Expeditions with a Summary of West Indian Shallow-water Species (Crustacea: Decapoda: Natania) Smithsonian Institute Press. 98: 179p.

Chitwood, B.G. 1951. North American Marine Nematodes. The Texas Journal of Science (4): 617-665.

Coe, Wesley R. 1951. The Nemertean Faunas of the Gulf of Mexico and of Southern Florida. Bulletin of Marine Science of the Gulf and Caribbean 1 (3): 149-186.

Cook, David G. and Ralph O. Brinkhurst. 1973. Marine Flora and Fauna of the Northeastern United States. Annelids: Oligochaeta. NOAA Technical Report NMFS CIRC-374 21p.

Correa, Diva Diniz. 1961. Nemerteans from Florida and Virgin Islands. Bulletin of Marine Science of the Gulf and Caribbean. 11 (1): 44p.

Cutler, Edward B. 1977. Marine Flora and Fauna of the Northeastern United States. Sipuncula NOAA Technical Report NMFS Circular 403 7 p.

Day, John H. 1973. New Polychaeta from Beaufort with a Key to all Species Recorded from North Carolina. NOAA Technical Report NMFS CIRC-375.

Deichmann, Elisabeth. 1939. The Holothurians of the Western Part of the Atlantic Ocean. Bulletin of the Museum of Comparative Zoology at Harvard College. 71 (3): 44-226.

de Laubenfels, M. W. 1949. Sponges of the Western Bahamas. American Museum Novitates. No. 1431 25p.

de Laubenfels, M. W. 1953. A guide to the Sponges of Eastern North America. University of Miami Press.

de Laubenfels, M. W. 1953. Sponges from the Gulf of Mexico. Bulletin of Marine Science of the Gulf and Caribbean 2 (3): 511-557.

Dowds, Richard E. 1979. References for the Identification of Marine Invertebrates on the Southern Atlantic Coast of the United States. U.S. Department of Commerce. (NOAA Technical Report NMFS SSRF-729) 37p.

Downey, Maureen E. Starfishes from the Caribbean and Gulf of Mexico. Smithsonian Contribution to Zoology 126|: 158.

Dorjes, Jurgen. 1972. Georgia Coastal Region, Sapelo Island, U.S.A.: Sedimentodogy and Biology. VII Distribution and Zonation of Macrobenthic Animals. Senchenbergiana marit. 4: 169-182.

*Emerson, William K. and Morris K. Jacobson. 1976. Guide to Shells. Land. Freshwater. and Marine from Nova Scotia to Florida. Alfred A. Knopf, New York. 482p.

Farrell, Douglas H. 1979. Guide to Shallow-water Mysids from Florida. Florida Department of Environmental Regulation, Tampa 71p.

Fauchald, Kristian, 1977a. The Polychaete Worms: Definition and Keys to the Orders. Families and Genera. Natural History Museum of Los Angelos County, Science Series 28.

Fauchald, Kristian, 1977b. Polychaetes from Intertidal Areas in Panama with a Review of Previous Shallow-Water Records. Smithsonian Institution Press, Washington, D.C. No. 221.

Field, Louise Randall. 1949. Sea Anemones and Corals of Beaufort, North Carolina. Duke University Press 5: 29p.

Fox, Richard S. and Kenneth H. Bynum. 1975. The Amphipod Crustaceans of North Carolina Estuarine Water. Chesapeake Science. 16 (4): 223-237.

Fox, Richard S. and Edward E. Ruppert. 1985. Shallow Water Marine Benthic Macroinvertebrates of South Carolina. University of South Carolina Press, Columbia. 329p.

* George, David and Jennifer. 1979. Marine Life: and Illustrated Encyclopedia of Invertebrates in the Sea. John Wiley and Sons, New York, 288p.

*Gosner, Kenneth L. 1978. A Field Guide to the Atlantic Seashore. Houghton Mifflin Company. Boston. 329p.

*Gosner, Kenneth L. 1971. A Guide to the Identification of Marine and Estuarine Invertebrates: Cape Hatteras to the Bay of Fundy. John Wiley & Sons, Inc. New York. 693p.

Gray, I.E., Maureen E. Downey and M. J. Cerame-Vivas. 1968. Sea Stars of North Carolina. Fishery Bulletin. 67 (1): 127-163.

Hartman, Olga. 1945. Marine Annelids of North Carolina. Duke University Marine Station Bulletin. 2: 53p.

Hiltunen, Jarl K. and Donald J. Leimm, 1980. A Guide to the Naididae (Annelida: Clitellata: Oligochaeta) of North America. U.S. Environmental Protection Agency Ohio.

Holme, N. A. and A. D. McIntyre, eds. 1984. Methods for the Study of Marine Benthos. Blackwell Scientific Publications, Oxford. 387p.

Holthuis, L. B. 1955. The Recent Genera of the Caridean and Stenopodidean Shrimps (Class Crustacea, Order Decapoda, Supersection Natantia) with Keys for Determination. Rijksnuseum van Naturrlijke Historie. Netherlands. 157p.

* Kaplan, Eugene H. 1982. A Field Guide to Coral Reefs of the Caribbean and Florida including Bermuda and the Bahamas. Houghton Mifflin Company, Boston. 289p.

Kaplan, Eugene H. 1988. A Field Guide to Southeastern and Caribbean Seashores: Cope Hatteras to the Gulf Coast, Florida and the Caribbean. Petersen Field Guide Series; Houghton Mifflin Company, Boston. 425p.

Keer, George A. 1976. Indian River Coastal Zone Study. Compass Publications. Arlington Va. (Prepared by T. Wolcott). 105p.

Kirkland, Patricia A. 1981. Identification Manual for Common Estuarine Invertebrates of the Little Jetties St. Johns River. Marine Science Education Center, Mayport, Florida. 19p.

Klemm, Donald J. 1982. Leeches (Annelida: Hirudinea) of North America. U.S. Environmental Protection Agency, Ohio.

Kramp, P. L. 1959. The Hydromedusae of the Atlantic Ocean and adjacent water. Dana Rep. 46, 284p.

Larson, Ronald J. 1976. Marine Flora and Fauna of the Northeast United d States Cnidaria: Scyphozoa. U. S. Government Printing Office. 18p.

McCain, J. C. 1968. The Caprellidae (Crustacea: Amphipoda) of Western North Atlantic. U. S. National Museum Bulletin 278 147p.

McCaul, William E. 1963. Rhynchocoela: Nemerteans from Marine and Estuarine Waters of Virginia. The Journal of the Mitchell Society. 111-124.

McCloskey, Lawrence R. 1973. Marine Flora and Fauna of the Northeastern United States: Pycnogonida. NOAA Technical Report NWFS CIRC 386 12p.

McDougall, Kenneth Dougal. 1943. Sessile Marine Invertebrates of Beaufort, North Carolina. Ecological Monographs 13 (3): 322 - 374.

Manning, Raymond B. and Fenner A. Chace, Jr. 1971. Shrimps of the Family Processidae from the Northwestern Atlantic Ocean. (Crustacea: Decapoda: Caridea). Smithsonian Institution Press. Washington.

Marcus, Eveline and Ernst. 1960. Opisthobranchs from American Atlantic Warm Waters. Bulletin of Marine Science of the Gulf and Caribbean. 10 (2): 129 - 203.

Maturo, Frank J. S. 1957. A Study of the Bryozoa of Beaufort, North Carolina and Vicinity. Journal of the Mitchell Society. 11-68.

Maturo, Frank J. S. 1966. Bryozoa of the Southeast Coast of the United States: Bugulidae and Beaniidae (Cheilostomata: Anasca) Bulletin of Marine Science. 16 (3): 556-583.

* Meimkoth, Norman A. 1981. The Audubon Society Field Guide to North American Seashore Creatures. Alfred A. Knopf, New York.

Menzies, R. J., O. H. Pilkey, B. W. Blackwelder, D. Dexter, P. Huling. A Submerged Reef Off North Carolina Internationale Revve Hydrobidgue. 15 (3): 393-431.

Mikkelsen, Paul S. and Robert W. Virnstein. 1982. An Illustrated Glossary of Polychaete. Terms. Harbor Branch Foundation, Inc. Technical Report No. 46.

* Miner, Roy Waldo. 1950. Field Book of Seashore Life. G. P. Putnam's Sons, New York. 888p.

* Morris, Percy A. 1973. A Field Guide to Shells of the Atlantic and Gulf Coasts and the West Indies. Houghton Mifflin Company, Boston. 330p.

Pawson, David L. 1977. Marine Flora and Fauna of the Northeastern United States. Echinodermata: Holothoroidoa. NOAA Technical Report NWFS Circular 405, National Marine Fisheries Service.

Pearse, A. S. and J. W. Littler. 1938. Polyclads of Beaufort, N. C. Journal of the Mitchell Society. 235-247.

Perez, Farfante, I. 1969. Western Atlantic Shrimps of the genus Penaeus. U. S. Fish and Wildlife Service, Fisheries Bulletin.

Perez, Farfante Isabel. 1978. Families Hippoolytidea, Palaemonidae (caridea) and Penaeidea, Sicyoniidae, and Solenoceridae (Penaeidae), in Fischer W. FAO Species Identification Sheets for Fishery Purposes, Western Central Atlantic Vol. VI.

Pettibone, Marian H. 1976. Revision of the Genus Mecelicepha McIntosh and the Subfamily Macellicephalinae Hartman-Schroder (Polychaeta: Polynoidae). Smithsonian Institution Press, Washington, D. C. No. 229.

Phelan, Thomas. 1970. A Field Guide to the Crinoid Echinoids of the Northwestern Atlantic Ocean, Gulf Mexico and Caribbean Sea. Smithsonian Institution Press, Washington, 40: 22p.

Pilsbry, Henry A. 1953. Notes on Florida Barnacles (Cirripedia) Proceedings of the Academy of Natural Science of Philadelphia CV: 13-30.

Plough, Harold H. 1978. Sea Squirts of the Atlantic Continental Shelf from Marine to Texas, The Johns Hopkins University Press, Maryland. 118p.

Provenzano, Anthony J., Jr. 1959. The Shallow-water Hermit Crabs of Florida. Bulletin of Marine Science of the Gulf and Caribbean. 9 (4): 349-420.

Reanod, Jeanne C. 1956. A report on some Polychaetous Annelids from the Miami-Bimini Area. American Museum Novitates. No. 1812 40p.

Sawyer, Roy T., Adrian R. Lawler, & Robin M. Overstreet. 1975. Marine Leeches of the Eastern United States and the Gulf of Mexico with a Key to the Species. Journal of Natural History. 9: 633-667.

Serafy, K. Keith. 1979. Echinoids (Echinodermata: Echinoidea) Memoirs of the Hourglass Cruises. Vol V Part III. Florida Department of Natural Resources Marine Research Laboratory. St. Petersburg.

Shier, Daniel E. 1964. Marine Bryozoa from Northwest Florida. Bulletin of Marine Science of the Gulf and Caribbean. 14 (4): 602-662.

Smith, Ralph I., ed. 1964. Keys to Marine Invertebrates of the Woods Hole Region. Spaulding Company, Massachusetts. 208p.

Stimpson, Kurt S., Donald J. Klemm, and Jarl K. Hiltunen. 1982. A Guide to the Freshwater Tubificidae (Annelida: Clitellata: Oligochaeta) of North America. U. S. Environmental Protection Agency, Ohio.

Stuck, Kenneth C., Harriet M. Perry and Richard W. Heard. 1979. An Annotated Key to the Mysidacea of the North Central Gulf of Mexico. Gulf Research Reports. 6 (3): 225-238.

Thomas, Lowell P. 1962. The Shallow Water Amphiurid Brittle Stars (Echinodermata, Ophiuroidea) of Florida. Bulletin of Marine Science of the Gulf and Caribbean. 12 (4): 623-694.

Van Dover, Cindy and William W. Kirby-Smith. 1979. Field Guide to Common Marine Invertebrates Part 1: Gastropoda, Bivalvia, Amphipoda, Decapoda and Echinodermata. Duke University Marine Laboratory. 78p.

Vincx, Magda. 1981. New and Little Known Nematodes from the North Sea. Cashiers De Biologie Marine. Vol. 8811: 431-451.

* Voss, Gilbert, Lee Opresko, and Ronald Thomas. 1973. The Potentially Commercial Species of Octopus and Squid of Florida, the Gulf of Mexico and the Caribbean Area. University of Miami Sea Grant Program. 33p.

Voss, Gilbert L. 1976. Seashore Life of Florida and the Caribbean. Banyan Books, Inc., Florida 199p.

Watling, Les. 1979. Marine Flora and Fauna of the Northeastern United States: Crustaccea: Cumacea. NOAA Technical Report NMFS Circular 423. 23p.

Wells, Harry W., Mary Jane Wells, and I. E. Gray. 1960. Marine Sponges of North Carolina. Journal of the Mitchell Society. 200-245.

Wells, Harry W. and I. E. Gray. 1964. Polychaetous Annelida of the Cape Hatteras Area. The Journal of the Mitchell Society. 70-78.

Wells, Harry W., Mary Jane Wells and I. E. Gray. 1964. The Calico Scallop Community of North Carolina. Bulletin of Marine Science of the Gulf and Caribbean. 14 (4): 561-593.

Williams, Austin B. 1964. Marine Decapod Crustaceans of the Carolinas. Fishery Bulletin. 65 (1): 292p.

Williams, Austin B. 1984. Shrimp, Lobsters, and Crabs of the Atlantic Coast of the Eastern United States, Maine to Florida. Washington, D.C.: Smithsonian Institution Press.

Wood, Carl E. 1974. Key to the Natantia (Crustacea, Decapoda) of the Coastal Waters on the Texas Coast. Contributions in Marine Science. 18: 35-55.

Zingmark, Richard G. ed. 1978. An Annotated Checklist of the Biota of the Coastal Zone of South Carolina. University of South Carolina Press, Columbia. 364p.

Zullo, Victor A. 1979. Marine Flora and Fauna of the Northeastern United States..Arthropoda: Cirripedia. NOAA Technical Report NMFS Circular 425. National Marine Fisheries Service.

Chapter 7

Sampling And Studying Fish On Artificial Reefs

by Stephen A. Bortone and
James A. Bohnsack

An Introduction to Fish

About 30,000 species of fish are thought to inhabit the world today. The potential number of species which one may encounter on a marine artificial reef is quite high. Of all the species of fish known today, about 58% occur in the marine environment. Of these, 40% inhabit the warm, shallow continental shelves, the areas where artificial reefs are usually located. Fish have existed on earth for about 600 million years and in that time have evolved and adapted into a wide variety of forms specialized for a wide variety of habitats. Most living fish are boney fish but a number of jawless (agnathous; e.g., lampreys and hagfish) and cartilaginous (boneless) fish (sharks, skates, and rays) are also known.

Fish are aquatic, cold-blooded vertebrates with gills and fins. They occur in fresh-, brackish-, and saltwater and individuals of some species can survive in waters below freezing in the Antarctic Ocean while others have been found in warm water springs hotter than 104° F (40° C). In addition, they have been recorded in mountainous areas at altitudes as high as 3.1 miles (5 km) and to depths of 6.8 miles (11 km) in the oceanic trenches.

Fish occur in a wide size range. Adult fish can be as small as 5/8 of an inch long (15 mm; the dwarf pygmy goby) and as large as 69 feet (21 m; the whale shark). All fish start out either as an externally or internally fertilized egg. Most eggs released into the water are externally fertilized and become either free living (pelagic) or attached to something (demersal) until hatching into a larvae stage. After a few weeks, the free swimming larvae often transform into juveniles which may resemble adults except for color and minor differences in shape. Eggs for many species do not undergo external development. They remain inside the body of the female where they are fertilized, nurtured, protected, and born resembling small adults.

Reasons and Objectives for Studying Artificial Reef Fish

There are many important reasons for studying the fish which live on artificial reefs. Many study reef fish simply because they are fascinating. It is no wonder that aquarium keeping is one of the most popular hobbies in the world today. Artificial reefs serve to enhance fishing and may increase fish abundance in local areas. By studying how the fish are associated with artificial reefs, we can discover what features, factors, or attributes of reefs help contribute to their potential effectiveness. We can assess the relative fitness or condition of the area, by observing an artificial reef for the kinds of fish, their numbers, and their condition. Even minor changes in environment may lead to noticeable dramatic changes in the composition of a fish community, since fish respond to changes in environmental conditions in the ocean. A data base of information collected for over a period of time on a fish community will permit us to detect the effects of environmental changes caused by naturally or human-induced activity.

The three most common goals of sampling studies on artificial reef fish populations are to:

1) monitor the reef fish community composition over time;
2) compare the fish populations between artificial and natural reefs;
3) evaluate various reef construction methods, materials and configurations, for the desired effect.

These studies can target a specific group such as a commercially important species or they can treat all observable species.

Several different kinds of data may be gathered to accomplish the above goals. Comparisons can be made within and between artificial reefs using a cumulative species list. This entails maintaining a list of species observed during each dive or survey on that site. An improvement on the species list data would be to include some ESTIMATE OF RELATIVE ABUNDANCE. This may be done subjectively (i.e., by using words like: abundant, common, few, rare, etc.) or objectively by including some method of quantification by counting. Improvements on a relative estimate of species' abundance would be to determine as accurately as possible the ABSOLUTE ABUNDANCE which could in turn be related to species density. A further improvement of the data may be made by obtaining not only an estimate of numbers but also of the sizes of individuals present. The methods designed to obtain these data will be discussed later.

Notes on the condition of individual fishes can be used to assess and determine the differences, similarities, or changes that may have taken place on a particular reef or between several artificial reefs. These data could include notes on the health of individual species, such as, the presence of open sores or wounds on their bodies, the number and types of parasites from specimens, and the general overall behavior of the fish. In short, just about any attribute of fish or their community can be recorded, monitored and analyzed to assess the differences and similarities of fish communities on various artificial reefs.

Problems Associated with Assessing Fish On Artificial Reefs

A discussion of the problems associated with the assessment process is essential in order to become aware of the limitations of particular methods and to correctly interpret and evaluate the data. These problems can be found at several levels:

1) problems involving the fish;

2) problems involving the habitat;

3) problems involving the observer that can be overcome; and

4) problems that cannot be overcome.

Fish all move to some degree. Some movements are relatively obvious such as those performed by: pelagic (free swimming) species, which form schools; or by those that shift or change position frequently. However, even those species which are sedentary (bottom dwelling and lethargic) move as well. Fish may also come together to form clumps, schools, or aggregations, which may themselves move. These clumps, aggregations, or "patches" of fish may result from one or more factors. Included among those are random chance, where no factor causes the aggregation. Most groupings, however, occur for one or more reasons. Many species congregate or disperse over an area because of changing requirements in their natural life history (i.e., way of life). For example, aggregations can form for reproduction, feeding or predator avoidance.

Fish may form loose aggregations or schools that can be very well ordered. Schools can be composed of one or several different species, and this can complicate underwater identification. Many fish have a particular habitat preference. For example, certain species are always found on the underside of a structure, and thus, may be abundant only where the reef has many overhanging features (such as a shipwreck having many exposed decks) or even absent from reefs without this type of cover (such as a barge with the hull intact).

Some species show very obvious patterns of daily activity which affect their apparent abundance. Day, night, and crepuscular (dusk and dawn) activity patterns in various species can severely affect our ability to observe the fish community on a reef. This must be considered in the sampling strategy. Some night-active (nocturnal) species, although common on an artificial reef, may seem absent because individuals are "resting" in crevices out of view of the daytime observer.

Changes or differences in water conditions can also influence the presence or relative abundance of fish species on artificial reefs. Lunar, solar, and other tidal factors may greatly influence current flow which, in turn, affects the dispersal and aggregation potential of fishes, especially on the shallow, inshore reefs, and around estuaries or entrances to bays and harbors. In some areas even minor tidal changes may produce extremely strong bottom currents, which may alter the turbidity (water clarity), temperature, and salinity. These changes can affect a species' chances of being seen since they may influence them to move from one place to another. This movement will, of course, affect the observed composition of a community associated with a given reef. The accuracy and consistency of underwater visual assessment techniques are also greatly affected by water clarity (turbidity), which impacts the effectiveness of each method as we will see later. When water clarity, and consequently visibility is reduced, the effective volume or area observed is reduced. Therefore, if one makes a visual assessment when the underwater visibility is 50 feet and then makes another assessment in the same place at another time when the visibility has been reduced to 10 feet, the actual volume of water observed has been drastically reduced. Depending on the method chosen, water clarity can have rather severe effects on the repeatability and subsequently, the comparability of the study.

Most of the sampling methods divers employ in studying artificial reefs involve some type of visual sampling. Behavior, color, and morphological (shape and size) differences among species can influence visual detectability. Large fish are usually more noticeable than small fish; and brightly colored, actively swimming fish are more noticeable than sedentary or cryptically (camouflaged) colored species. Secretive species, even when brightly colored, may be missed because they are hidden from the field of vision. Schooling species present their own sampling problems because of the geometry, size, and species composition of the school. One study has shown that divers consistently overestimate abundance of fish in a small school and typically underestimate abundance in large schools (Klima and Wickham, 1971).

Human activities can also influence a fish community. Continual harvesting by both commercial and recreational fishermen (this includes hook-and-line as well as spear fishing) can very quickly alter the community composition, especially on a small reef. This may occur in selective removal of all larger food fish or by the removal of only one or two of the preferred food fish. This removal can have indirect effects. For example, if a valuable food fish is removed from a reef by overfishing, it may be replaced by another perhaps less desirable fish, which could now exist on the reef because of reduced competition. Studies have shown that the faunal composition of a community shifts dramatically when the major predators are no longer present.

Collecting Data On Artificial Reefs

Physical Environment

The physical data or information describing the structure and environmental conditions associated with an artificial reef can be just as important as the data on the fish community itself. Physical data provide a basis to fully evaluate an artificial reef and establish its effectiveness or compare that to itself or another reef. Data are needed to help determine what factor or factors may be associated with, or responsible for, the differences in the fish communities. This is possible only through a careful examination and comparison of both the physical and biological data which will then allow us to understand or predict fish community structure.

Appendix J provides the minimal types of physical data which should be recorded during any assessment of the fish community on an artificial reef. The reader should refer to the other chapters in this handbook, specifically, "Chapter 4, Oceanographic Data Collection and Reef Mapping" and "Chapter 5, Site Selection and Evaluation by Diving" for specific methods of properly obtaining physical data.

Fish and Fauna Data

Perhaps the most important aspect of any study assessing the fish on artificial reefs is that the species' identifications must be accurate, reliable, and verifiable. The very basis for comparisons and evaluations is based on correct species identification. With a little training, practice, patience, and care, anyone can accurately identify most of the species encountered on artificial reefs in the coastal southeastern waters of the United States, especially in water shallower than 130 feet.

NOTE: Use of LOCAL COMMON NAMES OF FISHES SHOULD BE AVOIDED. Probably more problems, misinformation, and just plain bad data have resulted because of the use of local names. An example from the northern Gulf of Mexico illustrates this point rather well. Off Pensacola there occurs a species of grouper scientifically called Mycteroperca microlepis (note: scientific names for organisms are usually underlined or printed in italics). Its official and correct common name is the gag grouper. Unfortunately local fishermen refer to it as the black grouper. This in itself is not a major problem, except that off southern Florida there is another species of grouper whose official common name is the black grouper, Mycteroperca bonaci. This situation actually occurs very frequently. The result is that anyone not familiar with local common names will have great difficulty using data from a survey made in another area when local common names have been used. If data between two areas are compared, there would be a very real possibility of making false conclusions on the comparative abundance of two species, thought to be the same, but which are in reality quite different.

The American Fisheries Society has set standard common names for fishes in North America. This has resulted in a publication:

A List of Common and Scientific Names of Fishes from the United States and Canada", 1980, C.R. Robbins et al., available from the American Fisheries Society, 5410 Grosvenor Lane, Bethesda, Maryland, as Special Publication Number 12 ($10 paperback or $15 hardbound as of January 1986).

Most books, handbooks, and texts for identification of fishes use the common names as adopted and established by this American Fisheries Society publication.

One way to ensure that the fish are accurately identified, is to establish a voucher or reference collection of accurately identified and labeled fishes representing those species that are usually observed on the artificial reefs being studied. By a voucher collection we mean that at least one or more individuals (some males, females, and juveniles) should be collected, properly preserved, identified, labeled, and then saved for reference. The voucher collection can be used to train divers or serve as a kind of review for key characteristics that will aid them in fish identification. It will also aid in identifying observed fish suspected as being unusual or different. A correct fish identification can be assured by an observer who has taken the time and made the effort to become familiar with the one or two key or main anatomical features which aid in correctly determining a species' identity. Familiarity with the specimens in a voucher collection along with a knowledge of the descriptions and illustrations in various field identification books of fishes are important in this regard. Photographs and videotapes taken at study sites can be valuable because they show colors and patterns which may fade in preserved specimens.

Fish Collection

Collecting techniques used to make voucher collections are varied and no one single technique is effective on all species. Sometimes special techniques may have to be developed in order to obtain an especially difficult to catch species. Before using any technique, however, check local regulations.

Hook-and-line fishing is good for collecting most of the commercially and recreationally important fish species associated with artificial reefs. Using smaller hooks and/or special baits may help in collecting species not normally collected by usual fishing methods. Sometimes divers can actually use the hook-and-line method underwater to obtain certain fishes needed for the voucher collection or to verify a sight identification.

Baited fish traps are also useful in obtaining specimens but may require special care and expense on the part of the user. Some divers use a baited, large clear glass jar. Many small reef fish, such as wrasses and damsel fish, will venture inside the jar to obtain the bait even in the presence of a diver. Once the fish is inside a diver merely covers the mouth of the jar to trap the specimen.

Hand held nets or dip nets can be used to obtain smaller species such as gobies, blennies, and juveniles of larger species, such as snapper, grouper, grunts, and porgies. One technique found useful when using a hand net (1/4 or 3/8 inch mesh is good for most purposes) is to chase the fish into a corner or crevice, place the net over the entrance and use the other hand to force the fish out of its hiding place into the net. It is often useful then to transfer the fish to a holding bag. The holding bag can be constructed of scrap 1/4 or 3/8 inch nylon net material with a drawstring, or purchased from most dive shops under the colloquial name of "goodie-bag".

Cast nets of various diameters and mesh sizes can be used by divers in collecting fishes. A diver merely swims to a position above a specimen or even a small school of fish and drops the parachute-like net over them. The lead or bottom line conforms to the substrate and blocks the escape of the fish in all directions. Once entrapped, the fish is forced against the netting material where it can be held before transfer to a holding bag. A piece of 1/4 or 3/8 inch mesh nylon netting cut in a circle with a diameter of 3 feet and weighted with a piece of chain or some lead weights along the perimeter can serve as a miniature cast net. This net is especially useful for collecting smaller fishes. It is easy to make, easy to use, inexpensive, and effective.

A slurp gun, which is simply a large bore diameter clear plastic tube fitted with a plunger, can also be useful when capturing small fishes around artificial reefs. When operated, the plunger acts to create a vacuum in the tube and the fish is literally sucked in. The tube entrance must quickly be blocked to prevent escape. Many fishes tend to swim up-current. With this in mind, one can force water out of the tube and cause a fish to swim "up-current" into the mouth of the slurp gun where they can then be more easily "slurped". Much practice and patience is needed to be truly effective with a slurp gun.

Spear fishing has been, and will continue to be, one of the most popular and effective ways of capturing fishes on artificial reefs. Spear fishing can be used to obtain specimens but care must be taken not to excessively damage the fish. Many anatomical features of fish, especially those about the head area, are important for accurate identification. Obviously, smaller fish are the most susceptible to damage from spear fishing, especially if a large spearhead armed with a double or single barb, is used. An Australian (three-pronged, pyramid pattern) spearhead minimizes damage and is especially effective on smaller fish down the 3 or 4 inches in length. Sling-type spears may also be more useful to divers when trying to capture small specimens under turbid conditions.

Care should always be taken with speared fish because the blood from the speared fish may attract sharks. This problem can be relieved somewhat by quickly removing the fish from the water and by conducting the spear fishing at the end of the visual census period. Every effort should be made to keep fish slime and odors off the boat deck and off the divers. Hook-and-line fishing should be conducted as a last order of business in an area also. Taking these minimal precautions should reduce the chances of having a survey biased, interrupted or terminated by an unwanted hungry guest.

Trawls and other commercial fishing gear may prove useful in obtaining voucher specimens. Although commercial gear is generally not used directly in an area where an artificial reef is located, it can be extremely effective in sampling the adjacent fish fauna. Gill nets set over an artificial reef are useful for obtaining pelagic or free swimming fish. This type of gear is generally more effective in turbid water. Again, check local regulations regarding the use of any commercial fishing gear.

Photographic techniques using still photography, motion pictures, or video tapes (especially in color) are very good ways to "capture" a specimen. While it certainly is preferable to have a specimen "in hand" when trying to establish its correct identity, the next best thing would be to have a good clear photograph or motion picture. It would also be a good idea to have a picture of a living or freshly collected specimen to be used in conjunction with the actual specimen when trying to identify it. Live color characters are often important for identifying many fish species. We have avoided suggesting collecting methods which employ chemicals such as rotenone or explosives such as dynamite. While under certain conditions and with expert care, these can be effective in obtaining specimens, the obviously negative features preclude their use by most non-professionals. Their use requires proper training and legal permits.

There are few methods which can be used to capture fish on artificial reefs. Remember that ingenuity often prevails over frustrating attempts to employ "standard" techniques to capture particularly elusive specimens. The important thing is to collect a voucher specimen because without it there may be a question or doubt raised about a fish's correct identity.

Specimen Preservation

Once a fish has been collected, it should be photographed before color loss then care taken to permanently preserve it as a voucher specimen for reference and identification purposes. The preferred method for handling fish is to place them in a container of 10 percent Formalin as soon as possible then later preserving in alcohol. Formalin is prepared by diluting concentrated formaldehyde (obtainable at most pharmacies) with nine parts water (preferably with water from where the specimen was collected). Caution should be exercised when handling this chemical as it can burn or irritate the skin and is a possible carcinogen. Special precaution should be taken to avoid breathing, ingesting, or getting Formalin in open cuts, sores, or eyes. If this should happen, immediately flush the affected area with clean water and consult a physician.

If possible, fish should be alive when placed in the Formalin. If this is not possible, the fish should be quick-frozen upon capture and allowed to thaw in the Formalin. Less preferably, captured fish should be placed on ice and then put directly in the Formalin.

If specimens are larger than 4 or 5 inches, it will be necessary to make a small (1 or 2 inch) slit into the body cavity on the right side of the fishes' bellies (by tradition the left side should remain intact unless it is already damaged). This will allow the fixative, in this case Formalin, to more quickly penetrate the body cavity to insure proper fixation (fixation merely means making the tissues less vulnerable to bacterial decay) of the internal organs. On very large specimens (over 2 feet long) it is advisable to make a longer cut into the body cavity.

Do not force the fish into its container so that it becomes distorted and twisted. The fish should not be packed tightly in the container with very little Formalin fluid since plenty of fixative must surround each specimen to reduce bacterial decomposition.

Fish should be kept in Formalin for at least 3 days but no longer than a week. Then they should be transferred to a STORAGE FLUID OR PRESERVATIVE, which is usually made of alcohol. While Formalin is very good for fixing (killing) cells and stopping bacterial decay, it has a tendency to cause tissues to become soft with time, and the fumes can be irritating to the eyes, making handling quite unpleasant. The best and easiest way to transfer specimens from the fixation fluid to the preservative fluid (isopropyl or rubbing alcohol) is simply to pour off the Formalin in a well ventilated area, and replace it with the preservative. Isopropyl alcohol, available at most pharmacies, when diluted with an equal amount of tap water, becomes 50 percent isopropyl alcohol and makes a good and inexpensive preservative. It should be noted that the Formalin may be reused a couple of times, then disposed of as a hazardous waste.

The containers that specimens are kept in are also important. Clean glass jars should be used. For aesthetic purposes, the jars should be of the same type and generally plain in design. The jar lids should be plastic (either Bakelite or polypropylene). Metal lids should not be used for they quickly corrode, especially in the presence of Formalin. Good quality glass jars can be obtained from bottle and jar distributing companies. A partial list of North American bottle distributors, prepared by the American Society of Ichthyologists and Herpetologists, is found in Appendix K.

Larger voucher specimens (too large for gallon jars) may be maintained in tight sealing plastic buckets. Wooden boxes or containers lined with fiber glass resin and filled with preservative can also be used as holding or storage tanks when preserving larger specimens.

Whether the specimens are placed in tight sealing glass jars or wooden boxes with loose fitting tops, it will be necessary to periodically inspect the containers. Because the preservation fluids can evaporate rather quickly, fluid levels should be checked at least twice a year. If the amount of evaporation has not been too severe, merely "topping off" the containers with additional preservative should suffice. Extreme loss of fluids indicates a leak somewhere. To insure that the jars do not undergo excessive evaporation, it would be a good idea to keep them in an air conditioned room.

It is important to properly label all specimens with the appropriate field location and collection data. Labels should always be placed in the jar with the specimen and not on the outside of the container. Below are two typical labels which should serve as examples for size, format, and the minimal information necessary to insure proper identification of specimens: **Figure 7-1.**

Plastic papers, such as an underwater paper called Plaspyrus (available from Bel-Art Products, Pequannock, New Jersey) may be useful for making labels, but this paper may not accept indelible writing inks as will the rag paper. One advantage of this plastic paper is that it has other uses in our artificial reef assessments. A technical writing or drawing pen should be used with such inks as ordinary fountain pens will clog rather easily. Possible alternatives might be to use waterproof "laundry" pens or even No. 2 lead pencils. One should never attempt to use felt-tip or standard ball point pens. The ink will inevitably dissolve and a blank label (and missing data) will result.

Species Identification

Any research concerned with surveying fish must first begin by identifying and learning the species likely to be encountered in the study area while still on dry land. Our aim is to be able to visually identify fish species underwater with the aid of identification guides and voucher collections.

H. D. Hoese and R. H. Moore's book entitled "Fishes of the Gulf of Mexico" (1977, Texas A and M University Press, College Station, Texas) is an excellent book introducing anyone to the methods of identifying fish. It includes a good general account of each species and is comprehensive enough in its scope to include most, if not all species one might encounter on an artificial reef in Florida's inshore as well as offshore waters. Some other books that are useful are: "A Field Guide to Atlantic Coast Fishes of North America" by C.R. Robins, G.C. Ray & J. Douglas (1986 Houghton Mifflin Company, Boston), "Caribbean Reef Fishes" by J. E. Randall (1963, TFH Publications, Jersey City, New Jersey); "Guide to the Corals and Fishes of Florida, the Bahamas, and the Caribbean" by Iday and Jerry Greenberg (Seahawk Press, Miami, Florida); "Fishwatchers Guide to West Atlantic Coral Reefs" by C. G. Chaplin (1972, Livingston Publishing Co., Wynnewood, Pennsylvania); and "Hand Guide to the Reef Fishes of the Caribbean" by F. J. Stokes (1980, Lippencott & Crowell, New York).

These books are narrower in scope, however, and tend to include only the more popular and colorful fishes found on natural coral reefs. They might suffice for studies in the southern portion of Florida, but probably will prove somewhat inadequate in areas north of Tampa and Fort Lauderdale. They will supplement and complement each other and together all the above books will provide a good literature basis from which to begin a study.

Figure 7.1

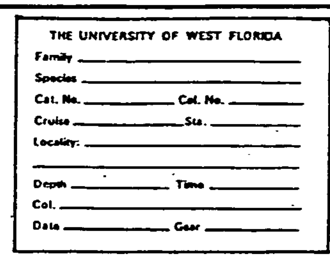
Specimen Labels

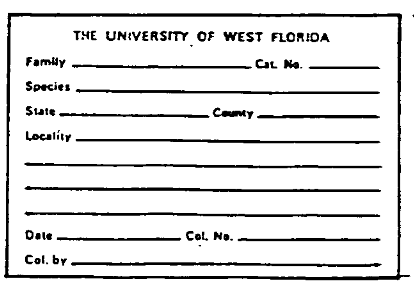
Preprinted labels with fancy lettering is nice but not essentianl. it is only important that the information be recorded and legible. The paper that the labels are made from is important, since normal paper deteriorates rapidly in alcohol or Formalin. The "best" paper for labeling is 100 percent cotton rag paper. The Byron Weston Co., of Dalton Mass., produces a paper called Byron Weston Resistall Linen Record, which is very good for this purpose. In the southeast this paper may be obtsained from the following dealers:

Strickland paper Co., Mobile, Ala.

Dillard Paper Co., Atlanta, Ga.

Knight Paper Co., Atlanta, Ga.





Many fish have color patterns that allow them to be identified from photographs of drawings. Others do not have features which make them easily recognized. Therefore, it is important to become familiar with the species likely to be encountered before making a dive to collect data. This is done by studying the drawings and photographs in the texts, and taking the time to collect and identify the voucher specimens.

At this point, the research diver should be ready to enter the water and begin some actual sight identifications. Before an actual survey begins, however, all the participants should make at least one or two inspection dives or trial runs in the area to do some preliminary identification.

Once in the water, a plastic writing slate or pad of underwater writing paper to record the species seen will be needed. Special anatomical characters should, of course, be noted. It is highly probable that one might see a species that is totally unfamiliar, but by writing down some distinguishing features, confirmation of its identity is more certain. Notes should immediately be written down regarding the species' notable characteristics, color patterns, and other features that will make it easier to identify. Underwater color photographs (or better yet, color transparencies) will be a great aid, especially if the specimen is suspected as being different or unknown and cannot be captured. It is important to compare notes with fellow observers and just as importantly, to learn to accept (or reject if need be) the identifications made by others. There are ichthyologists and fishery biologists at most of the universities throughout the Southeast, who can be called upon to help you with your identifications. We emphasize again that while variation and inaccuracies in data gathering on artificial reefs is inevitable, the data base must contain accurate species identifications. While it may not be possible to identify each individual to the species level an alternative would be to identify each individual at least to its correct genus or family.

Importance of Field Notes

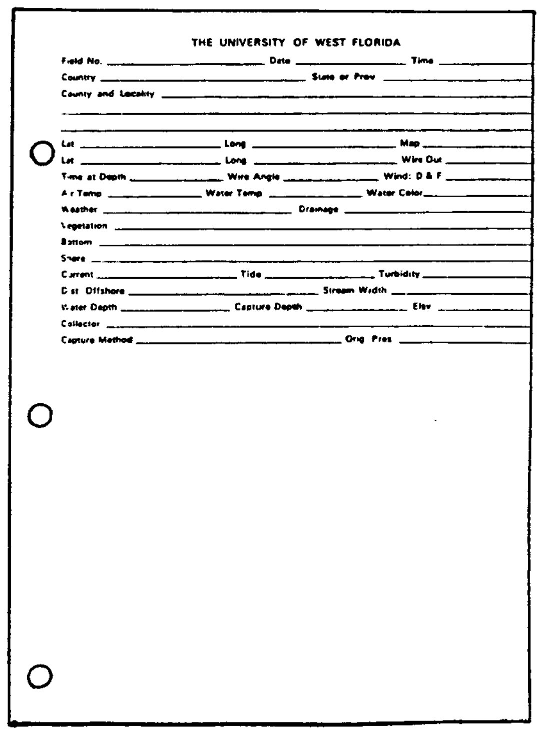
Too many trust their memories only to learn (or worse, never find out) that they have forgotten some character, species, or observation critical to a study. This happens most often when considerable time takes place between the dive and note writing or data recording. Even the best of us have problems keeping track of information when several dives are made on the same day, or the weather is rough and/or the excitement of the moment causes a lapse in memory. We suggest, in addition to recording the physical data as outlined previously, that a field notebook be used to write down your immediate impressions and observations. A three-ring, loose-leaf notebook or a surveyor's notebook will do for this and don't forget to use waterproof ink pen or pencil when writing. (NEVER USE FELT TIP PENS).

Figure 7-2 is an example of a field note sheet preprinted with the typical data one might want to jot down after a dive. Appendix B offers some additional examples. **(Please see Figure 7.2)**

The blank space below the preprinted lines is to record the species observed, characteristics of the fishes which might aid in their identification (i.e., color, size, etc.), relative abundance (rare, common, abundant, etc.), life stage (juvenile or adult, male or female), and any interesting behavioral or ecological features.

The data most desired by scientists concerning fish on artificial reefs are species composition, relative abundance, and estimates of individual sizes. A species listing by itself has relatively little value. However, if this is the only kind of data possible to collect, given the circumstances, conditions, or experience of the diver group, even some kind of comparison within and between reefs is still possible. It is preferable to use a sampling strategy which obtains a representative sample of the community. These data can be used directly as an index of relative abundance or they can be treated mathematically to estimate total abundance on a reef.

Figure 7.2


THE UNIVERSITY OF WEST FLORIDA

Field No. ______ Date ______ Time ______
Country ______ State or Prov ______
County and Locality ______
Lat ______ Long ______ Map ______
Lat ______ Long ______ Wire Out ______
Time at Depth ______ Wire Angle ______ Wind: D & F ______
Air Temp ______ Water Temp ______ Water Color ______
Weather ______ Drainage ______
Vegetation ______
Bottom ______
Shore ______
Current ______ Tide ______ Turbidity ______
Dist Offshore ______ Stream Width ______
Water Depth ______ Capture Depth ______ Elev ______
Collector ______
Capture Method ______ Orig Pres ______

Field Note Sheet

Beginners can start by simply identifying and recording species of interest. Thompson and Schmidt (1977) and Jones and Thompson (1978) developed a method in which divers swim randomly around a reef and attempt to locate and identify all possible species within a 50 minute period. Species are given a score of 5 to 1 depending on which respective 10 minute time interval they were first observed. This is an excellent method for producing a species list and for training divers on fish identification.

Advanced divers, using methods described below, should collect more quantitative data which estimates abundance and even sizes. Measuring sizes under water can be a problem because objects appear closer (and therefore enlarged). Divers who desire to estimate fish sizes should carry a measuring device of some type. One which we prefer consists of a rod approximately 3 feet long with a ruler attached perpendicularly on the far end. This will help avoid problems in estimating true sizes. Divers should practice estimating sizes of various objects from a distance and then compare their estimates to the measured size underwater.

Visual census data are most easily recorded with a pencil on plasticized paper held by a clipboard. We do not recommend using data sheets with preprinted species' names because they tend to bias the diver's observations and usually do not save time. It often takes considerable time to read and find names on a list underwater. Scientific names can usually be abbreviated using the first three letters of the genus and the first four letters of the specific name (e.g., the red snapper, Lutjanus campechanus becomes "lut camp". Plastic paper provides a convenient permanent recording medium. The Plaspyrus brand paper referred to earlier is good for this. Heavy rubber bands will help in holding sheets on a clipboard. Another method of recording data consists of using opaque (white) sheets of plexiglas which have had their surfaces roughened with sandpaper. These "slates" can be reused as they can be cleaned with scouring powder or sandpaper. Pencil can be used to write underwater on both materials (you can even erase underwater as well with a plain old rubber eraser). A simple way to transcribe the data on the slate, to paper, is by using a copy machine.

Sampling Methods

In order to properly assess fish on artificial reefs, we must have a firm understanding of the attributes and limitations of the methods we wish to employ. Below are two methods designed to quickly and simply visually monitor the reef fish populations. The first method, Moving Transect Samples, is used to sample specific species of interest, such as snapper and grouper, although the method can be used on any species or group of species. The second method, Fixed Point Sampling, provides an index of abundance of all observable species.

Moving Transect Sample

The lack of structural uniformity over space and time on artificial reefs often makes traditional transect sampling strategies difficult or impossible. For this reason, we recommend using a fixed search route or a timed search period in which all individual fish of interest are located and counted. In situations where the reef structure is relatively constant, like a ship wreck, a prescribed search route can be established. Careful attention should be given to precisely following the same route for each sample. The same starting and ending point should be used. A route map should be made for later use. Target species are recorded as they are observed. The data can be influenced by differences in water visibility. This can be minimized by recording only those individuals observed within a predetermined distance. The distance chosen should depend on prevailing conditions.

In complex habitats, a timed search period of 15 minutes per sample is suggested. During this period all observed individuals of the predetermined target species are recorded. Likely hiding places for particular species can be searched. In order for results to be comparable, a constant swimming speed should be maintained during the search. Swimming speed should be the slowest speed necessary to adequately take data on the densest concentration of the desired target species. Distance covered can be estimated by calibrating distance as a function of time at the established swimming speed, although in areas with strong currents such calibration may not be effective.

Several independent, small samples are generally more desirable than one large sample. Multiple samples are more desirable for statistical treatment. Therefore, small increments of search distance or time are recommended. More samples can be taken in large habitats and the average or mean values used. Buddy team members should collect data in order to provide a variance estimate between observers. The first sample collected on a given day can be used for comparison purposes in situations, where fish populations are affected by counting, such as when individual fish are frightened away from a reef by the presence of divers.

Fixed Point Sampling

This method is more suited for sampling all species on reefs with complex or diverse communities. Studies which concentrate only on a few species might not reveal all the information which is biologically important. Larger species are likely to be attracted to sites because of the presence of smaller "trashfish" or "baitfish" species. Scientists would like to know more about the relationships between the large and small species.

With this method, fixed points are selected from which data on community composition are collected. Points can be randomly selected (provided points chosen are truly random in the statistical sense) or they can be fixed at certain locations for purposes of comparison. On a particular artificial reef, such as a wreck, sites might be chosen which can be easily relocated, such as on the anchor, the fo'c'sle, or a point along the hull on the upcurrent or downcurrent side. Permanent points are recommended for detecting temporal (i.e., time associated) changes and when different divers are monitoring the same site.

At each point, both members of the buddy team first record all species observed within a preset distance of a 360° arc during a five minute period. This distance used should be constant. We recommend 8 meters (about 25 feet) in areas with prevailing clear water although shorter distances may be used. The distance to be sampled should be measured and marked at one point. Several brands of fiberglass tape measures are commercially available, which can be submerged in salt water. Usually a stationary object on the bottom will serve as a handy reference point for each sample.

Any fish that swims within the imaginary cylinder extending from the bottom to the surface within the five minute sample period is recorded. At the end of the sample period an estimate of the number of individuals observed for each species is then recorded. Minimum, average, and maximum size estimates for each species can also be recorded. Only a few individuals of most species appear within the sample radius during the five minute sample so their numbers can usually be easily remembered. Individual fish which are not likely to leave the sample radius can be counted after the five minute sample period by starting at one point and rotating around 360° until all the viewable area is covered. We recommend counting only one species at a time and working up the list from the bottom to avoid bias caused by a tendency to count each species when it is particularly noticeable or abundant. Working systematically back up the list reduces the chance of overlooking a species that remains within the sample area for only a short time can be counted as they appear during the five minute sample period. Usually only a few species are in this category.

When large schools of fish are present, it might be necessary to count by 10's, 20's, 50's, or even 100's. This method relies on detecting relative abundances so do not be concerned about obtaining absolute accuracy. The maximum number of individuals seen at one time can be used for species that continually swim through the sample area. This procedure will reduce chances of recording the same individuals more than once. Data on bottom features within the sample radius may be recorded for later reference. Photographs of the site may be helpful.

Again, great care must be taken to record and keep track of all essential information about the dive. Otherwise the data collected will be useless. Copies of raw data sheets and dive log sheets should be kept together, although later, the data can be recopied and organized for analysis. Names of divers, date, weather conditions, depth, name of reef and sample locations should be recorded. Numbering each sample is recommended. Any additional information that can be provided should be recorded such as visibility, sea conditions, tidal cycle, cloud cover, and unusual observations.

Fish Survey Data Type

Any analysis of the data obtained in a visual survey must be considered as to kind as well as quality of data. The kind of data will generally be at least one and perhaps all of the following:

1) species list;

2) qualitative species abundance;

3) relative species abundance;

4) absolute species abundance.

The appropriate ways to handle each of these data types will be considered below. In all cases you must compare data of the same type. For example, it would be erroneous and misleading to compare the seasonal changes in abundance of red grouper at a particular artificial reef, if some of the surveys recorded relative abundance and others used qualitative estimates. To analyze the data in the above example, one would have to go to the lowest common denominator of similarity in data type. In the above example, the relative abundance data would have to be converted into qualitative data to allow a meaningful analysis.

Species Lists

It is possible to compare artificial reefs merely based on a list of species known to inhabit them. Granted, the analysis may be crude, but there are some things which can be said in a study using these types of data providing one is aware of the assumptions necessary to validate the comparison.

A dive team may survey a reef and merely note the species observed at the site at a particular time of day or time of year. It may be possible to use the presence/absence of certain species to gain some insight into the nature of artificial reefs. Below are some hypothetical examples of the uses made from the kinds of information someone might gather from a simple species list.

1) A certain species of fish may have been absent at one time of the year and present the remainder. This implies a seasonal preference by the species.
2) A species may be absent at one type of reef, yet present at another reef which is close by but composed of a different type of material. This implies a habitat preference by the species.
3) Presence of a species only when another species was absent might imply competition between the two species.
4) Higher numbers of species consistently recorded on one reef in comparison to others implies that something in the nature of the structure allows or permits this to remain because of some factor such as size of the reef, amount of fishing pressure, proximity to natural reefs, or some other factor not easily recognized without further study.

There are several basic assumptions which are made when comparing artificial reefs by species lists. The first is that when a species is noted on a particular survey, it was in fact present (again errors in species identification can invalidate this assumption). The second assumption is that just because a species was not seen or recorded does not mean that the species was truly absent from the area. It is of course probable, although unlikely, that after a series of surveys on a particular reef that one might miss seeing a species when it was actually there all along. This may happen because of the geometric configuration of some artificial reefs, the behavioral features of some species, also the species' abundance, or variation between observers to see some species. It should be noted that even though a species list really only notes the presence of species, species abundance is important as it is theoretically easier to miss a species which is rare, especially if it is small and cryptically colored.

Qualitative Species Abundance

Species' abundance data of this type are preferred over species lists. This is because in a community, fish are not just present on a reef, but are also there in varying abundances. For example, even though gray triggerfish are present on two adjacent reefs, they may be vastly more numerous on one of these structures.

Qualitative abundance data are generally recorded on some type of verbal or numeric scale. A species may be said to be abundant, common, few, rare, or given a number score for the abundance assessment (e.g., 5,4,3,2,1) to signify the verbal qualifiers above. The verbal or numerical scales can vary of course. An extremely abundant fish could become a perfect 10 on a 10 point scale. It is preferable that if qualitative abundance scores are used, that they be accompanied by some relative abundance definitions: e.g., abundant = more than 100 individuals; common = 25 to 100 individuals; few = 5 to 24; rare = less than five.

If defined in some similar manner as above, qualitative data can be treated as relative abundance data and analyzed accordingly. The problem is that because of the wide ranges in potential species abundance and the necessarily narrow range of qualitative categories, a lot of useful information in our visual surveys may be lost.

Relative Species Abundance

Relative species' abundances are perhaps the most appropriate kind of data for scientific analysis of the fish fauna assemblages associated with artificial reefs. Most of the data gathering techniques outlined previously record relative species abundance. The abundance figures for each species are considered "relative" because they are relative to the particular technique used. For example, an estimate of grouper using a moving transect technique gives a number of grouper relative to that technique and would not be comparable to grouper abundance data gathered by a fixed point count technique.

Absolute Abundance Data

An improvement of the relative abundance data by species is the absolute abundance which relates the relative abundance to some special parameter such as the surface area of the reef and its value should be independent of the census method. For all practical purposes, these type of data will not be considered further because of the degree of sophistication required in their collection and verification. This is because in order to qualify as absolute abundance data, accuracy must be achieved on all levels of data gathering. The area of the reef must be determined with certainty and must be accompanied with accurate and precisely collected fish faunal data. Unless extreme care is taken to handle all possible variation in data due to experimental design, it is best to leave this type of data collecting to research scientists.

Data Analysis

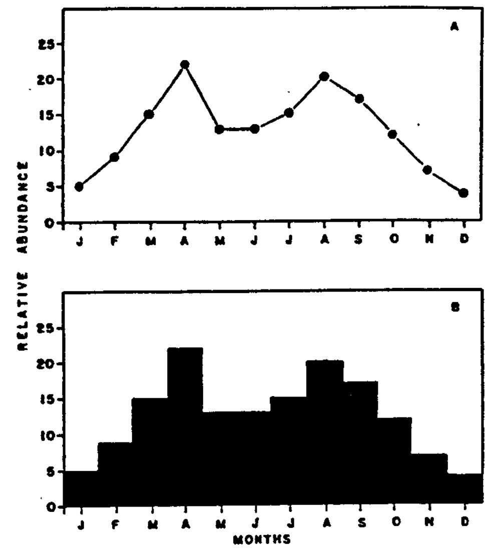
Volunteers should rely on professional scientists for data analysis. It is imperative that the volunteers appreciate the need for accuracy and consistency in their fish data collection. The major objectives of any study that assesses or surveys the community of fish on an artificial reef should be to look for changes in the fish fauna abundance and/or composition that occur within an area or to look for differences between areas. Whatever our objective, the most important aspect, allowing for further analysis of the data regardless of the method employed, is to obtain reliable data that have been recorded and reported consistently. This is essential, not only for the analysis of the fish assemblage data themselves, but also for the physical data that were recorded on each survey. One of the outcomes of any data gathering study is that the differences in measurements (species abundances or physical features) may occur. It is imperative that any differences we find not be caused by changes in the technique used to obtain the data. For example, let us say that your dive team wants to compare two artificial reefs. One dive team always surveys the shallowest reef and the other the deepest reef. In comparing the abundance data you notice there are always more red snapper at the deeper reef and more gray snapper at the shallow reef. While the differences may be real and reflect a natural habitat affinity for the two species in question, we must be sure that both dive groups conducted their surveys in the same manner and both groups knew the differences between red and gray snapper. Our analysis might conclude that deeper reefs tend to have more red snapper and shallower reefs more gray snapper. If the differences in species abundance were caused by misidentification of one group's preference to overestimate red snapper, then our conclusions that the depth difference between these two structures was responsible for the species abundance difference is likely to be false.

Graphic Analysis

Graphs are probably the simplest and clearest way to begin an analysis of artificial reef census data. A "first cut" of the data permits a "picture" of the census results and may lead one to conduct further analysis, which answer more sophisticated questions of the data. Graphs can be of several types, based on the kind of examination one would like to conduct. Perhaps the simplest type of graph is a plot of the abundance level of a particular species versus some feature of the physical data. This could be a plot of the total number of species or the total number of individuals of all species versus collection data. The relative abundance or qualitative score of individuals observed is located on the vertical axis while the date, month, season, or time of day is located on the horizontal axis. These plots can be represented either as a series of points connected by a line or a histogram (bar graph) as depicted in **Figure 7-3.**

It is also possible to use graphs to look for factors which may be related to the number species or number of individuals present. For example, a plot of abundance of white grunts versus the temperature recorded on a site may show a relationship like that in **Figure 7-4.**

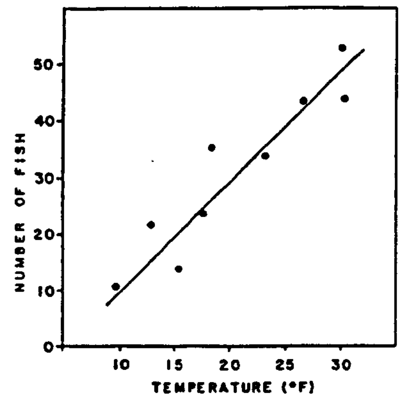
Figure 7.3



Relative Abundance Data vs. Month to Date Samples

Not carrying the analysis far enough is another point to watch. In the example of a hypothetical relationship between temperature and abundance of white grunt (Figure 7-4), the temptation is to say that an increase in temperature caused the increase in white grunt. To state this would, however, make an assumption that temperature caused the abundance levels when the data only indicate that temperature is related to abundance. We might just as well have argued that white grunt abundance caused the temperature change! While increased temperature may have been the cause of the increased fish abundance, our observation of the temperature-abundance relationship only allows us to infer what the cause was. In fact, the increased abundance of the white grunt may have resulted from an increased food supply independent of temperature. This is a major point and must be understood before proceeding with any analysis which uses a plot of a relationship between the census data and a physical feature of the artificial reefs.

Figure 7.4



Hypothetical Relationships--It is necessary to define and carry the analysis far enough to properly define the relationship. This hypothetical graph of temperature and abundance of white grunt shows how incomplete analysis can skew results.

Prediction & Trends

Through the process of plotting census data of fish communities (either the community as a whole or particular target groups within the community) it may be possible to eventually predict the status of the fish community by obtaining data on one or a few of the environmental factors which seem to have a relationship when we plot the data. For example, after examining a series of fish census data we might conclude that more snowy grouper occur on a reef when the temperature and depth are at a certain level.

While it is doubtful that accurate prediction of numbers of fish on a reef will always be possible using the technique above, it should be noted that by using more sophisticated statistical analyses with the same data, reasonably reliable predictions could occur. Again, university or research institution personnel should be able to aid you with these analyses as long as the data have been collected accurately and in a consistent manner.

Prediction in and of itself is interesting and may be important, but a potentially more important value of plotting data is to question the data that do not "fit". For example, let us say that a very strong relationship exists between the amount of surface area of artificial reefs and the number of species it normally has living on it, regardless of season. If a survey done on a very large reef has very few species on it (in other words, it doesn't seem to have as many species as it should have), then we are left with the interesting and often rewarding task of asking some additional questions such as:

1) Was it the technique?
2) Was there something about the conditions on the day that the study was conducted that might account for the unexpected difference (such as unusual weather or very low visibility)?
3) Was the reef in question newly constructed (it may take several years for a reef to "mature" and attain its "adult" or climax status)?
4) Were there some other recent factors, which weren't quite usual for the area such as a red tide, hurricane, or intense fishing pressure?

This searching and questioning aspect is what science is all about. First, establish what is out there; second, determine and document the relationships among the fish and their environment; and then try to explain why some of the data do not fit the expected pattern of relationships.

The above mentioned way of analyzing data allows us to look at trends among and within artificial reefs. In addition, we might also want to compare the species list or relative abundances of a particular species between two reefs. Here a numerical comparison is perhaps best. For example, reef A on a yearly basis tends to have 20 species of fish on it with a minimum of 15 and a maximum of 25 and a low average number of red snapper at 35 per survey. Reef B has fewer numbers of species on an annual basis 10 (minimum = 7, maximum = 15) but red snapper were more numerous with an average of 50 per visual inspection. Logically, we would first have to determine if the differences in number of species of red snapper are important or significant. Then we might try to determine what the differences in factors or features on the two structures are, which may have influenced the differences in the census data we observed. Whether or not the differences are significant is really a statistical question, which can only be answered by someone well versed in the subject of statistics.

Species Relationships

Another way to analyze the abundance data of artificial reef fishes is to plot the abundance of one species versus another. This will help determine the relationship that exists between any two species. For example, when the abundance of white grunts is plotted against the abundance of black sea bass, we might see a generally positive relationship that indicates that when there are a lot of white grunts, there are usually a lot of black sea bass. This might mean that the habitat features are favorable to both species. Let us say, however, that when we plot the abundance of white grunts versus pinfish we find the opposite to be true. That is, when white grunts are abundant, pinfish are rare or few. This could mean, in addition to the reverse for the similar habitat argument posed previously, that perhaps there was some competition taking place between the two species and that whenever one species becomes abundant it tends to exclude or outcompete the other.

Summary

It is not possible to go into all the fine details of the data analysis in this short introduction to the subject. It is, however, important to keep in mind some basic ideas when analyzing artificial reef fish visual census data.

1) Make sure the methods used to gather the data for any given analysis have been taken with a CONSISTENT method of censusing.
2) Double check the data for accuracy and be suspect (that doesn't mean throwing them away) of data that do not fit your expected pattern.
3) If they don't fit, try to determine why:
   a) natural phenomenon?
   b) error in data recording (yes, it happens to the best of us)?
4) Examine or inspect the data by graphically displaying them.
5) Look for relationships between community and species abundance with other species or environmental factors by plotting the data.
6) Try to use your graphs to help predict the abundance of a species.
7) See if your prediction works. If it doesn't, try to find out why.

If the species identification, abundance and environmental data have been collected accurately and with consistent procedures, you will have a valuable data base from which we can all learn a lot about the fishery potential and community dynamics of artificial reefs. Finally, store your data in such a way that others, in the future, can find and understand it. To do anything less, will render all your work worthless.

References

Bohnsack, J.A. 1982. Effects of piscivorous preditor removal on coral reef community structure. pp. 258-267.In: G.M. Caillet and C.A. Simenstad. Gutshop '81: Fish Food Habits Studies. Washington Sea Grant Program. Seattle.

Chaplin, C.G. 1972. Fishwatchers Guide to West Atlantic Coral Reefs. Livingston Publishing Co., Wynnewood, Pennsylvania.

Greenberg, I. and J. Greenberg. 1977. Guide to Corals and Fishes of Florida, the Bahamas, and the Caribbean. Seahawk Press, Miami, Florida.

Hoese, H.D. 1977. Fishes of the Gulf of Mexico. Texas A and M University Press, College Station, Texas.

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

Klima, E.F. and D.A. Wickham. 1971. Attraction of coastal pelagic fishes with artificial structures. Trans. Amer. Fish. Soc. 100(1): 86-99.

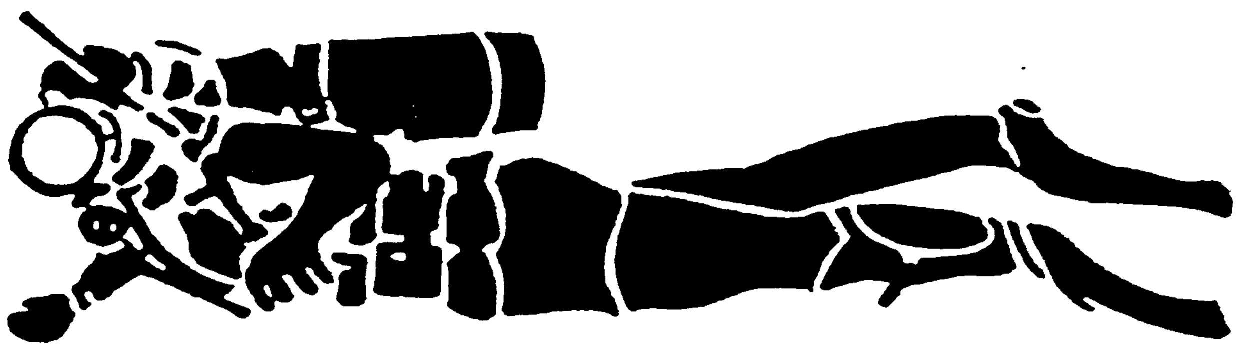
Randall, J.E. 1963. Caribbean Reef Fishes. TFH Publications, Jersey City, New Jersey.

Robbins, C.R., R.M. Bailey, C.E. Bond, J.R. Booker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. 4th ed.Amer. Fish. Soc. Spec. Pub. No. 12, Bethesda, Maryland.

Robbins, C.R., G.C. Ray & J. Douglass. 1986. A Field Guide to Atlantic Coast Fishes of North America. A Peterson Field Guide. Houghton Mifflin Company, Boston. V-XI, 354p.

Stokes, F.J. 1980. Handguide to the coral reef fishes of the Caribbean. Lippencott and Crowell, New York.

Thompson, M.J. and T.W. Schmidt. 1977. Validation of the species/time random count technique for sampling fish assemblages at Dry Tortugas. Proc. Third Internat. Coral Reef Symp. 1: 283-288.



Chapter 8

Survey Techniques: Identifying the Economic Benefits of Artificial Reef Habitat

J. Walter Milon and
Ronald L. Schmied

Artificial reefs represent man's attempt to augment the natural productivity of the oceans. While these structures may increase biological diversity and abundance, their ultimate success depends on the pleasure they provide to sport fishermen and sport divers. In the past, sportfishing clubs, civic groups and local governments have provided manpower and funds to establish reef projects. However, with increasing emphasis on fiscal conservation, artificial reef projects are being forced to compete with other civic and recreation projects for public spending. As a result, it is necessary to document the benefits of existing reef structures and to determine the potential benefits and costs of new reef projects. Neglect of economic factors can lead to underinvestment in reef habitat by government and/or private concerns.

This chapter provides an overview of alternative techniques to assess the economic benefits of artificial reefs. Since artificial reef use is not controlled through entrance gates or admission fees like many other recreation facilities, it is necessary to use survey techniques to determine usage and the associated recreational benefits. The first section discusses the basis of economic benefit measures for recreation activities where there are no explicit admission or user fees, as artificial reefs. The second section discusses three alternative methods for estimating economic benefits: 1) comparative valuation, 2) travel cost valuation and 3) contingent valuation. Examples of the survey questions that could be used for each method are provided as Appendices L & M. The third section assesses the relative merits of alternative data collection techniques for artificial reef usage surveys. Since it is not possible to provide a complete overview of economic benefit and cost techniques within the space of this handbook, the interested reader should consult "A Handbook for Economic Analysis of Coastal Recreation Projects" by J.W. Milton and Grace Johns. This publication is available through the Sea Grant Extension Program, Building 803, University of Florida, Gainesville, Florida 32611. The cost is $2.00.

The Basis for Economic Benefits

There is a common perception that artificial reefs are just like other marine habitats and should be available to everyone. The difference, however, is that artificial reefs are often created at public expense and are not a gift of nature. While they are open and available to everyone, everyone does not have the right to demand more artificial reef construction. Local or state governments for example would not be fiscally responsible to their taxpayers if they built artificial reefs which did not provide larger economic benefits than the costs incurred. The analogy to a private recreation facility should be obvious. No businessman would invest in a fishing pier unless he expected the economic returns to be at least equal to the cost.

We assume that artificial reefs provide an environment in which a food chain is established that encourages the propagation or recruitment of socially desirable marine species. Sport fishermen and divers benefit from the structures because they enjoy recreational experiences that might not otherwise be available or they would have to travel longer distances to enjoy a comparable experience. The task in identifying the benefits of artificial reefs is to determine how much the users of these facilities would be "willing to pay" for the right to continue using an existing reef or to use a new reef.

It is difficult to determine how much an artificial reef user would be willing to pay for the experience since it is not possible to charge an admission fee. Therefore it is necessary to use indirect methods to determine how much fishermen and divers would pay for a typical "user day". This amount becomes the basis for establishing the total benefits of an artificial reef. If the number of user days per fishermen/diver can be determined and the total number of users in a given year, the total annual benefits can be established through the formula:

	Cell One	Cell Two	Cell Three
Total Annual Benefits	**Willingness to pay Per Day**	**Number of User Day Per Diver**	**Total Number of Divers**
This total equals	Cell One times Cell Two	Cell Two times Cell Three	

For example, if the average diver were willing to pay $5.00 per trip to an existing artificial reef, the average number of trips to that reef was four per year, and the total number of divers using the reef during the year was 1,000, the total annual benefits for divers would be:

$$\$20,000 = \$5.00 \times 4 \times 1,000$$

A comparable calculation for sport fishermen could be made to determine the total annual benefits of the reef.

One of the difficulties in establishing these user day values is the exact nature of the "recreation experience." Is this experience on an existing reef or on a new reef? Is this new reef the first in the area or do several already exist? Are the types of experiences different on artificial reefs at different water depths? All of these are relevant concerns in establishing economic value, however, each creates a separate research problem. In the following discussion, we will assume that we are trying to estimate the economic benefits for an existing artificial reef. We will look at three alternative methods (comparative, travel cost, and contingent valuation) of establishing user day values and the total benefits for the reef. After a discussion of the three methods, we will conclude with some suggestions for assessing the value of new reef projects.

User Day Value Methods

Comparative Valuation Method

The comparative valuation method is perhaps the simplest but the least precise approach. The basic premise is that the price of a comparable recreational experience can serve as a proxy for the user day value of a particular recreation. For example, in order to establish the user day value of an artificial reef to divers, a comparative valuation would use the cost of a private charter dive trip to some local reef site. If the going rate is $15 per trip, then it would be assumed that this is the user day value for diving experiences in the area.

The advantage of this method is that it is quick and data are easy to collect. The disadvantages are numerous. First, this approach only measures the cost of getting to the dive site, not the actual value of the dive experience.This is similar to saying that the only value in going to Disney World is the expense of getting there. Second, there is no distinction between the quality of the recreation experiences. An artificial reef may be more or less enjoyable than a natural reef or other dive site but this method cannot allow for these differences between different destinations. Finally, establishing a measure of the user day value is only one part of determining the total benefits of an artificial reef. It would still be necessary to determine the number of user days per diver and the total number of divers using the reef during the year. The next method offers some help on these aspects.

Travel Cost Method

The travel cost method depends on users' expenditures to get to a site as a measure of their willingness to pay for that site. This method has been used since the 1950's to value recreation sites for Federal projects, including the U.S. Army Corps of Engineers. It can be shown by using a simple example. Suppose that a survey procedure has been set up so that interviews can be conducted with divers at an artificial reef site. The interviewing is done randomly among divers at the site and the interviews are conducted at different intervals during the season (year). The interview questionnaire (see Appendix L) is designed to determine the diver's place of permanent residence, the distance traveled to the site (local marina or ramp), the number of dives made at the site per year, the number of divers in the party and the expenses incurred enroute. Suppose the following data had been collected and broken down into three groups on the basis of distance travelled (travel zone).

(1)	(2)	(3)	(4)
Average Distance Traveled	**Number of Divers from Travel Zone**	**Number of Dives at Site/Year**	**Average Expenses Incurred**
200 miles	**200**	**1**	**$150**
100 miles	**200**	**2**	**$100**
50 miles	**400**	**4**	**$ 50**

This information can now be used to determine economic benefits for all divers. First, it is necessary to estimate the total number of potential reef divers in each of the travel zones. Suppose for our example that this was done using membership lists from local diving clubs and certification lists from a diver certifying agency. Cross checking was used to eliminate double counting. We can combine this information with the survey information in the following table:

(1)	(2)	(3)	(4)
Travel Zone	**Total Number of Divers in Travel Zone**	**Participation**	**Total Number of RateTrips Per Travel**
200 miles	1,000	25%	250
100 miles	1,000	25%	500
50 miles	1,000	50%	2,000

The participation rate (Column [3]) is determined by dividing the number of divers from each zone by the total number of divers sampled. The total number of trips per travel zone is determined by multiplying the participation rate times the total number of divers per travel zone and then multiplying by the average number of dives at the site per year.

Total benefits are determined by making two assumptions: 1) the travel costs of the divers from the farthest zone measure the maximum willingness to pay for use of the site, and 2) the difference between maximum willingness to pay and the costs incurred by divers from other travel zones is a measure of benefits received. Thus total benefits can be calculated as follows:

Travel Zone	**Average Benefit Per Trip by Travel Zone**	**Total Number of Trips Per Zone**	**Total AnnualBenefits**
200 miles	**$150 - $150 = 0**	250	0
100 miles	**$150 - $100 = $50**	500	$25,000
50 miles	**$150 - 50 = $100**	2,000	$200,000

The travel cost method uses a number of simplifying assumptions to determine an annual benefits estimate. There are a number of alternatives that can be used to introduce more realistic assumptions but these extensions are beyond the scope of this discussion. The interested reader should consult pages 36-50 of A Handbook for Economic Analysis of Coastal Recreation Projects.

Contingent Valuation Method

One alternative to using a proxy such as travel cost for the "willingness to pay" of divers for an artificial reef site is to ask them directly what value they place on the dive site. The primary advantage of this approach is that is provides a direct estimate of benefits without the restrictive assumptions of the travel cost model. The major shortcoming is the hypothetical nature of the questions. Respondents may not understand the question or they may not respond seriously or the interviewer may bias the responses by certain remarks or gestures. Some of these shortcomings can be overcome by careful instructions and proper question design.

The simplest form of the contingent valuation approach is direct questioning. For example, an interviewer at a dive site could ask divers the following question:

"If an annual permit system was established for diving at this site, what is the maximum amount you would be willing to pay for this permit?"

The average amount that divers indicate as their willingness to pay is a measure of the average benefits and could be combined with other information on the total number of divers at the site to determine the total annual benefits. The main objection to direct questioning is that it is too open-ended to produce realistic responses. An alternative is to use iterative bidding instead. The objective is to introduce some payment vehicle (e.g. a dive site permit or increases in fuel costs) and then suggest dollar amounts. The respondent will eventually converge to a final response and this will be the willingness to pay. Let's consider an example. The interviewer asks the following questions and receives the answers in parentheses; the process stops when the respondents' maximum willingness to pay is reached.

1) If an annual permit system was established for this reef site, would you buy a permit if it cost $50? (No)
2) Would you buy one if the cost was $20? (Yes)
3) Would you buy one if the cost was $30? (No)
4) Would you buy one if the cost was $25? (Yes)

Thus a maximum willingness to pay of $25 has been established.

It is very important that the respondent understand that the purpose of the question is not to "tax" them for diving or to actually institute a permit system. This could lead to deceptive responses. An example of the type of introduction that could be used is given in Appendix M. Another consideration is the starting point in the iterative bidding process. In general when an interviewer starts off with a high initial price, the respondent will end with a higher willingness to pay than if a lower starting point had been selected. This problem can be avoided by randomly switching between high and low starting points (say, $200 and $50). In addition, the interviewer should not deliberately change the starting point because of perceived differences in income of the respondents.

Since much of the same basic information needed for the travel cost method is also needed for the contingent valuation method, it is useful to combine the two in a questionnaire. In this manner the annual benefits per diver can be compared and a range of economic benefits determined.

Survey Methods

Most recreation surveys collect two types of data: 1) basic descriptive data about frequency of site use, purpose of trip, hometown, etc., and 2) measures of benefits such as travel costs or willingness to pay for the recreation experience. In attempting diving/fishing surveys there are two critical issues: determining how to contact divers using the site and determining how many divers in total are using the site. In general, a sampling procedure can be set up that uses either mail, telephone, or personal interview methods to determine the total number of divers. For example, local dive club lists and certification lists could be used to determine the total number of divers in the immediate area that could be using the artificial reef. Then either a mail or telephone survey of these divers could be used to determine if they use the artificial reef. Information of type (1) could be gathered in this manner and the total number of users determined.

The difficulty arises in collecting information of type (2). It is possible to use mail and telephone surveys to collect this information but there are serious questions whether these methods are accurate for this information. Personal interviews, preferably on site or at a local marina or boat ramp, are preferred since they allow the interviewer to correctly interpret the questions for the respondent. The major problem with the interview approach is cost. It is expensive to keep an interviewer at a site and to repeat this process in order to provide a sufficiently large sample. However, if accuracy is very important to the final results, the interview approach is highly recommended.

Summary

These considerations are summarized in the following table. The ranking runs from A - most preferred to C - least preferred. These rankings are based on general results of recreation studies for other types of facilities and the personal experiences of the authors.

Survey Method			
	Mail	Telephone	Site-interview
Response Rate	C	B	A
Purpose of Trip	C	B	A
Expenditures	A	B	B
Valuation questions	C	B	A
Cost of Information	A	B	C

(A = most preferred, C = least preferred)

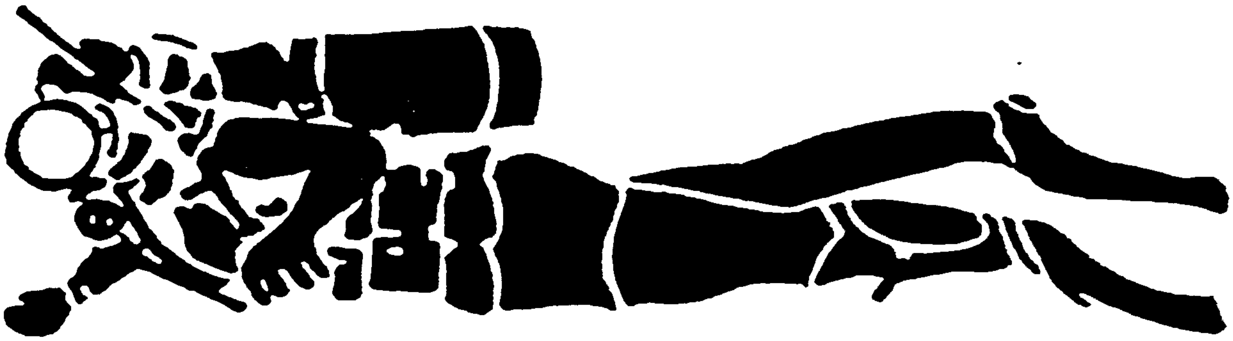
The best approach to surveying reef users for economic benefits would be to consult with your local Sea Grant Extension Agent before you begin any survey work. Your agent can put you in touch with qualified university researchers who can assist you in designing and implementing a survey for artificial reefs in your area. This will save you money in the long run and will assure that you collect the right kind of information.

References

Ditton, R. B. et al. "Predicting Marine Recreational fushing from boat Characteristics and Equipment." Transactions of the American Fisheries Society, Vol. 109 (1980): 644-648.

Milton, J. W. and Johns, G. A Handbook for Economic Analysis of Coastal Recreation Projects, Florida Sea Grant Report Number 45, University of Florida, Gainesville Fla. 32611

Thompson, M. E. and Roberts, K. K. "An Empirical Application of the Contingent Validation Technique to Value Marien Recreation" (draft), Louisiana State University, Center for Wetland Resources, Baton Rouge, La. 70803.



Chapter 9

Disseminating Information on Reef Research Activities

by Thomas M. Leahy

Information obtained through monitoring of reefs or other reef research activities is relatively useless unless it is passed on to those who need it and those who, although not necessarily in need, are interested. As a result, divers who have this information are almost certain to be faced with communicating it to others in one way or another. In fact, communication of research information is a vital element of a reef research program.

This does not mean that divers must also be professional communicators. They do not need the trained voice of a broadcaster or the writing skills of a veteran newspaper feature writer, but it helps to be able to think logically and clearly, to speak distinctly, and to write literately--qualifications it is assumed the divers already possess.

The purpose of this chapter, then, is not to attempt to teach writing or speaking, but to discuss the most effective channels for disseminating information and methods for using these channels.

But first, two cautions to remember. In most cases the divers will not be scientists. They are trained as diver technicians, and are qualified to gather data, to map a reef, and to report on what has been observed. They are not qualified to interpret the data and should not attempt to do so. Any request for information which depends upon interpretation of collected data should be referred to the scientist who has been given the information.

Also, the importance of accuracy should always be kept in mind. Sometimes, despite the utmost care in reporting, errors will creep in. This is evident in the fact that although newspaper reporters and editors are trained to provide accuracy in published news stories, incorrect information still continues to appear in print from time to time.

How to Use Channels of Communication

There are a number of ways or channels of communication available to the divers for relaying information. The channel or channels used will depend upon the type of information to be conveyed, the audience to be reached, and the purpose to be achieved by reporting the information.

The channels can be arbitrarily divided into two broad categories: personal and mass media.

Personal Channels

Person-to-Person Contact on a One-to-One Basis

This informal channel is the simplest and most direct means for conveying information and can also be the most effective: Immediate feedback from the person receiving the information is possible, any questions can be answered on the spot, and any misunderstanding immediately cleared up. The disadvantage to this method of communication is that it is feasible only when a few people must be contacted. It is slow and time-consuming and in many cases would not serve the purpose intended.

No special skills or instructions apply to use of this channel since it is something we all do every day. It is important, however, to remember the importance of "intelligibility" in what is communicated. This can be assured through good speech characteristics and logical development of the subject. Listening critically to one's own speech as well as to that of other people will create an awareness of improvements which are needed.

Person-to-Person Contact at Group Meetings

This, too, is a relatively simple and direct means for conveying information and if the group is not too large it can also be very effective. As with the one-to-one contact, immediate feedback from the audience is possible (or, if not immediate, during question session following the formal presentation at which time any misunderstandings can be cleared up). More people can be reached at one time than in the one-to-one method but it is still much slower and reaches far fewer people than is possible through other means.

Using this channel requires more organization of the information to be presented so some time must be spent in preparation in order to make the remarks effective. In preparing the report, consideration should be given to the composition of the audience and the reaction which is expected or desired from them. If the purpose of the presentation is to inform, then the reaction desired would be an increased understanding on the part of the audience. If on the other hand the purpose is to stimulate action, then the audience must not only be convinced of the necessity for such action but actually persuaded to take the steps to accomplish it.

In relating information concerning the condition of artificial reefs or in discussing information concerning a planned artificial reef program or any other related information, it can be assumed that the audience will have an interest in the subject and therefore the speaker will not have to be particularly concerned with motivating the audience to listen.

Presenting the Information

The size of the audience will have a definite influence on the way in which the information is presented. If a small group is being addressed, the presentation may be very informal with the speaker and audience sitting around in a random circle of chairs and discussing the situation point by point. If it is a much larger group, the presentation may be more formal and with the speaker using a microphone and questions being delayed until completion of the formal talk. The latter situation requires a greater amount of preparation on the part of the speaker to organize the material for presentation to the larger audience.

The best rule for speaking to a group has been used so often it is almost a cliche: Tell them what you're going to tell them; tell them; tell them what you told them. In other words--state your purpose, deliver your message, and summarize it briefly. You can't do much more than that.

Use of Slides

In making a presentation before a group of any size it may be helpful in terms of audience understanding to have some visual materials, particularly slides to accompany your talk.

If the information is such that it will be shown a number of times to different groups, it might be advantageous to prepare a slide/tape show with an electronically pulsed cassette tape to move the slides at the appropriate time. This, of course, requires special equipment to pulse the tape as well as projection equipment which will permit coordination of the tape and slides.

Some guidelines for working with slides are contained in Appendix N.

Newsletters

A periodic newsletter can be a very effective channel for dissemination of information to a selected audience such as members of a local fishing club, the local artificial reef committee, community officials charged with making decisions concerning local reefs and the reef program and other interested persons. It may be desirable to compile information for dissemination on a regular basis (quarterly for example) to keep those individuals informed as to the progress of any current monitoring efforts or reef research which is planned or already underway.

Using this channel does require some effort but the advantages over the mass media are fairly obvious. The writer of the newsletter has complete control over the information because it will not be edited in any way. The writer and distributor also have control over who gets the information and when the information is distributed. None of this can be controlled if the information is to appear in the mass media. It is true that the newsletter has to compete for attention with all other items in the mailbox leaving the possibility that it might not be read, but on the other hand, the recipient would be presumed to have an interest in the information and therefore this should not be a problem.

Using a newsletter for dissemination of information requires compiling the information, writing it in an acceptable style, having it duplicated and finally distributed.

Writing the Newsletter

Most writing in newsletters is a rather informal, chatty style of writing along the lines of a personal letter. Some newsletters are produced with the writer sitting down and typing out each bit of information until finished, and then perhaps signing his or her name. Others are set in type by a professional typesetter, with professional design and layout. Even when the letter is typed rather than typeset it is generally preferable to have two columns than to have the material typed across the entire page. This makes the information easier to read.

Packaging the Newsletter

If the newsletter is to be an "economy model" it can be, and should be, as neat and attractive as possible. This means a neat typing job, adequate margins, and a clean duplicating effort. It may have a title or a heading along with a logo if the organization has a logo. Color can be added by using a colored paper. If it is to be printed or mimeographed on both sides of the paper the weight of the paper should be heavy enough so that there will be no "show through."

How simple or elaborate the newsletter is, depends upon such factors as the amount of money available to produce and distribute it, the expertise of the person who prepares it, etc. When a newsletter is aimed at a specific group interested in the subject matter it is not necessary to package it expensively to attract attention and promote reading. Presumable the recipient will want to read it anyway.

Distribution of the Newsletter

Distribution of the newsletter requires development of a mailing list and keeping the list up to date. Small mailing lists are relatively easy to handle but larger lists have a greater turnover and require more effort to keep current with additions, deletions and changes of address.

Maintenance of mailing lists may be a sophisticated or as simple as time and equipment permit. If you have access to a computer and a qualified computer operator the maintenance of the mailing list can be accomplished quickly and accurately and the computer can also be used to sort and print mailing labels. Much more time consuming but still satisfactory is to maintain the list manually using a card file or other method. Mailing labels can be typed or even written by hand if the list is small. For larger lists where this is impractical, mailing labels may be printed on pre-gummed labels sheets from a master list using a xerox or similar type copier. If necessary to divide your list by special audiences (divers, fishermen, reef supporters, community planners, etc.) to provide flexibility in mailing certain information to some groups but not to others, a coding system may be improvised for filing and sorting. With a computer, of course, this task is handled much more quickly and efficiently than in a manual operation.

Regardless of the means used to maintain your mailing list, to be most effective it should be surveyed periodically to determine if those receiving the newsletter want to continue to receive it and to locate those addresses which are no longer current.

A newsletter requires some effort but it is usually worthwhile and may be the most effective communication tool available. The proof of this is the tremendous number of newsletters issued every week by thousands of organizations countrywide ranging from churches and small service organizations to huge corporations and government enterprises. In addition to the fact that they are timely and useful, surveys have shown that many newsletter recipients save copies of the newsletters for future reference.

Mass Media Channels

Newspapers

The local newspaper, whether daily or weekly, can be a very effective way of reaching a large audience. Many counties, depending upon the population, will have at least one daily paper and several smaller weekly papers. All represent a channel through which information may reach the decision makers and other influential and interested people in the area covered by the paper.

Remember, however, that the newspaper is a business and like any other business, it must make money in order to keep on operating. Whether a paper makes money depends upon its circulation and the amount of advertising sold. How much a paper may charge for advertising usually depends upon the size of the circulation, and circulation depends on news. This means simply that the editor is not interested in items which are only self-serving pieces of information for some group, but in items that are newsworthy and of interest to the readers of the paper.

Remember, also, that most newspapers have access to far more material than they can use and therefore must be selective in what is run in the paper. Thus it is extremely important that a news release, or a call to an editor or reporter suggesting an interview be based on material that is newsworthy.

Using the Newspaper

There are essentially two routes to getting material into a newspaper. Providing information to a writer or reporter for the newspaper who then writes the story, or preparing a press release for submission to the newspaper.

In the first instance, the reporter might contact you and request an interview for a story, or you may have information of news value to the paper and you will call a reporter, or reporters if several papers are involved. If the request is initiated by you it is very important that the material is newsworthy. If not, the next time you call the reporters they may not respond at all.

A media contact's role is to provide accurate and complete information to the reporter who will be responsible for assembling it into a story for publication in the newspaper. The reporter will probably not show you the story before it is run so it is important that information given the reporter be accurate. Even then, by the time the copy is typeset and proofread there is a chance for error to slip in. With accurate information from the beginning this is less apt to happen.

The second possibility is for you to prepare a press release for submission to the newspaper. Since, as mentioned above, newspapers have more material than they can use, it is more difficult to place information in the paper this way, than if reporters for the paper wrote and submitted it, but there will be times when you have information which you feel is important to place in the newspaper but not newsworthy enough to call a reporter. Since writing and typing a press release in final form will take some time, a good rule of thumb to follow is that if you have information which is timely, which should appear in the newspaper's next issue, call the reporter, if it is information which lends itself to "feature" material rather than "hard news" then you have time to write and develop the press release yourself.

Getting to know the editorial staff writers increases the chances of placing material in a newspaper. A visit to the newspaper where you hope to get publicity will be well worthwhile. On daily papers the city editor is the person who deals with local news and is the best person to see. If the newspaper has an outdoor editor he can also be a valuable contact for you.

Preparing the Press Release

Appendix O, "Guidelines For Preparation of Information For the News Media," contains information on the actual writing of a press release, specific information on how the release should be presented and packaged, and an example of a sample press release. Since all copy is edited before appearing in the newspaper, a press release, if otherwise interesting and newsworthy, would not be rejected solely because it did not conform strictly to the newspaper's style. However, preparing a professional press release is beneficial.

Magazines

Writing occasional articles for magazines can be a very rewarding experience. In addition to providing information to readers of the magazine. It may also prove to be quite profitable. Most of the general interest magazines of years past have ceased publication. Taking their places on the newsstands are special interest magazines which focus on a particular subject such as health, fashion, beauty, women, family, business, computers, diving, outdoors, fishing, boating, sailing, natural history, science etc. The list is almost as endless as the interests of people.

Some of the magazines which may be interested in articles concerning artificial reefs, diving to monitor reefs and related ideas are Florida Sportsman, Florida Fishing News, Pleasure Boating, Florida Scuba News, Sea Frontiers, Skin Diver, National Fisherman and even larger more general magazines with national coverage such as Smithsonian, National Geographic, Natural History and Scientific American. However, it should be understood that placing an article in large circulation national magazines is extremely difficult. In many cases, articles are assigned by editors to writers of known quality.

Placing stories in appropriate smaller magazines with primarily local, state, or regional coverage, while still difficult, is easier than breaking into the national media. But since magazines come and go, before submitting an article, make an on the spot assessment of just which magazines are now on the newsstands or in the library or otherwise available in your particular area. From the above comments it can be seen that the magazine market is difficult to fit into a regular channel for dissemination of information. The exception would be those rare cases in which a magazine would agree to run a column by a diver/writer in each issue. Such an opportunity would most likely be found in the smaller, local magazines serving a community, the state or a particular region of the state. It would be, for all practical purposes, extremely difficult to arrange this with a national magazine.

But despite the obvious obstacles, this market should not be neglected for it functions well as an additional channel when there is information which can be appropriately packaged for readers of some particular specialized magazine.

Writing the Magazine Article

Before beginning the writing of a magazine article you should determine the purpose of the article and the intended audience. This will have much to do with the way in which you prepare and present the material in the article.

The next step will be to decide which magazines may be interested in the article. Study these magazines to see what type of articles they publish and how the articles are written. At this point you could begin writing the article attempting to "slant" it to one particular magazine. It will probably save time, however, to first write to the editor of the magazine stating that you have an idea for an article which you believe will be of interest to the readers of the magazine and explain briefly what it is. If the editor does not respond favorably, write to another editor and another until one indicates an interest in the material. Although writing and sending out these query letters takes some time, in the long run it may save a lot of writing time because the editor who indicates interest will most likely have certain requirements to pass on to you such as the length of the article and how the subject should be treated.

And remember--whenever you send in a query letter or a completed manuscript always enclose a stamped, self-addressed envelope for reply.

Help in writing and preparing the manuscript in an accepted format is addresses in Appendix P).

Radio

Radio has been called a very personal and intimate channel of communication because it can bring the speaker right into the presence of the listener. Radio is everywhere. There is hardly a place in the world where radio cannot be found. In a sense, communicating through the means of radio is much like a person-to-person contact on a one-to-one basis or speaking in person to a group, except that the speaker cannot see the listener audience, cannot judge the impact of what is being said, and is not aware of any questions the listeners may have. But the audience reached at one time may be much larger. Instead of one person, the radio broadcast may be reaching hundreds or even thousands.

But radio has disadvantages, too. Like newspapers, a radio station is a business and must make a profit to stay in business. It usually has more material than it can use so if it is to be broadcast, the message must be newsworthy and of interest to the radio audience. Although as part of the licensing procedure a station agrees to operate in the public interest, convenience, and necessity and indicates what types of public service programming it plans to have, there is usually not enough available air time to accommodate all of the requests the station receives to broadcast noncommercial, public service announcements (PSAs).

Another disadvantage of radio is that the message is fleeting and appeals to only one sense--hearing. It is spoken and then gone. If the listener does not have the radio turned on or is momentarily distracted while the message is being aired, it is missed altogether. Usually a radio listener is doing something else while listening such as driving a car, eating, or doing some type of work. In such cases the message cannot be readily written down and filed away for future reference. If it cannot be easily remembered it will probably be forgotten very quickly. Radio, then, is good for some information dissemination and not good for others and is most effective when the message to be delivered is simple, short and to the point--something that can be remembered without being written down immediately.

Most radio programming today features a music/news format with a five minute news segment every half hour or every hour. It is primarily "headline" journalism. Interspersed with the music are commercials, brief commentaries, or sometimes PSAs. But it moves at a rapid pace and in brief segments with very little time going by without returning to the music. To fit into such a format any message must be brief and to the point. PSAs, for example, run no longer than 60 seconds and most frequently no longer than 15 or 30 seconds. There are some stations which have a talk format with much more news and commentary interviews. Such a station, offers a more flexible format and greater opportunity to participate in longer programs.

Material which is of a broad, general interest has a greater chance of being aired than does information which is focused on a much narrower listening audience.

Using Radio

Radio use will probably be in one of three ways--through brief news items on the local news, PSAs at whatever time the station can fit them in, or by participating in an interview or on a talk show. Also, there is always the possibility of a personal five-to-fifteen-minute program on a recurring basis, for example once a week or once a month.

Getting to know the staff at the local station or stations is a good public relations practice. Depending upon its size, most stations will have, at a minimum, a <u>station manager</u> who is responsible for the entire operation, a <u>program director</u> who is responsible for the programming and for regular and special broadcasts, and a <u>news director</u> who is in charge of news gathering and reporting. At smaller stations the manager may also be the program and news director.

Being Interviewed

An interview could come about in different ways. For example, the station might request an interview with you if you have information which they want to report. Or you might suggest to the news director that you be interviewed because you have news of local interest to their listeners. In either case, the interview might occur in the studio, or on location where the news is happening, or it might be a telephone interview wherein your comments on the phone are taped for later airing.

The interviewee's function in the interview is simply to provide the information you have in as clear and logical a way as possible. A trained radio voice is not necessary but speaking clearly and distinctly is necessary. A halting monotone or an obvious and irritating speech habit distracts the listener, who may miss the importance of the information being presented.

One word of caution. There is an old saying, "Before opening mouth put brain in gear." This is very good advice and you should always think before answering a question since an experienced interviewer can sometimes cause you to say something you did not want to say or should not say. One way to counteract this is to come to the interview with a list of prepared questions for the interviewer to use. He may not want to restrict the questions to the list but you will at least have established the general area in which you are willing to speak.

Your Own Program

When you are the host of a program, even if it is only five minutes long, listeners will be aware that you are not a professional broadcaster and will not expect perfection, but the program will be more enjoyable for everyone concerned if you speak as professionally as possible. Don't be afraid to be human though! There's no need for belabored apologies for mistakes made on the air.

In this type of situation, localize the program as much as possible for this is important in holding listeners. Personalize the information using names when appropriate and not making general references.

The ratio of available time to material is very important. It will be quite obvious to the listener if you attempt to fill some extra time by adlibbing. At the same time don't try to cram in too much. The best way to insure that your material is of the proper time length is to time it beforehand. Adding music at the beginning and end will set the tone and familiarize the listener with your program as they become accustomed to hearing it each time.

Writing For Radio

Writing for radio is a specialized kind of writing. Sentences must be short, easily read, and easily understood. To aid the announcer who is reading the copy over the air, hard-to-pronounce or often misunderstood words must be written phonetically or in some cases even spelled out for clarity. This applies also to symbols which are written out such as pounds, degrees, and percent, and to numerals and sums of money which are written out differently for easier reading. In addition, a news item submitted for broadcast over the radio is prepared in a specific format. The same applied to PSAs.

For these reasons it is suggested that you not spend time in attempting to prepare news or PSAs for a radio station as they would most likely be completely rewritten before use anyway. A news release that has been prepared for submission to newspapers may also be mailed to the radio stations. If the station considers it newsworthy enough for broadcast over the local news program, the newscaster will rewrite it in acceptable style for reading over the air or will call you for an interview.

PSA information should be prepared in as brief a form as possible, typed and submitted to the station. If the station decides to give it air time, it will be rewritten in an acceptable form for easier reading.

Of course, if you already have the knowledge and training to prepare a news story or PSA to be read over the radio, your chances for having it used are increased. Taking the information to the station and discussing it with the program director or news director is strongly recommended and will greatly increase the possibility of the material being broadcast.

Television

Television is the giant of communications tools available today. It reaches millions of people and has had more impact on social and economic patterns in our country and throughout the world than any other medium

The strength of television and its tremendous ability to communicate is based on its unique combination of sight, sound and motion. Since it appeals to both the sense of hearing and sight, the viewer is more apt to retain the message longer. Research into using television as a teaching tool has shown that students learn as readily by watching TV presentations as in listening to a teacher in person. Since viewing TV requires both sight and hearing the viewer is not apt to be engaged in anything other than viewing, except perhaps eating, so there is more of an opportunity to record a message on paper to be remembered later.

Despite its advantages, television also has many of the disadvantages of radio. It is a big business and must make money to continue operation and although committed to some public service time, that time is very limited. The message, although appealing to two senses, is still fleeting and must be seen and heard at the time it is aired. As with radio, any Public Service Announcement presented for possible use on television should be simple, short and to the point.

There is overwhelming evidence that television is effective. And it should certainly be considered in any type of information dissemination program. But in doing so, the limitations must also be taken into account and the message packaged accordingly.

Preparing a Public Service Announcement (PSA)

It may be that information concerning a community's artificial reef program will not lend itself to presentation as a Public Service Announcement (PSA) on television. But if a situation exists where this appears feasible you should plan your announcement to fit the intervals where the station interrupts its programming for commercial messages or to identify itself. PSAs may run as long as 60 seconds or as short as 10 seconds and are usually of two basic types--a videotape, or for the shorter announcement, for example 20 seconds, a single 35mm slide with a spoken message. Remember, your PSA must be broadcast quality. That means VHS or Beta tapes produced with home video cameras are not acceptable. As a result, you'll have to obtain services of video professionals.

However, since television stations vary widely in what their public service and program departments will accept in the way of PSAs, it is highly recommended that you first check with the station to determine what type of announcements are used, and where they are inserted in the program.

Moreover, preparation of a PSA either on videotape or for a slide spot requires a certain level of professional knowledge, skill and special equipment. You will most likely need to seek help on this. Station personnel may be able to direct you to someone who can assist.

The recommended course of action is to have your material in mind, whether it be for a videotape presentation, or for a slide spot, and then approach the public service department at the station for recommendations on how to proceed. For a videotape presentation, have in mind what is to be taped and a suggested script for the spoken part of the message. For the slide spot, have the slide or the idea of what the slide will be and a script of the spoken message which will accompany it.

Using Commercial Television Stations

Access to a local independent or network affiliated commercial television station or a Public Broadcasting System (PBS) station could be through appearance on a local news show or presentation of a 10, 20, or 30 second Public Service Announcement. Local news programs are the most likely outlet for information on the condition of certain reefs and the artificial reef program in the community. Some stations will also have other local programming such as interviews, or talk shows which conceivably could be devoted to the subject of artificial reefs. These shows are usually scheduled for early morning or other off-time viewing hours rather than for the prime evening viewing time when regular network shows are programmed.

The procedure recommended for bringing news to the attention of radio stations is suggested for the television stations as well. A prepared news release for the newspapers should also be sent to the television stations. Again, establishing a personal identity with the station manager and/or the news director is beneficial.

Interviews will most likely be in the studio or onsite. Portable television cameras now permit videotaping almost any place for instant use back in the studio. But remember that being on television is not the same as being on radio. You are being seen as well as heard. Concentrate on the person doing the interviewing--not on the camera or other distractions. Onsite there may be only two people involved in interviewing and filming the sequence--the person operating the camera and the person doing the interviewing. In the studio there will be more people--most likely a producer, a director, a floor manager and several cameramen depending upon the number of cameras being used.

Using the Local Cable TV Channel

The growth of cable TV in many communities, especially those away from larger urban areas, has opened up possibilities not available at commercial stations. Contracts governing cable TV companies operating in a community may specify that at least one or more cable channels must be available for local programming at certain times. This provides the opportunity for local programming and presentation of information of local interest such as conditions of locally established artificial reefs as determined by reef research divers, etc. It is also easier to get time on the cable channel than on the commercial television station. The disadvantage is that the audience reached will be smaller because programming on the local cable is often not regular programming so there may be no preprinted program.

Appearing on Television

It is important on television as on radio to speak as well as you can, and be natural. A good conversational voice is best. And remember that any unnecessary movements, gestures, facial expressions, etc. (although you think you are off camera) may be seen and may be a distracting influence during the interview. If you are seated in a rocking chair, for example, the temptation to rock may be overpowering but if you persist in rocking, it may become very disconcerting to the viewer. If you must point to some visual aid such as a map, for example, deliberately move slowly so the cameraman can follow you. Fast movements cannot easily be tracked.

Summing Up

Choices for dissemination of information exist, with potential audiences from 1 to a million. Although impersonal channels - newspaper, magazines, radio and television--have the potential of reaching far greater numbers, the fleeting radio or TV spot, or the newspaper item glanced at over a hurried cup of coffee, will not have the impact of personal contact, either one-on-one or in a group or contact through a direct mail newsletter. If your objective is to try to inform as large an audience as possible with no expected reaction from them other than that they are aware of your message than the mass media may be a good channel to use. If, on the other hand, you seek feedback or need assistance from certain specific interest groups, the personal channels are the ones which will work best.

Audiences to be reached and messages to be disseminated should determine the media channels chosen.

Suggested Reading

Communications Made Easy: A 4-H Guide to Presenting Information, 4-H Youth Programs, Cooperative Extension Service, Michigan State University.

Communications Handbook, 3rd Edition. 1976. American Association of Agricultural College Editors. The Interstate Printers and Publishers, Inc. Danville, Illinois.

Millward, Celia, 1983. Handbook for Writers, 2nd Edition. Holt, Rinehart and Winston. New York, New York. i-xii, 1-523p.

Chapter 10

Training Volunteer Divers to Research and Document Artificial Reefs For Their Community

by Joseph G. Halusky

Artificial reef construction in Florida is largely a result of volunteer efforts. Properly trained sport divers with training, can assist the reef builders by providing feedback information about the success or failure of their reefs so that the most effective reefs can be built for the least amount of effort and money. Volunteer divers can provide a valuable public service by establishing their own professionally supervised reef research, monitoring and documentation projects and storing this information in a publicly accessible reef data archives.

The basic philosophy and strategy for a training program is outlined so that volunteer sport divers can:

1) assist reef builders with site selection;
2) design and implement their own reef documentation and monitoring projects with advice from professional scientists and assist visiting scientists with reef research;
3) store reef information in a local public reef data archives and specimen reference collection;
4) communicate their observations to the reef builders, their community, appropriate agencies and the scientific community, in a credible manner.

Properly trained volunteer divers can provide the following services:

- SURVEY reef sites. They can gather information to document, evaluate and monitor man-made reefs BEFORE and AFTER reef placement.

- FIND & VERIFY the existence of old and alleged artificial reef sites and live bottoms. Many sites that were built prior to the use of the LORAN C radio navigation system were frequently "lost". The rediscovery and verification of these old reefs would provide a significant contribution to the knowledge about long term physical changes and biological succession, since so many of these reefs have been down for well over 25 years.

- MONITOR existing reefs by coordinated teams of trained divers, to regularly document physical and biological changes over long periods of time.

- CREATING PUBLIC AWARENESS about their FINDINGS (ie. Documented Observations) about the reefs. This is accomplished through presentations to civic organizations, legislative delegations, fishery managers and sport fishermen with talks illustrated by underwater photographs, videos and maps. Such local feedback is essential for gaining the taxpayers' support to encourage local and state government involvement in artificial reef projects.

-ESTABLISH an ARCHIVES and REFERENCE COLLECTION to deposit reef data, photos and videos, physical and biological samples which could be used by scientists, educators, citizens, agencies and reef builders. Since properly built reefs may last for hundreds, perhaps thousands of years, this information would be most valuable for future professional reef researchers who are financially unable to conduct such long-term projects or accurately reconstruct the reef building history.

Role Of The Sea Grant Extension Program

In Florida, some limited research in artificial reef technology has been transferred to many reef builders through local Extension Agents of the Florida Sea Grant Extension Program (SGEP) and from a Sea Grant supported, Artificial Reef Resource Team. Florida SGEP agents have worked with reef builders, sportfishing clubs, county and state government agencies and diving groups since the mid 1970's. They have organized artificial reef conferences, local workshops, and presented a variety of talks to assist with the transfer of reef technology from the scientific community. The SGEP has published reef conference proceedings, a comprehensive bibliography on reef research work and fact sheets on site and materials selection, buoy construction and permit application procedures (See references for a listing of Florida Sea Grant Reef Publications). The Sea Grant Reef Resource Team, has assisted the SGEP by consulting with various reef building groups, performing preliminary site surveys for new reef permit applications and assisting with reef research diver training.

The original Florida Artificial Reef Research Diver Training Program (ARRDTP) was initiated by the in N.E. Florida Sea Grant Extension Agent at Daytona Beach in 1980. The resulting series of seven workshops, spread over a seven month period led to the model agenda that follows.

The SGEP Marine Agent plays a central, coordinating role in organizing the training agenda. While the marine agent may not necessarily dive himself, he functions to find and schedule the proper teaching staff in the variety of subjects covered. As a member of the Sea Grant Network, he or she has access to many professional researchers, many having underwater research experience, who can provide the theoretical background necessary to teach the program. Consequently, an essential first step for organizing an ARRDTP begins with identifying a marine agent who can help to organize the a special ARRDTP planning committee.

Planning Committee

When the community determines it needs an Artificial Reef Research Diver Training Program it should communicate with a Sea Grant Marine Extension Agent to create a special ARRDTP Planning Committee. The committee functions to identify and link up all local program supporters as well as nearby academic resources. A program of this nature requires many resources as boat transportation, classroom and limited laboratory space, special data gathering equipment (which may need to be purchased or fabricated) and a professional certified diving instructor to serve as the course divemaster. Where possible, these items or services should be contributed, to keep costs down, and facilitate involvement and cooperation between various community groups. If possible, the committee should have representatives from local dive and fishing clubs, dive shops, local government agency involved with reef building, professional academic researcher(s) and commercial fishing industry. This assures community involvement and support for the project from the beginning.

Once the ARRDTP Planning Committee has identified all the needed resources, received commitments from various supporters of the program, the selection of trainees and teachers arranged, the final agenda can be established. (Trainee selection criteria will be discussed below).

Normally a registration fee is charged to help defray expenses of guest speakers, purchase equipment and supplies, and cover boat transportation costs. Since many reef research jobs may not involve actual diving, non-diving "auditors" may also participate for a lesser fee. An important consideration for a fee rate is that it is a measure of the degree of commitment by the trainee for the program. A higher fee usually results in less absenteeism.

Student Selection

Selection and acceptance of participants in the ARRDTP requires the organization of a small screening committee, made up of those who are developing and coordinating the agenda. It should have representatives from the reef building group, as well as leaders in the diving community, such as dive club officials, dive shop owners or key instructors. The Sea Grant Extension Agent, who may serve as the overall course director, should insure that at least one representative of the scientific community is involved in the selection process.

Selection of fully enrolled students (those that actually dive during the training) should be limited to between 12 and 24, depending on the availability of qualified divemasters, instructors, and boat support. Normally, most dive instructors are limited by their liability insurance coverage to having no more than eight to ten students in the water at any one time, unless they have qualified assistant instructors to help. The number of Auditors, who do not dive, may be limited only by the size and availability of adequate meeting facilities.

Qualifications of the fully enrolled student, should be based on: their diver certification (at least advanced open water); physical condition (in compliance with minimum AAUS standards--see Appendix A); experience in the local reef environment; maturity; interest in the subject and WILLINGNESS TO CONTINUED INVOLVEMENT IN REEF RESEARCH after the training is over. Of prime consideration are additional skills the diver may have, that would make him an asset to the reef research effort. These include such things as underwater photography and video, computer experience, mapping and drafting, public relations, specialized hobbies, etc. Since one premise of the training is that the graduates will train others, then evidence of teaching ability and leadership skills should also be considered.

Obviously, great care should be given during the selection process, if a reef research program is to continue after the training is over. Immature, macho-types should be avoided. Emphasis should be placed on solid, grass roots individuals, who have a sincere interest in supporting their communities' reef building interests as a PUBLIC SERVICE.

The Artificial Reef Research Diver Training Program Model Description

The Florida Sea Grant Artificial Reef Research Diver Training Program (ARRDTP) primarily is a practical, hands on course in underwater data collection and storage methods for the non-scientist, trained experienced sport SCUBA diver. Secondarily, it provides limited training for non-divers in data handling, storage and retrieval methods and public relations.

- It is a course in UNDERWATER DATA COLLECTION METHODS.
- It is NOT a diver training course.

The AIM of the ARRDTP

- To train volunteer, non-scientist, SCUBA divers and non-divers, how to OBSERVE, GATHER, DOCUMENT and STORE physical and biological information and specimens from their community's artificial reefs.
- To gather and store artificial reef information in such a way that it is acceptable, retrievable and useful to the reef builders and the scientific community through the establishment of a public reef data ARCHIVES and specimen REFERENCE COLLECTION.
- To communicate and exchange artificial reef information with reef builders, other reef research groups, the scientific community, government agencies and the public. NOTE: Particular attention is given towards cautioning ARRDTP students to NOT interpret their observations or draw conclusions from them, but merely report what they observe thorough maps, photography or quantified data summaries only. Data interpretation falls within the realm of the professional scientist(s) who advise the reef research divers.
- To encourage volunteer divers to take leadership in designing their own reef data gathering projects in consultation with a professional underwater researcher.
- To involve and train others to observe and gather needed artificial reef information. This includes developing some form of organizational structure that would insure consistency and longevity in reef monitoring projects and the archives.

The ARRDTP is merely a simplified course that teaches the first step in the scientific method - that is - MAKE AN OBSERVATION and DOCUMENT IT! It is specific in that it focuses on underwater data collection methods within the limits of sport SCUBA equipment and standard practices. It is unique in that it concentrates on teaching volunteers how to design data collection under scientific supervision, and lead and store information from their own artificial reef documentation projects. On completion of the training, the students are NOT certified, for this is not a diver certification program. Instead they receive acknowledgement that they have received training in collecting data in underwater environments, expedition leadership and public relations.

ARRDTP Course Outline & Topics

The ARRDTP course series of two to three day workshops over a seven-month period is preferred since there are a large number of guest lecturers from a variety of academic and government institutions, who are sometimes drawn from great distances. Part of the intent of the program is to give the participants enough time with each speaker so that they get to know them on an informal basis to building working relationships for future projects. This would not happen if many guest speakers were limited to a tight and busy agenda. The opportunity for developing an evolving leadership is another effect of the program lasting over several months.

Each workshop is usually made up of a one day lecture, discussion or lab exercise followed by a one day underwater field experience. The underwater experience coincides with the lecture material presented with the guest lecturer serving as the "chief scientist" for the field exercise. Where possible, field exercises are held under conditions typical for the region where the students will be working after the training. Near the end of the workshop series, an intense, three-day leadership training expedition is held, usually at some remote marine lab. This gives the students an opportunity to experience planning, organizing and leading the documentation of a real reef site. The students actually plan and lead the exercise under limited supervision from the staff. The last workshop is focused on local project design, with the assistance of a local professional scientist.

Model Arrdtp Agenda

WORKSHOP I--Orientation to Scientific Diving & Diving Skills Review

Lecture Session - This session introduces the student to the basic concepts of artificial reef technology and strategies for gathering and storing data from an underwater environment. (Chapters 1

& 2). It makes a clear distinction between Scientific Diving (Diving for Science) and Diving Technology (Science of Diving) to insure the student understands that the workshops focus is on the former, that is, learning how to gather information underwater. Discussions center around defining what data and documentation is, specimens and labeling, and the function of a reef archives and reference collection. Some time is spent reviewing safe dive procedures to be used in the course. A standardized logbook and dive log procedure is outlined and used to review repetitive dive procedures. (See Appendix B for example log sheets).

Water Session - Usually in a well controlled, open water setting, where basic dive skills are reviewed and final screening of fully enrolled students is accomplished by the course divemaster and course director. They may at this time screen out any student who cannot demonstrate an adequate and safe level of performance. A human performance (compass accuracy) exercise is run to familiarize students with scientific diving organizational procedures, the concept of task loading and logbook and data storage methods. See Appendix B for underwater compass skills training.

WORKSHOP II--Underwater Science Photography and Public Relations.

Lecture Session - Describes how still, movie and video photography is used as a data gathering tool to document artificial reefs and associated marine life (See Chapter 3). The public relations training is focused on how non-scientist volunteers can present their reef data to the community without discrediting themselves or their work (See Chapter 9). Practical exercises on radio and TV interviewing are given in which students' interviews are recorded and critiqued.

Water Session - Underwater still- and video-photography data-gathering methods are practiced. These exercises focus on using the camera to systematically sample some physical or biological phenomena such as distribution of reef materials along a transect, or the amount of substrate covered by encrusting organisms.

WORKSHOP III--Artificial Reef Site Selection, Documentation, Mapping, Engineering, Construction and Collecting Physical Data.

Lecture Session - These presentations describe how to evaluate a reef site for its suitability for supporting reef materials on the bottom including how to create a deployment map of reef materials and how to standardize and document physical data from a reef site. Topics include such things as; measuring visibility, currents, water temperature, salinity, sediment characterization and sampling depth, reef profile and configuration. (Chapter 4).

Artificial reef construction practices are also described. This includes materials selection, handling, how to configure materials on the bottom and what features are most desirable in the reef structure based on the best research available (Chapter 5).

Water Session - This is a practical exercise designed to actually document bottom conditions on a potential reef site and develop a written report about it. Also, an underwater mapping exercise of an existing reef site provides the students with at least a beginning experience for learning how to produce greatly simplified maps of reef materials.

WORKSHOP IV--Artificial Reef Biological Sampling and Building a Reference Collection - Emphasis on Invertebrates.

Water Session - This workshop, unlike the others, begins with a water session. After a short discussion on how to observe and collect biological samples of encrusting invertebrates from a reef structure, a collecting dive is held. Specimens gathered are stored and used in the lecture/lab session on the following day. A systematic photo survey method is also used to document the amount and distribution of invertebrates on the reef.

Lecture/lab Session - Students learn, in a lab setting, how to properly preserve, quantify and identify the encrusting invertebrates and plants gathered from the reef on the previous day. They learn how to catalog their specimens and develop their own reference collection. Discussions center on marine ecology, the succession of encrusting organisms and their relation to fishes on the reef (Chapter 6).

WORKSHOP V--Sampling and Documenting Artificial Reef Fish Populations.

Lecture Session - Students learn how to identify reef fish, and learn of their limitations for accurately counting and identifying fish in their natural setting. Descriptions of various fish counting methods are given, with comment about their limitations and accuracy. The volunteers are also encouraged to survey reef fish populations, by using still photography and video methods (Chapter 7).

Water Session - Various methods (including photo survey) for counting fish on an artificial reef site are practiced. Some sampling of fish for addition to the reference collection is employed in this exercise.

WORKSHOP VI--Artificial Reef Research Expedition Leadership Training.

A three day practical field exercise. This exercise should be held at a remote marine research lab where students have access to wet labs, shoreside facilities, a research vessel and dive locker facilities to refill air cylinders and store equipment. The exercise lasts a full 24 hours/day for three days. Its purpose is to train students how to plan, organize and lead their own artificial reef documentation expedition while under limited time pressure (Chapter 11).

Workshop begins with a briefing. The staff appoints one student as "chief scientist" and another as "divemaster". They are assigned to document a known reef site which is selected by the staff. From that moment on, the appointed students actually lead the research expedition. The course staff serve as consultants to the expedition. The staff does not make decisions or otherwise interfere with the expedition unless an unsafe decision is made by the students. An in-depth debriefing is held at the end of the exercise.

This workshop is also used to encourage leadership development within the group that will carry on well after the training is over.

WORKSHOP VII--Planning an Artificial Reef Documentation Program for the Community.

Lecture Session - This is the first planning session for designing an artificial reef research program for the volunteer divers. Workshop staff consisting of the course director and a professional scientist(s) first discusses various brainstorming and prioritizing techniques then serves as discussion facilitators and consultants to the dive group. Then a brainstorming session is lead to develop a list of potential projects for the group. Leaders from the reef construction effort, local authorities, academic representatives and volunteer divers participate in the discussions to prioritize reef program information needs and design a strategy to meet them. Individual projects are selected, with project leaders appointed.

Notes

Hopefully, by this time, an organizational structure has emerged from within the group that will keep the volunteer group together well after the end of the training. Leadership should be officially turned over to the one of the students as the Reef Research Team Coordinator. (See Chapter 13 and Appendix Q for an example organizational structure and job descriptions).

Water Session - This is the first working dive for the volunteer divers that begins their effort to document their reef sites. It is based on the previous day's discussions and communication with the reef builders.

On completion of the training, the participants in the ARRDTP are encouraged to design and lead their own reef research projects, with the assistance of some academic researcher. The professional researchers oversee their projects to insure that the data remains acceptable to the scientific community, and that their project design remains sound. The researcher benefits by having access to new data that he would otherwise never receive. The Sea Grant Extension Agent continues to serve the volunteer group as their advisor and contact with the research community.

Discussion

No additional diving skills beyond those required in a good advanced open water SCUBA course are needed for this type of activity. However, if local reef conditions warrant that additional training is needed to safely conduct underwater research, additional training should be required. For example, deep diving methods or diving in overhead environments, as may be found in shipwreck penetration, may be essential. Accuracy in compass work and good dive logging procedures are essential. A basic premise is that:

"Good data comes from a comfortable Diver And Good Leadership and

"Never should safety be sacrificed for data"

All Dive Planning and sampling procedures should aim towards this end. This requires a project leader to use sound, mature judgement to avoid unnecessary stress and physically exhaustive data gathering procedures. Unnecessary time pressure and task loading should be avoided. If it is not, the additional stress on the diver will render the data suspect, and it may need to be discarded.

Summary

Volunteers with proper training, can play a vital role in the development of artificial reef technology. They can be the eyes and ears for the scientific community on the leading edge of this new form of aquaculture. As coastal fisheries habitats become increasingly stressed by human development, volunteer reef research divers will be needed to provide the long term information and sometimes unique insights necessary for the proper assessment of artificial reefs as a fishery management tool.

References & Suggested Reading

FriedmAnn, Peggy. 1982. Divers Monitor Our Artificial Reefs, Jacksonville Magazine, Vol 19, No. 4, pgs. 22-26, 93.

Friedmann, Peggy, 1985. Researching the Reefs, Florida Sportsman, January Issue, Vol. 16, No. 1, pgs. 12-15.

Leahy, Thomas M., 1983. Sport Divers Monitor Artificial Reefs, Sea Grant Today, Vol., 13, No. 1, pgs. 6-7.

Miller, James W. 1979. NOAA Diving Manual: Diving for Science and Technology, 2nd Edition, U.S. Government Printing Office, Washington DC 20402. Stock No. 003-017-00468-6.

Parker, Jr., R. O., R.B. Stone, C.C. Buchanan & F.W. Steimle, Jr., 1974. How to Build Marine Artificial Reefs, Fishery Facts 10, Stock No. 0320-00091, Supt. of Documents, U.S. Government Printing Office, Washington D.C. 204302, I-IV, pgs. 1-47.

Rioux, Margaret A. 1987. Bibliography on Diving and Diving Safety for a Scientific Diving Program. Woods Hole Oceanographic Institution Technical Report WHOI-87-29.

Seaman, Jr., William & D. Aska, 1985. The Florida Reef Network: Strategies to Enhance User Benefits. In Artificial Reefs Marine and Freshwater Applications Ed. by Frank M. D'Itri, Lewis Publishers, Inc. 121 S. Main St., Chelsea, MI 48118, pgs. 545-560.

Florida Sea Grant Artificial Reef Publications

There is a minimum fee for some publications. Contact the Florida Sea Grant College program to order publications. Write to:

Florida Sea Grant Extension Program
Building 803
University of FLorida
Gainesville, FL 32611.

- **MAFS-9** Constructing an Artificial Reef Buoy.
- **MAFS-20** Artificial Reef Site Selection and Evaluation.
- **MAP-29** Artificial Fishing Reefs Materials and Construction.
- **MAP-30** Atlas of Artificial Reefs in Florida by Don Y. Aska & Don W. Pybas.
- **SGEB-2** Directory of Organizations and Persons Involved with Artificial Reefs in Florida October 1987.
- **SGEB-4** Artificial Reefs: Permit Application Guidelines.
- **SGR-7** Annotated Bibliography of Artificial Reef Research and Management.
- **SGR-41** Artificial Reefs: Conference Proceedings.

Chapter 11

Underwater Research Project Management

By Gregg Stanton

Successfully gathering data underwater involves the coordination of several complementary components. They are:

1) Clearly defined realistic objectives;
2) Adequate support (academic, funding, and man power) of those objectives;
3) A logistical plan to achieve those objectives;
4) A measure of good fortune, and perseverance.

This chapter will focus on logistical planning and will assume that clearly defined objectives, adequate support, and a measure of good fortune have been provided. Also assumed is the diving competency of the audience, whether academic or amateur, for the ocean treats us all alike when we are within its grasp.

Research project managers are really risk managers and may draw from the vast wealth of this industries' models to better focus our attention. Kenneth MacCrimmon and Donald Wehrung, in their book titled **"Taking Risks"**, defined risk as "the exposure to a chance of a loss" which must be balanced against the chance of a gain. They report that successful projects proceed through a series of easily defined self regulating steps to minimize loss and maximize gain. The remainder of their book is devoted to explaining this model (**See Figure 11-1**). This model will serve as a guide for underwater research projects.

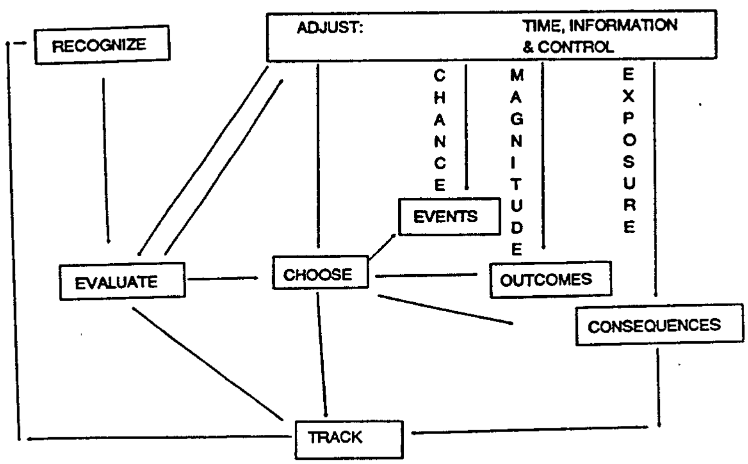
Perception of a Problem

Diving in support of research underwater is troubled by perceptual distortions which not only compromise the quality of the data collected, but can significantly endanger the data collector. These distortions may be brought about by factors within the underwater environment or by complications of the research design. Both are complicated by stress. These problems may cause the observer to record information which may not represent the reality to be documented. Environmental distortions are physical phenomenon, such as reduced visibility (turbidity) or light (as in a night dive),visual enlargement due to the refractive index of light across an air/water or salt/fresh water interface, and the relative natureof temperature upon our body's perceptual mechanism to name afew. Poorly defined or documented research designs often createconfusion and inefficiency resulting in less than acceptable data.

Stress is a common occurrence on a research project especially one conducted underwater. It may come from predetermined phobias, sea sickness, real or imagined lack of training, unforeseen problems, time and support deficiencies just to name a few. Excessive stress is not uncommon in underwater research and is considered an underlying cause for most accidents. Stress can distort what the physical senses detect with a number of inappropriate responses. These include perceptual narrowing, (a concentration on details of the immediate topic at the exclusion of a more endangering greater topic), and task loading (greater expectations than are humanly possible under the circum-

Figure 11.1

RISK MANAGEMENT (REACT) MODEL



stances). Both conditions compromise the quality of the data and the safety of the data collector, for in both cases, vital information is ignored (See figure 11.1).

Perception of a problem is the key to effective risk management of diving to support underwater research. If an individual is incapable of detecting problems, risk management is impossible. The challenge is to find a way that in this high-stress environment, the risk managers can be unencumbered by stressors that may adversely affect his judgement.

The most popular method to isolate the stress from the manager is to separate the dive management (dive master) from the science management (chief scientist). While both individuals in this model should be risk managers (in their own distinct areas), each now has more manageable tasks, and when in equal authority on a project, complement each other. Often, when excessive stress compromises either science or safety, there is a less-stressed manager available to respond and correct the situation. This may be in the form of simplifying the tasks, aborting the dives or restructuring the project through an evaluation of the perceived problem.

Identify a Problem

Now we have a person who is responsible for the diving safety and a different person responsible for the collection of data on every dive project, and at every dive site. When a problem is perceived, the **REACT** model requires that it be evaluated, modified and put into perspective. Once perceived as such, problems are quickly set into two categories: those that have been reviewed before and have policy guidance; and those that do not. This risk management model has an adjustment section that is important to understand. Follow the arrows up to the right from the **Evaluate** box and you will reach the **Adjust** box. Only with adjustments can the perceived problem be changed.

Good risk management seeks adjustments by acquiring greater **Time, Information** and **Control** over an event that was previouslyidentified as a problem. This adjustment period (in the interest of safety) must be balanced against the loss or gain of opportunity which may result from the inevitable delays or additional constraints.

Time often cures many problems on a project. A good rest from an arduous project may resolve the excessive stress that brought on the problem in the first place. Personal or personnel problems are often reduced given the time and room to be worked out. Time may bring better weather or site conditions.

Information regarding a problem is often elusive, shrouded in personal interpretations and motives. Yet, as data collectors, we are masters of the art of information retrieval. Open discussion regarding a problem often brings out further information that easily solves a problem before it becomes a major stumbling block. Information is not without cost however, in that what effort is spent collecting it to resolve problems is detracted from perhaps more productive data collections. The search for information should therefore be focused toward a specific objective to be effective.

Control of the project is a relative issue as we have so many who influence our activities. Control over the quality of research is rightly protected by the chief scientist as is control over the safety of the diving personnel by the dive master. Each seeks to control significant aspects of the research effort. The better these two individuals understand and appreciate their responsibility (and control), the less time it will take to dispatch problems.

Following the **React** model, the next stage is choosing an action. Additional time, information and control over the problem, have been balanced against the risk of loss. Decisions now will increase or decrease the chance of a loss regarding the actual **Event**, increase or decrease the magnitude of the loss regarding the **General Outcomes** and increase or decrease the exposure to loss regarding the **Consequences**.

Effective risk managers strive to minimize the chance of a loss, if there is to be a loss, minimize the magnitude of the loss, and if at all possible minimize the exposure (or possibility) of a loss while maximizing opportunity. This is entirely relative to the amount of risk an individual is willing to take. Because people vary greatly as risk takers, agencies which are responsible for underwater research have often established risk policy in terms of acceptable and unacceptable loss. One agency may accept a 5% incidence of decompression sickness as tolerable because they nearly always have a recompression chamber at the site and use only young healthy men. Another agency may accept a 0 percent incidence for the same malady because they seldom have a chamber within 2 hours of the site and use a wide variety of people who are often out of physical shape. The dive profiles of each of these agencies at the same site conducting the same task will vary greatly due to individual agency risk policies.

Success is seldom measured by the absence of loss, but rather by the realization of opportunity. As underwater data collectors we take risks, calculated risks which are within the agency's policy on risk, in our quest to collect the data. Regardless of the outcome of choice of action in the **REACT** model, the results of the action must be tracked. Only through such a continuous debriefing can researchers learn from mistakes, find solutions and improve chance of success while reducing the risk of loss. Additional tasks to be addressed during an underwater research project may be divided into two separate yet overlapping areas of support: logistical support and dive stations. Dive stations are tasks that are undertaken during dives while logistical support refers to non diving tasks performed apart from the dives.

Logistical Areas Described in Detail

The logistical support described below may be combined and covered by a single individual for small projects or expanded as the complexity of the project expands. Due to economic and space restrictions on underwater research projects, the diving staff often doubles up on the logistical support when not diving. Thus the person responsible for food may also have been diving for data on the previous shift. A project management form (found in APPENDIX R) has been created to assist in the coordination of logistical tasks and dives on an underwater research project.

Food

This individual is responsible for planning the menu, cooking facilities and utensils and securing a budget. Underwater research projects often succeed or fail based upon the abundance and quality of the food. Diving requires a high caloric intake and plenty of on-site nondiuretic fluids. If the data collectors are poorly fed, the quality of the data suffers. Again, the complexity of the project dictates the complexity of the food task. For a single day outing, a "bring your own lunch" policy may suffice. A week long cruise on the state run research vessel may provide a part-time cook. A month at the Dry Tortugas may require a nondiving full time cook. Regardless of the task, the rest of the diving staff will be expected to pitch in with the dishes or even cook on occasion.

Lodging

A place to sleep, may be as critical as the food. Projects which are on the road moving from site to site will need a person who is responsible for securing advanced lodging and other related support. This task can be as easy as finding tents and camp sites near the research area, to coordinating complementary accommodations at government facilities or on board boats. Once the lodging is secured, this individual usually is responsible for securing payment for the services consistent with their agency or project policy.

Transportation

This task is often combined with lodging or boats (especially small boats) in that moving people about may share common problems with their lodging arrangements. Agencies (or even small groups) often require lengthy forms authorizing travel, insurance, and fuel reimbursements. Equipment requirements such as compressors, tanks, boats and specialty research equipment will need to be moved and stored during a project. This individual may have tasks as simple as sizing the trailer hitch to the boat trailer for a trip down to a local launch, to master-minding the transport of 10 tons of supplies out to Palau, Micronisia. His task is critical to the success of the project as lost or late equipment often delays critical research.

Boats

Be it a small runabout on a trip down river or a research vessel cruise to the Tortugas Islands, a boat is one of the basic life support facilities of the diving scientist. While the individual responsible for making boat arrangements does not need to be a licensed captain, it should be someone with knowledge and skills in boating. The responsibilities that come with this category include: selection of boats for the research; checking out the condition and auxiliary support of each boat; arranging for fuel, maintenance needs and other supplies; training personnel in boat handling for conditions you expect to be working in and many other unanticipated considerations. Even if you are working with a state research vessel, there are tasks that must be performed which are best left to someone not otherwise over committed, such as inspection of the facilities to be assured of its appropriate cargo area and capacity, function of the support equipment (compressor, a chase boat etc.) and special rules that personnel should be aware of PRIOR to arrival.

Equipment & Air

Apart from the Chief Scientist and the Dive Master, this individual has the greatest chance of task loading. All of the support equipment not directly related to specialized data collection, boating, cooking or transportation must be assembled and tested prior to departure and managed throughout the project by this person. This includes all the life support gear (tanks, regulators, BC, etc.), compressors, scooters, cameras, first aid supplies, just to name a few. Small projects may rely upon the individuals of a project to see to their own equipment, but the loss or failure of one regulator may reduce the efficiency of the entire group. More complex projects will need to subdivide this responsibility between more people.

Safety Officer

A task that usually is covered by the Dive Master except on very large projects. The person responsible for safety works closely with the entire staff. This person will set up the emergency communication and evacuation procedures, secure and manage the first aid kits, and be on a constant lookout for safety problems which need to be resolved.

Principal Investigator

This individual usually is the instigator of the research, (although that is not required) and carries the burden of supervising the quality of the data collected and providing for its security. Often, this person is the central figure of the project. The Principal Investigator acts as a coordinator for all of the other tasks, but seldom deviating from his focus on the research. He or she is responsible for developing a clearly documented research design and related training for all to understand. This person usually controls the budget, writes the proposals, and is responsible for publishing the projects findings.

Dive Supervisor

Equal in responsibility to the Principal Investigator, the Dive Supervisor works closely with project managers to insure that the highest possible personal safety of the research team is assured. This individual often performs his duties as an extension of the sponsoring agency's office of Environmental Health and Safety or Diving Program. He or she must be very competent in life support and compressed gas technology, and underwater project risk management. As with all the other tasks listed above, this one will grow in complexity dependent upon the level of diver life support technology required (SCUBA vs. mix-gas vs surface supply, etc.), and the number of participants, location of the project and nature of the research objectives. The Dive Supervisor may either make personnel assignments for the dive teams based upon the objectives presented by the Principal Investigator or simply approve those choices made by the Principal Investigator.

At no time may the dive supervisor assume the responsibility of the principal investigator or the principal investigator assume the responsibility of the dive supervisor.

Dive Stations Described

Once the dive flag has been hoisted, project participants change over from their logistical support tasks and into their dive stations. These roles may be consolidated into a few individuals depending upon the site, size and complexity of the project. Agency safety policies usually dictate the minimal crew size which may vary between two and three. Be aware that if you do not adjust to the complexity of your project by increasing the staff size or reducing the research objectives, increased stress will reduce the quality and quantity of the data.

Captain

By US Coast Guard rules, the Captain of a boat is responsible for the safety of his ship and all aboard. He or she should always be consulted prior to the cruise for site selection and proposed diving or other use of the facility. The Captain should work closely with the Chief Scientist and the Dive Master during a dive to insure that the data is collected safely and in a reliable way. The Captain may abort a dive, a station or a cruise if he feels that the safety of those on board is in jeopardy.

Chief Scientist

This individual is responsible for managing the collection of data in support of the research design as established by the Principal Investigator (which could be one and the same person). Pre-dive planning and post-dive debriefings with the Captain and the Dive Master and the diving staff will promote efficient data collections. The Chief Scientist may select team members, specific collecting schedules, techniques and technology which must be approved by the Dive Master. If the quality of the data is not acceptable, the Chief Scientist may abort a dive, station or cruise independent of the level of the safety. The Chief Scientist may not assume the responsibilities of the Dive Master or Dive Supervisor.

Dive Master

This person performs his duties as an extension of the Diving Supervisor (and may be one and the same individual). The Dive Master works closely with the Chief Scientist with considerable pre and post-dive planning and supervision with the diving staff. Typically the Dive Master will set up the dive station, inspect all the life support equipment prior to deployment, discuss specific tasks with team members, supervises the divers, their logs and dive schedules while in and out of the water, coordinate with the Captain to commence and terminate a dive, and supervise the chase boat and compressor operations, just to name a few. Divers who have problems must feel free to discuss them with the Dive Master. This person forms a team with the Chief Scientist. The Divemaster may never assume the responsibilities or role of the Chief Scientist or Principal Investigator.

Time Keeper

This is an optional task which becomes very valuable as projects become complex. The Dive Master quickly becomes task loaded when more than six people are diving on a continuous schedule. The Time Keeper maintains the diver logs and schedules such that every person on the project has an ongoing dive profile which is constantly monitored. Prior to the dive the Time Keeper will work with the diving staff to fill out forms and log the status of the life support equipment. During the dive he or she will maintain stop watches and help with the tracking of divers in the water. After the dive this individual will work again with the staff to properly record data and dive profiles.

Standby Diver

A safety system of Standby Divers is often advisable, where an individual or two, (depending upon the complexity of the research and hazards of the site situation) is/are maintained at the surface in a ready state should problems arise that require their assistance. They may only enter the water at the direction of the Dive Master. No divers may enter the water until the Standby Diver(s) is (are) ready.

Boat Operator

A second safety is the chase boat, which is often tethered behind the stern of a larger vessel. Should divers develop problems away from the mother ship the chase boat is deployed to assist in an emergency rather than wait until the remainder of the diving staff can be recalled, and the anchor pulled on the mother ship. The boat operator is responsible to check over the engine and boat, be familiar with its operation and be ready to deploy immediately at the request of the Dive Master. During night dives, an underwater lamp will be located in the chase boat. Under arduous conditions, a second Standby Diver may be assigned to the chase boat.

Team Leader

In any dive team, one member should be designated as the Team Leader, and be responsible for the safety and efficient data collection during the dive. This individual should be careful to understand every aspect of the research objective and prevailingenvironmental conditions.

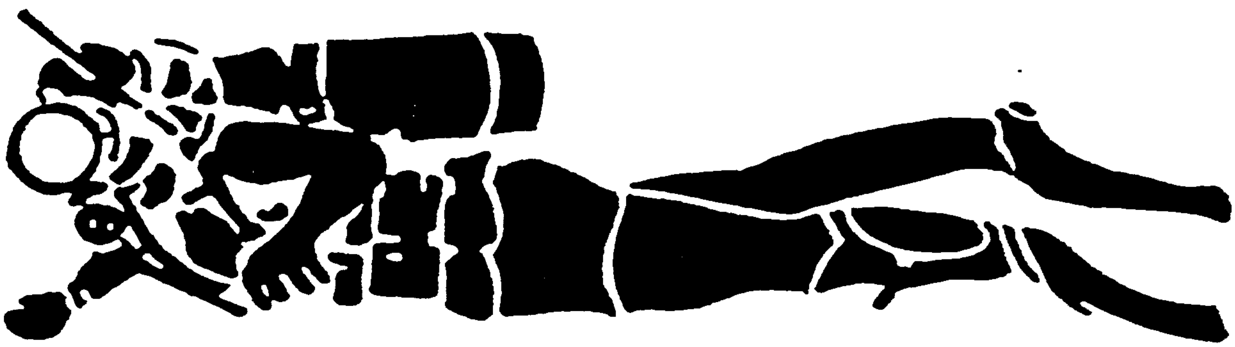
Divers

Individual members of the diving staff are responsible to conduct safe diving procedures at all times. The Diver must maintain "Emotional, Intellectual, and Physical fitness". Should any problems develop which would reduce the level of fitness below acceptable limits, the Diver is required to notify the DiveMaster immediately. If the condition is severe enough, the Dive Master and/or Diver should elect to abort their dive.

Successful data collection underwater is the product of hard and well thought out work, much facilitated by good project and risk management and a measure of good luck.

References

Kenneth R. MacCrimmon and Donald A. Wehrung. 1986. Taking Risks, The Management of Uncertainty. The Free Press - Collier Macmillan Publishers, London. 380 pages.



Chapter 12

Establishing An Artificial Reef Data Archives

by Joe Halusky and Shawn Brayton

The principal role played by volunteer reef research divers is to collect and record information about artificial reefs in their community. Their efforts would be futile, if the information were to become lost, destroyed, scattered or preserved in a fashion that only a few individuals understood or had access to. It is surprising, how much valuable reef data has already been lost, simply because the "Reef Scrapbook" that ole Fred kept, was lost in a fire, or ole Fred moved or died and his widow tossed it out with all the other junk he kept. The primary purpose for establishing a Reef Data Archives is to insure that this will never happen. Establishing an Archives and speciment reference collection should be the focal point for any volunteer reef diver organization.

The objective evaluation and monitoring of a reef site demands that complete and accurate documentation of the reefs history and subsequent changes exist. Minimally, this initial documentation should include:

- preliminary reports, bottom surveys and biological observations of the site before placement;
- news clippings about the reef's construction;
- the precise reef placement location;
- lists of persons who actually observed the placement;
- the exact date and time of the placement;
- a description (with photos) of the amount and types of materials used;
- if possible, an accurate scatter map of the reef;
- follow up documents, maps, reports and photographs from those who actually observed the reef placement should also be gathered and included in the reef's initial documentation. Frequently, magazine articles and feature news stories about a reef placement may be delayed by many weeks or even months. These too, need to find their way back into the reef's initial documentation file.

A vast amount of information is generated by a single reef placement. Obtaining complete information becomes a formidable task. This is further complicated by the fact that many individuals from different agencies or associations are involved in such projects, each requiring or generating its own format for the information. Regulatory agencies requiring permits, the press wanting a story, a research scientist wanting specific types of data or the fishing club members wanting "just the numbers" are only a few examples of the many demands which are likely to be made from the reef's documentation.

Obviously, reef building activity does not stop after the last material disappears below the water's surface. The builders incur an obligation to record their historic event for the community, future reef builders and even academic marine researchers. They may even need documentation to resolve a future liability concern. A well maintained Reef Data Archives and Specimen Reference Collection should help meet this obligation.

The establishment of the Archives and Collection is the most important activity of any reef research effort! Without it, all research diving is simply a waste of time! Consequently, the first and key issue to be resolved by any group wishing to begin a reef monitoring activity, is to determine how and where an ARCHIVES is going to be established and who will maintain it. Any reef data handling procedures already used by those building reefs should also be determined and included in the plans for the reef archives. Once a commitment by the group is made and the necessary communication with reef builders has been established, then procedures for setting up the archives should begin.

Artificial Reef Data Archives

Archives is defined as a place where public records and historical documents are kept. An artificial reef research archives, kept by a volunteer organization for their communities' reef placement program is specific and limited to that need. The archives is a depository of artificial reef data and historical information which is gathered in one organized storage facility and maintained solely by the appointed archivist or assistant. It should be set up in a public facility such as a local library, county administrators office, nearby college or university, extension office or even a willing public school. A less desirable, but acceptable location would be with the organization who is responsible for maintaining the artificial reef permits. The only difficulty with this is that access to files in this situation is often restricted and their security may depend on the fate of the organization. Organizations having a long stable history and strong leadership are more likely to continue, thus making them suitable hosts for an archives.

The Archivist

The reef research diver organization or reef builders should appoint a competent individual as an archivist. This person becomes central to the organization and to all reef research projects of the group. This means he or she must be a good communicator as well as a good organizer who can take the time to establish the archives and keep it up to date.

The archivist should not be confused with the groups historian and should not be the same person. The historians duties are limited to keeping a record of the groups activities or perhaps historical research about the reefs. The archivist, however, stores the actual data gathered by the research divers and reef builders. Unlike the historian, the archivist plays a key role designing the data sheets necessary to record observations and develops ways to store this information in an appropriate data base. Persons having some computer experience and an understanding of how to handle scientific data make ideal archivists. Of course, the historian should create the historical file to be included with the archives, and assist the archivist where possible.

The archivist is also the liaison with the chief scientist who is advising the reef research group, other scientists, agencies, and the divers who are individual project leaders. The reef research group may be involved with many different projects at the same time, all reporting their data through their project leader to the chief scientist and finally the archivist. The chief scientist having direct knowledge of these activities is in the best position to screen the data and keep the archivist up to date. The archivist is also a ready source of information for the group's coordinator or leader, the rest of the membership and the public affairs coordinator as well. Appendix S outlines a standard operating procedure for handling information for the archives.

The Archive's Components

The reef archives generally consists of the following components:

1) Library;
2) Historic Records;
3) Reef Site Data and Project Data & Reports;
4) Reference Collection & Catalog;
5) Reef research Personnel and Training Records;
6) Reef research Equipment Records, Manuals and Technical file.

Organizational administrative records should be kept by the elected leadership and not by the archivist, although they may be stored at the same location.

The archives, at first, should start with a copy of the reef site permit files stored in a file cabinet. Since documentation can take many forms such as video tapes, computer data bases, news photos and various written articles and reports, special provisions may be needed to safely store, index and cross index this material. The archivist would be well advised to consult with a professional librarian during the initial stages of setting it up. Consideration must also be made regarding screening information for quality and quantity before it is placed in the files. The chief scientist should be responsible for this. Arbitrarily placing anything and everything in the file would soon render it useless for data retrieval.

Library

The library portion of the archives consists of references, conference summaries and proceedings, bibliographies, general and technical reef reports which are not about specific reef sites the group is concerned with. It should contain an up to date file of the laws, policies and correspondence affecting reef programs. Copies of reef management plans as well as various fishery management plans should be kept in the general library. The library is also the logical place to keep administrative records and organizational correspondence. Maintenance of the general reference library can be shared between the archivist, organizational secretary and any designated member of the group. Care should be taken to insure all documents are properly filed indexed and cross indexed. A library loaning and checkout policy should be established.

Historic Records

The historic record, maintained by the organization historian, consists of documents, news articles and records of the group's general activities and the chronology of events. It is the "Scrap Book" usually kept by most dive clubs or other social organizations. While the information in the historical file cannot be classified as "technical data" it still provides background information which may be needed to understand the "whys or hows" various reef programs came to be. It should capture the "politics" or "flavor" of the situation at the time.

Some attempt should be made by the historian, to gather historical information from those who have been involved with past reef construction projects. While much of this information is highly subjective, full of personal interpretations and inaccuracies, it often provides important clues about when and where reefs were built and who built them. These clues can fill informational gaps for later verification. Tape recorded or video taped interviews of some of the "old timers" are useful for gathering this information. Many times, these historical searches uncover written documents as old fishing logbooks, maps and even photographs of reef material before it was "dropped".

Thorough historical research can become the basis for designing reef research dives to verify earlier placements. While earlier navigation methods were crude at best, relocation and verification of these earlier reef placements by divers is essential for a complete inventory and evaluation of the areas reefs. Many "lost" reefs can be found and placed back on the fishing maps.

Where possible, the historian, chief scientist and archivist should collaborate in reviewing the historic information. They should screen it for data that can be incorporated into the data archives. Most important would be dates, locations, names of observers and materials lists of previous reef placements. Photos and detailed maps or logbook notes having navigation information should also be included in the reef data files. Occasionally, a well documented record of a fish catch or observation from a specific site, if accurate and verified, should also be included in the data file.

Reef Site Data & Project Files

This is the essence of the archives. This file contains the actual dive logs (or verified copies), raw data sheets, placement reports, fishing surveys, special project data and reports, maps and copies of the reef permits. This file should be organized according to each reef location. Access to this file should be exclusively controlled by the archivist. Controlled access to this file ensures that the information in it is of high quality, verifiable, consistent and stored in a manner that is retrievable. In addition, any information stored in this file should be duplicated and stored in another location as a backup. The back up system is necessary to prevent loss of data from theft, accidents or just plain carelessness from some user.

Raw data gathered by divers, fishermen, researchers and/or reef builders should be entered on a standardized form in pencil or permanent ink (no felt tip pens please, for they smudge when wet) when possible, and always accompanied by the original dive log information filled out on the dive site. Standardized data sheets serve to remind the researcher, of the basic information needed, make data gathering more consistent, and make data analysis much easier. Projects requiring specific informational needs such as an experiment or for monitoring some change over a long period of time, requires that a form be designed for that project. This ensures that the required information is consistently taken.

All blanks on a standardized form should be filled out, even if "no observation" is made. When an observation is NOT made for a specific item on a standard sheet, a dash (-), or a Not Applicable (NA) is entered, not a zero, (0). Zero (0) is a real number which indicates that something was searched for and not observed. A dash (-) or NA indicates that the data was not even searched for, taken or Not Applicable for this situation.

Appendix B contains examples of the dive log and data sheets used in the N. E. Florida Area. The basic dive log sheet (Appendix B) which documents the most elementary dive information includes; who dived, where, when and conditions relevant to the divers performance and safety. Of course, any limitations (such as limited visibility or currents etc.) on diver performance should be noted since it will effect the amount, accuracy and credibility of data recovered on the dive. This information is very essential for those who must interpret the data later. Without it, the value of the raw data should be questioned and if in doubt, discarded.

File organization for Reef Site Data & Projects should be keyed to the site location by either site name or by numeric (LORAN C and Latitude - Longitude) coordinates. Projects specific to one site should be filed under the site name. Projects which cover more than one site should be filed under the projects name, and cross referenced in the site specific files. For example, a "Snapper Survey" project involving three reef sites should be filed under the heading "Snapper Survey". A note should be placed in each site file indicating "See Snapper Survey" to show data from that site is also available in another file. If possible, data sheets should be duplicated and filed under each of the three site files.

Reference Collection Documentation

Research of any oceanographic or biological nature will usually result in the collection and handling of physical or biological specimens which must be stored in a reference collection and catalouged. The definition of a specimen in this case can be expanded to include film, video and audio tape recordings. Documentation of a specimen usually begins with the proper labeling of the specimen at the time of collection. Afterwards, it is assigned a unique specimen number, and entered in the catalogue, creating a paper trail to account for its storage location and disposition. A specimen catalogue, should be cross referenced with the site data and dive log file. For example, the catalog may show a soil sample Number 19870521-3, from reef site "Miss Anna", is stored by Dr. T.W. Smith, in Jacksonville Universities Biology Lab, Room 25, at Jacksonville, Florida. If the sample is borrowed, perhaps by "Dr. Jones" at another university, a record of its loan should be made by the originating curator (Dr. Smith) and kept until its return. The designated "Specimen Curator" and "Reef Data Archivist" must keep in constant communication regarding the storage location, preservation requirements and accounting of reef specimens.

Standardized data sheets which originally accompanied the specimens during their collection, should be cited in the catalogue, and their file location noted. It is important to be able to match a specimen with a data and dive log sheet, in the event further study is needed. The use of unique specimen numbers greatly simplifies this job.

One example of a numbering system, used above, makes use of the date the specimen was collected. For example, the number 19870521-3, indicates that it was sample number 3, collected on the 21st of May, 1987. Its format is YYYYMMDD-(Sample No.), where YYYY is the number of the year, MM is the month number, DD is the day of the month and the sample number is arbitrarily assigned on the day of collection. It is unlikely that this number will be duplicated, unless a large number of samples are taken by different people on the same day. If that happens, the archivist can assign additional identifying codes in the specimen catalog. Using such a numbering system forces the catalog to be organized chronologically. It further simplifies matching dive site data with the specimen since both are keyed to the date of collection.

Maintaining specimens and their accounting requires the services of a well trained curator. Careful thought must be given towards finding a suitable Reference Collection storage site and curator. Most often, a nearby university, college, junior college or even high school may have more than adequate storage and recordkeeping facilities. Many even have faculty willing to serve as curators, especially if the specimens can be used for educational programs.

Reef Research Personnel & Training Records

Personnel and training records provide the background information about the volunteer reef researchers. This information is essential for documenting their credentials as qualified underwater data gatherers.

Future investigators, concerned about the credibility of the data will need this information to analyze the reef data for individual variations. Verification of an important observation may also require that the investigator personally contact the diver who made the observation. Monitoring training progress is also essential for future project team selection and developing leadership roles and special job assignments.

Finally, there are the legal implications for maintaining such records. Should an accident occur or legal conflict arise, this file may become admissible as evidence in a trial or legal hearing. The timely maintenance of this file provides further assurance that all research divers meet minimum safety standards and are current with respect to timely training requirements and regular checkups as with CPR training and physicals.

The research teams Divemaster, "Training Director(s) and Diving Control Board should be responsible for establishing this record keeping system and keeping this file up to date. They may elect to limit access to this file and not store it with the regular "public" archives. The archivist should be kept apprised of this files status.

Research Equipment Records & Manuals

This file contains all documents, purchase records and technical operating manuals for equipment owned by the reef research team. If the reef research group is organized as a not for profit corporation, these records will be required by law to show that the equipment is properly accounted for, in good repair and disposed of should the organization cease to exist. It also insures that technical manuals for sophisticated equipment are not lost, or warranty information misplaced. If the equipment requires periodic maintenance, then a Suspense File of required maintenance activities should be established. A Suspense File is merely organized according to the future dates when a maintenance activity is needed. Each piece of equipment should have an Equipment Use & Maintenance Log with it.

Some coordination may be needed between the Chief Scientist, Divemaster and Training Director(s) to limit access only to qualified equipment operators. For example, a research team member wanting to use the video camera may require special training before having access to it. Some record should be màde in the individuals training file listing what organizational equipment he/she is qualified to use. Controlling access to equipment is especially important for specialized life support equipment since it has a bearing on safety. (i.e., decompression computers, surface supplied equipment or air compressors).

Using The Archives & Specimen Collection

The questions, "Who owns the data and specimens ?" and "Who should have access to it ?" are sure to arise. This is especially true after a few years of data and specimen collecting, when word gets around, and the information's value begins to increase. Schools may wish to borrow a "few" specimens for a class or science fair. Divers, fishermen and reporters may wish to look through the data files to record reef "numbers" or to write a story. One prime concern is whether the inexperienced (unfamiliar) file user, will return the data to its proper place in the file, without harm or alteration. Altered or lost data is costly, especially if it is irreplaceable.

Who Owns The Data & Who Should Have Assess To It?

The answer to this question rests with the question "Who paid for it ?". If the research divers were performing as volunteer members of a not for profit corporation (which in essence is supported by the taxpayer) then the data is public information. If the organization is a private corporation, and financed the research project from either within the corporation, or if the corporation was hired, than the data is owned by the corporation or whoever hired it. If the data was gathered as part of a public grant, it belongs to the public. If it was funded by a University researcher, it belongs to that scientist and the agency providing the grant (most often this is public tax dollars).

More often than not, the answer simply will be that the public owns the data, and is therefore entitled to access to it. Of course this does not imply that the public is entitled to unlimited access and indiscriminate use of this information, especially if it results in its loss or alteration. The reef research organization and the archivist should design a system that encourages public access without unnecessary inconvenience to either.

Controlling & Retrieving The Reef Research Information

The Archivist will need to use every means at their disposal to insure that the data will always be understandable, never lost or destroyed, yet within easy access of the public. This can be assured by first designing standardized data records, a redundant filing system and publishing user access guidelines. The redundant system creates a backup file that should not be readily available to the public. While expensive initially, its long term value is self evident. This file should be physically located away from the original archives storage site in another building, perhaps even with some other organization.

Misfiled data can become lost even within the same file cabinet. Use of standardized library coding and filing systems can minimize misfiling. The Library of Congress Subject Heading System (LCSH) is the most widely available subject heading system available for general purpose manual files. It has a list of subject headings and a set of rules of how to set up for those items not included on the list. The LCSH is a basic tool of most libraries and should not be difficult to find. Consulting with the local librarian should be a first starting point before creating the file system.

The use of a database program on a micro computer offers an excellent means for storing large amounts of information which can be quickly sorted and reorganized to suit the users needs. This makes future analysis easier, and ensures a higher degree of standardization (unless it is frequently changed). Of course, more planning must be done during the earlier stages of file development to ensure all appropriate data is included. Needless to say, any computerized system should be user friendly so that anyone having even the most rudimentary computer knowledge can easily access the information. The computer system should use a common disk operating system (DOS), and should not be some unusual or hard to find brand. The primary concern is that the data will be easily accessible even ten or twenty years in the future. The data stored in a micro computer should always have a hardcopy (paper) backup of the raw data and summarized reports. All disks should be copied as backups as well.

Summary

Establishing the Artificial Reef Data Archives is no small task. It requires the dedication and commitment of a sincere, hard working individual and the complete support of the reef research team. It is the focal point of all reef research efforts. Perhaps the willingness of the group to make a firm commitment to creating the archives should be considered the first test of the organization's strength and dedication.

The archivist should be appointed as a semi-permanent position. Consistency in this position is essential to creating an effective and efficient information storage and retrieval system. Anything less is inviting chaos.

References

Library of Congress. 1980. Library of Congress Subject Headings 9th ed. (LCSH)., Library of Congress, Washington, DC. Note: This should be readily available in the local library. Very useful for designing your own subject headings.

Ritzenthaler, Mary Lynn. 1984. Archives & Manuscripts: Administration of Photographic Collections., Society of American Archivists, Chicago.

Robl, Ernest H. 1986. Organizing Your Photographs, Amphoto an imprint of Watson-Guptill Publications, 191 pgs.

Useful Organizations

American Library Association

Largest North American library organization publishing journals and books on filing and cataloging rules. Monthly journal "American Libraries" is available at most libraries.

American Library Association
50 East Huron Street
Chicago, IL 60611

American Society of Picture Professionals

Publishes a directory and a newsletter for photographers, picture researchers, editors, archivists and librarians on the business and legal aspects of picture use.

American Society of Picture Professionals
P.O. Box 5253
Grand Central Station
New York, NY 10163

Society of American Archivists

Interest in historical and contemporary collections of materials.

Society of American Archivists
600 S. Federal St., Suite 504
Chicago, IL 60606

Special Libraries Association

Publishes journal "Special Libraries", a monthly "Specialist" and a membership directory. Also has a variety of books in librarianship and related fields.

Special Libraries Association
1700 18th St. NW
Washington, DC 20009

Chapter 13

Guidelines For Organizing A Volunteer Reef Research Diver Organization

by Scott L. Braunsroth and Dennis Short

It is obvious that there are more recreational divers than marine scientists and that the majority of marine scientists never dive, yet it is these scientists that have dedicated years of study and research to the understanding of the complexity of our marine environment. The big question, is just how do we get these two groups together? One scenario involves the formation of a well organized volunteer organization dedicated to this end, in the interest of artificial reef technology of science.

The thought of forming volunteer research service organizations dedicated to a distinct aspect of our society or environment is not new. For example, volunteers of the National Audubon Society for years has been surveying bird populations in a coordinated nationwide effort. The concept of using volunteer sport diver organizations for the collection of scientifically valid marine data is based in the American Littoral Society's original attempts to collect data and record observations by sport fishermen and sport divers. Florida Sea Grant's Extension Program has spawned training for Volunteer research diving groups meet the increasing need for reef data in the face of rising costs of reef construction, manpower shortages and the unlikelihood of government agencies collecting such information for a local project.

The concept of voluntary sport diver research activities is not limited to artificial reefs in the marine environment.The idea can be applied equally to the study of beaver ponds in the northwest or the reservoirs of the Tennessee River Valley. However, it is first essential to establish if a need for volunteer research effort truly exists. Contacts with state and federal agencies may reveal an already established monitoring program which may thwart the most well-meaning of intentions. Once the need for underwater data is established, the group of motivated sport divers can proceed with the establishment of a formal organizational structure and training, which would facilitate their primary goal; the safe collection, storing, and protection of information gathered. There is also a place for nondivers who have special skills which would benefit the group.

Initial Considerations

Formalizing a Volunteer Research Dive Team, one must remember that the average volunteer diver, though motivated and well initiated, is none the less a volunteer who's career may be far removed from professional marine scientists. Thus, a volunteer program must address six basic criteria in order to be initiated, maintained and kept on the continuing path of development:

1) A particular need must be established;
2) Organizational structure must be clear;
3) Volunteers and scientists must work as partners;
4) The public must provide support; (Volunteer research is not free)
5) The program must be educational, interesting and fun; and
6) A means to publish and communicate their finds and events in their community.

There is also a place for nondivers who have special skills which would benefit the group. The usefulness of acquiring highly-talented certified sport divers such as divemasters and instructors is readily apparent for the management of safe, successful diving operations. But most sport divers also have other useful skills. Sport divers come from virtually all social and economic levels of our society. Their individual professional skills and abilities can also have a significant impact on the effectiveness of the organization and the research information it collects. The assistance of a diver who may also be a doctor or an attorney is readily appreciated, but not so quickly recognized are the added benefits of divers who also are bookkeepers, boat mechanics, public relations experts, teachers, or welders. It is rare that the potential member is unable to provide more than just his or her diving talents for the benefits of the organization. Ironically, those members who also have accounting or secretarial skills may prove to be the more valuable members of the organization.

Let us consider these six points in greater depth and determine how each contribute to the overall success of the volunteer program.

Need

The recognition of a need is paramount in the initial formation of a volunteer group. This need must be presented to the respective participants in such a manner that will encourage them to not only give up their free time but have them enlist the help of others. Without a legitimate need, the volunteer recruitment effort will be an arduous task. This essential first step is probably the easiest to achieve. The environment is a very emotional issue and does not take a great deal of persuasion for individuals, especially end users of the environmental resource, to want to get involved. The importance to learn more, to assist the scientific community or to inform the public, are all examples of vital needs that could spark enthusiasm among the volunteers, thus promoting a rallying point at which to proceed to the next step; form an organization.

Organizational Structure

This element in the establishment of a successful Volunteer Research Diving Team is the make or break ingredient. Without a clear organizational structure, all the best intentions and enthusiasm in the world will not sustain a Volunteer Research Diving program for long, yet ironically, it is the formation of this very element that often causes the demise of the volunteer effort. The average volunteer diver neither has the time, required skill, or the inclination to endure an extensive organizational process. It is during this grueling exercise that the volunteers bury their enthusiasm under a mound of paperwork, procedures, rules, regulations, and constitutional or charter bureaucracy. Exhausted, frustrated and disillusioned, an otherwise capable volunteer group throw in the towel either unable or unwilling to undergo this tribulation and they should not be required to. Remember, they are volunteers, not paid employees. To eliminate this initial hurdle as well as tilt the scale of success to the more positive side, two alternatives should be considered:

- A) Approach an active recreational dive club that would be willing to broaden its activities to include reef research functions. This would eliminate or at the very least reduce the energies needed in developing a new organizational structure. Conforming to the requirements of a reef research program from which the reef research team can concentrate their efforts on data collection.
- B) Follow a pre-established outline or canned program on the "How To s" in establishing a new organizational structure for Reef Research divers. Reinventing the wheel must be avoided. If volunteers are provided a step-by-step system on how to establish an organizational structure, including a directory on what agencies to contact for Incorporation status, tax exempt information, liability and grant preparation, their efforts can be directed in a more productive manner and success is more likely to be assured.

Now let's look at an organizational structure that has shown some relative success. At first glance its obvious why (See Appendix Q).

The Executive Board

The Executive Board of seven members sets the tone of the team and establishes the overall direction. They also act on suggestions presented to them by the team and they must submit all programs before the team for approval. Because they are kept to seven members, decisions are made more efficiently. In case of a split decision, the coordinator can break a tie. In this administrative structure, there are no general rules, only lieutenants. Everyone has an equal voice and the coordinator acts only in a facilitator capacity.

The Committees

Predesignated working committees provide areas to which team members can direct their energies most sufficiently. The committee is a useful tool which can assume any responsibility that best suits the needs of the Reef Research Team.

Operational charts and designated committees provide avenues to direct the members effects but procedures are needed to explain how.

Procedure manuals are a must for members to keep their possession and review. Examples are:

- Organizational/Committee Procedures--explains responsibilities and methods.
- Diving Safety Manual--sets standards to promote diving safety and liability responsibility.
- Research Data Collection Methods Manual--standardizes accepted data collection methods that can be accepted by marine scientists and easily implemented by research divers.

Going Public

When drawing from an established dive club, the key element for going public is proper communication. The fact that sport divers represent a small segment of the population of a community actually lends itself to easy communications with prospective members. Notices can be posted in dive shops and personal contacts with local dive clubs can expose a high percentage of the diving community to the intents of the organization, so these avenues should be exploited. Notifications posted at local universities can also lead to contacts with members of the academic community, something which is a necessity. The minimal effect from this public exposure is the establishment of the organization's identity in the community, an important first step in building it's credibility.

The location for "a gathering of the minds," can also have more ramifications than are at first apparent. Solicitation for a meeting to be held at a specific dive shop or at the meeting place of an established dive club can tend to alienate some members of the community, so it is suggested that a neutral site such as an extension office, library, school or college campus, be selected for the initial meetings. The meeting site selection should also depend upon the anticipated turnout, a centralized location, and at a time which avoids conflicts with other diving activities.

A friendly social atmosphere at the original meeting must be tempered with the knowledge that certain minimal business essentials must be accomplished. It is vitally important, at this stage, for someone to take charge and conduct the business at hand. In addition to providing a focal point for audience attention, the chairperson acts as a moderator for group discussion and otherwise directs the course and success of the meeting. An experienced chairperson from some other organization can even be asked to facilitate the first organizational meetings.

At an absolute minimum, a roster of attendance, with mailing addresses and phone numbers, must be compiled during the first meeting. Most importantly, before the initial meeting is over, a date, location and commitment must be made to meet again . The initial meeting is also a good time to get new prospective members directly involved by assigning them a simple task.

Secondary meetings should include briefings for new attendees and continued maintenance of rosters of attendance. The synthesis of a small cadre of dedicated workers will soon reveal itself and will provide a pool for the delegation of other, more involved administrative duties.

An item to be pursued with expedience should be the election of pro tem officers for the organization. It is essential to fulfill what will be found to be a rapidly expanding need for decision making and other administrative functions. A slate of officers, even in a pro tem capacity, is instrumental in maintaining the momentum of a growing organization.

The selection and appointment of pro tem officers would be pursued with no small degree of caution. The success of the organization will depend upon the perseverance of these appointed members, especially during the often mundane ensuing period of organizational, structural and political development. Because the pro tem officers are often swept into permanent offices, wisdom should be employed in their selection. It should be taken into account that perhaps a more reserved, but highly motivated member, may actually be more of an asset than a more obvious, or even more highly qualified person, who is unwilling to contribute.

Development of the Constitution

Either the development of a constitution and/or a charter for a volunteer reef research diver organization can be an arduous process and, regrettably, a period with a high attrition rate among the general membership. Most recreational divers are more motivated to dive than they are to spend hours discussing small points of contention in the formulation of the organizational charter. Consequently, it is highly advisable that as many aspects of this process as possible be delegated to committee action, thus limiting time consuming, relatively unproductive open floor debate during general business meetings. A model constitution is found in Appendix T.

Naming the Organization

One item that calls for general participation is the selection of an organization title or name. The name alone can reveal as much, or as little, of the nature of the group as its members wish. As an example, "Dive Research Group" has an air of ambiguity that could lend itself to any locale or research purpose, while the "Alameda Marine Algae Analysts," reveals the limits to the location and objectives of the group. It certainly limits the scope of activities of the organization and, consequently, its attractiveness to a diverse membership. The name should be specific about the groups interests and should clearly imply that it is a service group and not a social club. A name such as "Reef Research Society" sounds far more scientifically credible than "Rollicking Reef Raiders".

Acronyms, the technique of using the first letter of the words in the title, can also be helpful in simplifying what otherwise might be a cumbersome title. Consider having to say National Aeronautic and Space Administration every time NASA comes to mind and the benefits of acronyms is apparent.

Name selection is a very important aspect of organizational development and the implications of the many possible choices must be carefully explored before a final decision is made.The application for corporate status for the group could disclose a conflict in names, so it may be wise to have an alternate ready before a final decision is made.

Once again, we see that a seemingly simple decision such as naming the group can be complicated by a lack of foresight on the part of the organization. Once decided upon, it is highly unlikely, and very inconvenient, to change the organization's name. The astute participant in the name selection process will realize that justifications for particular name choices also provide clues to the key elements to be included in the charter and help define the purposes and objectives of the organization.

The Charter

The Charter should be distinctive enough to readily describe the functions of the organization, yet allow some degree of flexibility for future interpretation and adjustments. Just as a national constitution is subject to changes of interpretation with changing times, it is suggested that the organizational charter have enough flexibility to be effective for the foreseeable future.

Role models may help. Even Thomas Jefferson relied upon examples of idealogy from such philosophers as Locke and Rousseau for his contributions to our national Constitution. Likewise, those involved in authoring a charter and constitution should avail themselves of the multitude of examples available. An example of the Jacksonville Scubanauts Reef Research Team Constitution is found in Appendix Q. The use of role models does not have to be limited to those of like character. Examples from both recreational and professional sources can be invaluable. The charter of a college fraternity could possibly provide insight into committee structures or election procedures. Business sections of the public library system can provide numerous examples to follow.

Current experience has shown the need for some basic provisions to be included in the constitutional body of a volunteer research divers organization. Membership standards and qualifications and the issue of funding prove to be the most hotly debated issues, and a time consuming affair to resolve. Membership qualification for those who dive in a diving organization, for example, must include a provision for the evaluation of the individual's diving abilities and experience with some provision for further training and even discipline when needed. The standards for these abilities necessarily would vary relative to the tasks, projects and diving conditions confronting the organization. Thus, the organization should provide for training and retraining its members, and should define the related experience standards for its diving members, with respect to various projects needs. For example, a highly experienced freshwater diver may not be ready to participate in a reef monitoring project 20 miles offshore in the ocean and a highly experienced ocean diver may still need special training in underwater mapping methods, if the project needs demand it.

Duties of Officers and Committees

Determining a slate of officers and a business calendar should also reflect the specific needs, goals and projects of the organization. While the officers' primary duties are to assume the business activities, the committees and the respective chairmen fill a more specific purpose. Incorporating these positions into the structure of organizational officers may make the election process unwieldy. It is for this reason that the committee chairmen should be appointed to their positions.

The business duties of organizational officers is somewhat self-explanatory with the secretarial and treasury positions perhaps requiring more clerical expertise than the executive officers. Often, unless the organization is quite large, members may be required to "wear more than one hat"; i.e., assume committee chairmanship in addition to being an officer. It is the committee chairmen who will ultimately assume responsibility for the actual projects undertaken.

The types of committees will necessarily reflect the needs of the group as they change over time. Appendix Q provides job descriptions. There are some committees which are felt to be uniquely essential for an organization whose goal is the collection and storage of data. One such permanent committee is the data and historical archives committee. Too often the need for retrievable data storage and the collection of organizational history or documentation is not realized, except as an afterthought. Often, by that time, much of the information cannot be retrieved. Old photos, news clippings, minutes of special meetings and copies of dive logs and raw data notes provide not only nostalgia for the membership but also valuable informational data for future publications when documentation of past activities is necessary.

Diver training and safety, while an overriding consideration for all water activity, benefits from a centralized permanent committee. This is a natural post for the members of the organization who are scuba diving instructors. Their knowledge of safe diving procedure and equipment usage and their proven instructional talents in the field are invaluable. The input from training and safety personnel can also be valuable in the formulation of membership ethics for diving practices while working under the auspices of the organization. This committee can formulate a program of standardized techniques for accomplishing the specific task at hand while taking into consideration local diving environments.

With the precedent for organizational ownership of equipment established in the constitution, procedures for the usage, maintenance and storage of this equipment becomes a necessity. Conceivably, the organization may be so small, or the amount of equipment so limited, that a committee for this purpose may be unnecessary. But, as membership and inventory of organizational equipment increases, it will be a requirement to know where and in what condition the tools of your trade are when the occasion arises to use them.

The benefits of individual committee structure and standardization of technique can also be seen when applied to data collection, charts and graphs, and photography. In each case, the best available talents may be utilized and directed to provide standards of technique to be employed by the rest of the organization. The end result will be a uniformity of procedure, lending itself to smooth operation and increased credibility of the organization's efforts.

Funding and Incorporation

Provisions for funding a reef research organization involve more than the question of whether or not to levy dues upon the membership. Aspects of funds, accrual, and disbursement towards various projects should be addressed, and policies for the handling of organizational monies determined. Provisions may also be included regarding organizational purchased and ownership and maintenance of property. The important issue seems to be the need to set a constitutional precedent for the organization to handle money.

It is important that the financial status of the organization begin on a firm foundation. It is advisable to seek professional assistance in setting up organizational bookkeeping procedures, especially if it decides to pursue a corporate or nonprofit corporation status. Present experience has shown incorporation to be a highly desirable avenue to explore. Legal consultation is highly advisable before pursuing this step of development, but in some states it is not a necessity to establish corporate status. If a prospective member is an attorney, he could be of great assistance at this point.

Corporate status can most readily be seen beneficial to the organization in its ability to somewhat limit considerations of liability in the event of a mishap during diving activities sponsored by the organization.

The complexities and the vagaries of the ramifications of the financial and liability considerations of corporate status dictate the need for proper legal referral. A professional legal consultation at this stage may prove to save hours, if not weeks or months, of frustrated effort in the future.

The concept under consideration here (that of a volunteer research diver organization) is too new to provide a track record of experience with liability issues. Liability problems are not absolved with the establishment of corporate status. However, it is generally considered advantageous to incorporate so that legal responsibilities can be laid to the corporation rather than individual members.

By far, the most important aspect of liability to remember is the proverbial "ounce of protection". The potentially dangerous nature of diving requires the adoption of, and adherence to, accepted safety standards. When diving activities are combined with the logistics of boat transportation, exposure to risk is greatly increased.

Liability waivers may be comforting, but very few, if any, will withstand intense legal scrutiny. None are valid in the event of negligence on the part of anyone involved.

To best avoid difficulties of this nature, consult with diving instructors, boat captains, the Coast Guard and, if possible, an attorney. Their advice will lead to the implementation of operating procedures designed to minimize exposure to risk. It is then the organization's responsibility to develop a consistency of technique which will lend itself to the safety of the entire operation. In addition, the volunteer team should consider adopting the safety standards of the American Academy of Underwater Sciences (AAUS) which have been recognized by the Occupational Safety and Health Administration (OSHA) for scientific diving (See Appendix A).

A more easily recognized benefit of nonprofit status is its application to state and federal tax structures. While the particulars may vary from state to state, nonprofit corporate structures enjoy varying degrees of tax exemption on earnings. In addition, other individuals or organizations may have the privilege of tax benefits for items or services donated to the research group. This fact alone may well warrant the application for nonprofit status.

It must be remembered that the difficult part of these affairs is following the various rules required of nonprofit organizations. The application for this status is usually a relatively simple affair. It is essential that the application be handled correctly, however.

Subsequent to acceptance of these articles, many times a form letter type of procedure, the corporation is assigned an identifying tax permit number to be used in conjunction with organizational business. It is this number which will be required for the validation of gifts to the corporation so that the donors may make proper tax claims.

Academic Liaison

Volunteers & Scientists As Partners

There has been a misconception that volunteer research divers had to work for a marine scientist to acquire credibility. The scientist would set the agenda, direct the activities and take the bows. This type of relationship may work in the short term but is doomed to failure down the road. An attitude of cooperation and mutual respect must replace intimidation. Volunteers and scientists must learn to work as partners with a common objective and purpose and dispense with the "Overseer and Field Hand" mentality. There should be joint ownership of the data.

Contacts with academia are essential. To be assured that data gathered by the organization has scientific value, the work must be performed under the guidance of a qualified scientific advisor. The scientific advisor post will usually be filled by a doctoral level academic with interests and training similar to the intents of the research group. If the interests of the organization are varied, the position may be occupied by one or more experts with different areas of expertise. Regardless of the field of interest, the team's chief scientist is a necessary connection to the academic community through the scientific advisor.

The necessity of a scientific advisor is not a detriment; it is the volunteer research group's greatest asset. It must be remembered that, unlike college days, the scientific advisor is no longer a Svengali character, who directs every aspect of the organization's activities. Rather, his role will be one of providing guidance and insight in the pursuit of projects chosen by the group and the data gathering and handling methods used. He is also an invaluable educational source and a ready reference on proper scientific technique, whether he is a diver or not. His endorsement of the data gathered can make, or break, the organization and its reputation in the community.

The enlistment of a scientific advisor could be accomplished by a canvassing of academic personnel of nearby universities. But, this rather arduous technique may be averted by taking advantage of some established government programs. The Cooperative Extension Program in Florida, for example, has designated personnel to serve as agents of the Florida Sea Grant Extension Program (SGEP). The primary goal of the Sea Grant Extension Agent is to act as a liaison between the general public and those faculty in a position to assist with marine oriented issues.

Inquiries to your local Sea Grant Extension Agent will probably result in a wealth of leads to follow in the quest for a scientific advisor. The agent, in many cases, will also be a source for connections with appropriate consultants from other private and public organizations, as well as serve as a consultant to the reef research group itself.

While this is not the definitive treatise on establishing a volunteer reef research group, it is hoped that some questions on organizational obstacles have been answered. We are pursuing avenues for which there are no established directives.

As stated earlier, this formulative stage is one often characterized by a high attrition rate among the general membership. This tendency may be countered, to some extent, by a commitment to involve as many members as possible early in the process.

Liability issues should be satisfied before conducting sanctioned diving activities. Alternate activities, such as training, equipment building activities, public education events or fund raising projects can aid in maintaining membership involvement.

Once organizational duties have been accomplished to everyone's satisfaction and project priorities have been established, pursue them. Though it may be difficult to rein in the more ambitious members, choose a primary task which is well within the capability of the membership to achieve. An initial project, no matter how simple, which is completed credibly will contribute greatly to the morale of the membership and enhance the organization's standing in the academic community. For the group of volunteers who survive the formulative period and accomplish their first goals, the accolades are appropriate. One means for doing this is by making their efforts public. This should also increase public support for the team.

The collection of data may help fill the archives with valuable information that may assist scientists and the community in their study, yet if the public cannot perceive a benefit, then support may be lacking.

SECTION TWO

Underwater Research Method Summary

Title:____
Date:__________________________

Contributed by:
Name:____
Address:______________________________________
Phone:_______________________________________

General Description of the Method and its Purpose

Data to be Collected (List specific parameters.)

Data Gathering Equipment (Add an attachment sheet, if needed, to include drawing of special equipment.)

Minimum Dive Team Description (# Divers, Job Titles and Job Descriptions.)

Sources of Additional Information

Outline of Dive Procedure in Sequence by Tasks (Use reverse side if needed.)

Please fold paper in half, staple and stamp.

Please Place
Stamp Here

Florida Sea Grant College Program
PO Box 110409
University of Florida
Gainesville, FL 32611-0409
ATTN: Scientific Diving Methods (Halusky)

Excavation by Portable Couple Jet Blower

Contributed By

James S. Dunbar
Bureau of Archeological Research
Department of State, The Capitol Tallahassee, FL 32301
(904) 487-2333
3 April 1986

General Description of the Method & Its Purpose

This is Equipment used for quick but not highly controlled excavation of relatively broad areas in open water situations. The equipment is highly mobil and diver operated thus has great advantages of prop wash diverters mounted on anchored vessels. The hand held blower becomes a diver propulsion vehicle between Excavation sites and the surface pump can be floated on a floatation tube for maximum mobility

Data to be Collected

(List specific parameters.)

1. Stratigraphic testing for mapping and observe subsurface sediment sequences.
2. Cleaning thin sediment layers from hard surfaces such as ship structure for photographing and mapping.
3. Cleaning out crevices and cracks in bedrock or other wise excavating sediments to obtain an idea of artifact or fossil frequency in subsurface sediments.

Data Gathering Equipment

(On Attachment Sheet include drawing of special equipment.)

1. Water pump w/suction hose (intake)
2. Floatation device for pump
3. Jet hose, length as needed for job.
4. 3" couple-jet rigged with balancing nozzle and 1/4 turn ball balance.

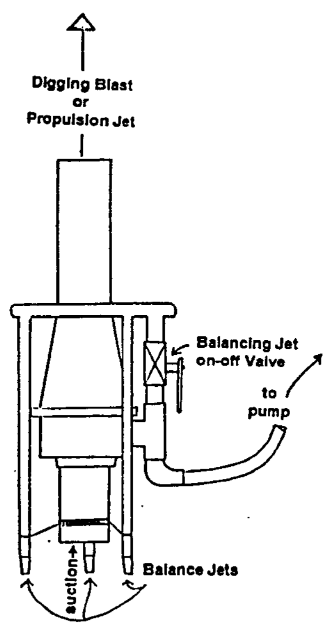
Minimum Dive Team Description

(# Divers, Job Titles and Job Descriptions.)

One to two depending on diving equipment

Sources of Additional Information

None given



DIVER OPERATED PORTABLE BLOWER
Using a Couple-Jet

Outline of Dive Procedure in Sequence by Tasks

1. Rig pump with suction w/jet hoses and prime pump with water
2. Connect Jet hose into water-jacket of couple jet.
3. Start pump making sure jet hose allows unrestricted flow of water into couple-jet.
4. Turn OFF water flow to balancing nozzles with 1/4 turn ball valve to use one system as a diver propulsion vehicle and travel to work site.
5. Turn ON water balancing Nozzles and point couple-jet discharge head at area to be excavated or cleaned of sediment.
6. Repeat setup 4 & 5 as needed.

Fish Assessment - Cinetransect

Contributed By

S. A. Bortone
Biology Department, University of West Florida, Pensacola, FL
(904) 474-2647
10 April, 1983

General Description of the Method & Its Purpose

While swimming along a transect a diver shoots a roll of super 8 movie film to access the fish community on a reef. The technique gathers a permanent record of the habitat as well as the fish community which can be examined repeatedly at a later time to determine the fish community.

Data to be Collected

(List specific parameters.)

-A permanent record of the habitat.

-A record of the fish community which can be repeatedly examined for census information.

-Abundance estimates of species "seen" by the movie camera.

Data Gathering Equipment

(On Attachment Sheet include drawing.)

-A 100 m transect.

-A super 8 low light movie camera fitted with an underwater housing.

-Several rolls of movie film (Kodak ektachrome 50 ft.)

-An underwater movie light if filming is to be in water deeper than 30 feet or at night.

-A movie projector with stop and slow motion, and reverse capabilities.

Minimum Dive Team Description

A diver swims slowly along a transect shooting the roll of film while slowly (very slowly) panning the camera from side to side.

Sources of Additional Information

Alevizon, W.S. and M.G. Brooks, 1975. The Comparative structure of two Western Atlantic Reef-fish assemblages. Bull. Mar. Sci. 25(4):482-490.

Outline of Dive Procedure in Sequence by Tasks

1. Fish counts are obtained by exposing a roll of high speed Ektachrome film while a diver swims along a transect about 1m above the substrate and slowly panning from side to side to record within 4-5m of the transect.
2. After developing the film, slow, stop and reverse projection are used to determine the species and their abundance as recorded by the movie camera.
3. To avoid errors, individuals are counted only if they occurred at less than 5m from the camera. Also, fishes too close the camera are omitted from enumeration.
4. Species counts may be used directly for faunal comparisons or transposed to a scale of abundance as suggested by Alevizon and Brooks (1975).
5. Several rolls (between 4 and 8) of film should be shot to act as repetitive samples so that effects of random movement of fishes (or bad technique by divers) are minimized. Multiple sampling when using a movie film is essential as the total sample time for a 50' roll of film is less than 3 minutes.

Fish Assessment - Point Count

Contributed By

S. A. Bortone
Biology Department
University of West Florida
Pensacola, FL
(904) 474-2647
10 April 1983

General Description of the Method & Its Purpose

Assessment of fish is made at a point or place on the reef. The place or point can be determined by random assignment or by choosing a point along a transect at fixed intervals. A diver simply sits back and observes the "point" and area around it, determines the species present, counts the number of individuals and estimates the size as well. The purpose is to obtain a point estimate of the fish community composition. By repeating the technique and averaging the results a picture of the relative abundances of each species emerges.

Data to be Collected

-species identification
-abundance of each species
-size estimate of each species

Data Gathering Equipment

-writing slate or pad and pencil
-watch
-transect marked off in 10 m intervals

Minimum Dive Team Description

Diver positions him/herself about 5 m (or less depending on the visibility) away from the point and counts the individuals by species that pass through an imaginary 2m x 2m x 2m cube at the point. Later the diver approaches the point and slowly inspects the point for any cryptic, diminutive or sedentary species missed doing the first part of the inspection.

Sources of Additional Information

Slobodkin, L.B. and L. Fishelson, 1974. The effect of the cleaner-fish Labroides dimidiatus on the point diversity of fishes on the reef front at Silat. Amer. Naturalist. 108(961):369-376.

Outline of Dive Procedure in Sequence by Tasks

1. A random series of points or places to conduct the survey's are selected or the points may be chosen at 10m intervals along a transect line.
2. A diver moves away from the point (5m or less depending upon the visibility) and counts by species all the individual fish that swim through or are located in an imaginary 2m x 2m x 2m cube located on the point.
3. Care should be taken not to count any individual twice.
4. If part of a school enters the cube then the entire school is included in the count.
5. The count is conducted for a specific time internal. Twenty minutes has been suggested as a good length of time by the authors of the method. Experience indicated that 5 or 10 minutes may be more realistic on artificial reefs. The important thing is that the amount of time be kept consistent.
6. At the end of the sample time, the diver swims up to the point to locate and count cryptic or diminutive individuals not noticed during the first part of the survey.
7. The technique is repeated at least twenty times at different points to obtain an overall picture of the fauna composition of the area.
8. Notes should be taken on the physical factor at each point.

Fish Assessment - Rapid Visual Technique

Contributed By

S.A. Bortone
Biology Department
University of West Florida
Pensacola, Florida
(904) 474-2647
10 April 1983

General Description of the Method & Its Purpose

A general census technique for assessing the qualitative and relative abundance of fishes. A diver records species in the order in which they are first observed. The basic premise is that species which are most abundant are more likely to be seen first and most often while those that are least abundant are likely to be observed last or least often. By repeating the technique and scaling the results according to when they were observed species can be "scored" as to their relative abundance on an artificial reef.

Data to be Collected

-A list of species is obtained.

-The order of which is determined by the time when they are initially observed in a sample.

Data Gathering Equipment

-a slate or writing pad and pencil

-a watch

Minimum Dive Team Description

A diver swims more or less randomly over the reef site and records all the species in a 50 minute interval in the order in which they were observed.

Sources of Additional Information

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

Outline of Dive Procedure in Sequence by Tasks

1. Within a prescribed area or over the entire artificial reef a diver swims "randomly" over the reef structure.
2. On a slate or writing pad the diver records all the species observed in a 10 minute period. During the next 10 minute period the diver records all species seen by does not include or repeat any observed in the first 10 minute period. The technique is repeated for a 50 minute period so that in the 5th 10 minutes a diver lists only those species not seen in the previous 40 minutes.
3. Shorter sampling intervals such as 5 five minutes maybe effective.
4. The 50 minute sampling time is repeated at least 8 times.
5. Species are given a score of 5 if they were observed in the first 10 minute time interval, 4 in the second, 3 in the third, etc.
6. A species total score (or score of relative abundance) is obtained by adding up the score for a particular species over the 8 sample periods. For example, a species observed in the first 10 minute time interval are each of the 8 repetitive samples which have an abundance score of 40 (8 x 5). A species observed only once in the last time interval would receive a score of 1.
7. For within and between reef comparison abundances scores can be treated as relative abundance data as in fish counts and analyzed accordingly.

Fish Assessment- Species/Time Random Count

Contributed By

Scott Andree
Marine Advisory Program
P.O. Box 820
Perry, FL 32347
(904) 584-9350
23 May 1983

General Description of the Method & Its Purpose

The species/time random count technique is a visual censusing method based upon the rate at which fish species are encountered by a free swimming observer. The technique is taken from the basic concept of species-area used by most ecologists. However, in this case time is substituted for area. Species composition, species diversity and relative abundance of fish species can be generated by this method. This technique uses very little equipment and can be accomplished easily by two member dive teams. Reliability of the data collected is dependent upon visibility, experience of the observer, number of repetitions, depth and time of day. This method is limited too the more ubiquitous fishes and cryptic or secretive fish are missed; therefore, the "state of the community" as measured by this method is accurate, but relative only.

Data to be Collected

-Visibility, depth, current and temperature (optional)
-Location of starting point (Loran C coordinate, reef landmarks or quadrant)
-Start and stop times of observation period
-10 minute time intervals
-Fish species encountered (recorded only once)

Data Gathering Equipment

-Plexiglass writing slates with attached pencil
-extra pencil
-watch
-fish identification guide (waterproof)
-mimeographed data sheets/vellum sheets (optional)

Minimum Dive Team Description

One two-member dive team with each diver acting as an observer. Caution must be exercised that each diver maintain visual contact with his partner.

Sources of Additional Information

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

Thompson, M. John and Thomas W. Schmidt. 1977. Validation of species/time random count technique sampling fish assemblages at Dry Tortugas. Proceedings, 3rd International Coral Reef Symposium, University of Miami, FL pp. 283-288.

Outline of Dive Procedure in Sequence by Tasks

1. Following entry, dive team leader should record location on the reef (prominent landmarks, reef quadrant, etc.) depth, temperature (if possible), visibility and current direction.
2. Both divers should record the time that the census begins.
3. Both divers should swim randomly into the current maintaining safe visual distances with the partner. All habitats within the reef are available to the observers; it is only necessary that each diver stay within the physical confines of the specific reef being studied. There is no requirement to stay on a transect or within a quadrant.

4. The search time is 50 minutes long (can be modified due to depth and bottom time), broken up into 10 minute intervals. Species are recorded only once and credited to the specific 10 minute time interval in which they are first encountered. (see attached data sheet). A total of five 10 minute intervals are used.
5. This procedure is repeated to achieve the desired number of replicated surveys. Eight replicates are generally considered a minimum.

ATTACHMENT SHEET
SAMPLE DATA SHEET ____________________

Location ____________ Time Start ____________ Date __________

Current ____________ Time End ____________ Census NO.______

Temperature __________ ______________________________

Time	Species	Time	Species	Time	Species

NOTE: To determine relative abundance, species are given ranks based on the time interval encountered, e.g., 0-10: 5, 10-20: 4, 20-30: 3, 30-40: 2, 40-50: 1. The ranks are totaled over the number of replicates and these cumulative values are statistically valid (see Jones and Thompson, 1978). The most abundant species will have the highest rank.

Fish Assessment - Transect

Contributed By

S. A. Bortone
Biology Department, University of
West Florida, Pensacola, FL
(904) 474-2647
10 April 1983

General Description of the Method & Its Purpose

To assess or estimate the relative abundance of fishes on artificial reef a transect or length of rope is established on or over the reef structure. Two divers swim side by side, one on each side of the transect line and identify, count and estimate the sizes of fishes encountered. The transect method may be used to gather relative abundance data on all species or only a few "target" or economically important species. Length of the transect line and swimming speed should be kept constant for within and between reef comparisons of abundance.

Data to be Collected

-Identification of species present.
-Estimate of numbers of individuals for each species.
-Size estimates of individuals.

Data Gathering Equipment

-100 meter transect line (marked off at 10m intervals for reference).
-stop watch to determine elapsed time of transect assessment.
-underwater slate or writing pad and pencil.

Minimum Dive Team Description

Transect is set in either a predetermined straight line, or random pattern. Divers swim on either side of transect and count, identify, and estimate size of fishes encountered. Census data are recorded on slates or writing pads.

Sources of Additional Information

Brock, V. 1954. A preliminary report on a method of estimating reef fish populations. J. Wildlife Management 18 (3):297-308.

Chance, E.H. and D.B. Eckert. 1974. Ecological aspects of the distribution of fishes at Famming Island. Pacific Science 28(3):297-317.

Outline of Dive Procedure in Sequence by Tasks

1. Establish the transect line in a reef area over the type of substrate to be surveyed. Depending upon the question to be answered by the data it might be preferable to set the transect line over the same type of habitat or to set it over many different kinds of habitat.
2. A transect line length of 100 m has been used as a "standard" however shorter length may be preferable especially if the artificial reef is not that extensive. The length of the line is not as important as using the same transect length for all studies by the dive group.
3. The dive team consisting of two divers note the time and slowly swimming down either side of the transect line each diver records and counts the number of individuals of each species seen and tries to estimates their size.
4. The abundance of fishes will occurring in schools may have to be estimated. If part of a school swims in front of a diver the entire school is included in the count.
5. Occasionally fishes will swim around a diver. Care should be taken for counting each fish only once.
6. If a fish swims from one side of the transect to the other it should be counted by both divers.

7. The transect method should be repeated at least 4 times with divers alternating sides.

8. Data are in the form of relative abundance but may be converted to absolute abundance if an estimate of the area surveyed is made.

9. The time at the end of each transect swim should also be recorded as it has been observed that the amount of time spent surveying a transect affects the census results. It should take about 20-30 minutes to swim and record data on a 100 m transect.

Mapping - Circular Strip Map

Contributed by

Joseph G. Halusky
Marine Education Center
233 Marine Center Drive, A1A South
Marineland, St Augustine, FL 32086
(904) 471-0092
21 September 1982

General Description of the Methods & Its Purpose

This is a method for constructing a crude scatter map of artificial reef material in a circle of up to 100 meters in diameter. Generally a team of two divers could accomplish this (depending on current and visibility in approximately 1 to 2 hours on the bottom. For a 100 meter diameter circle, the divers would swim a total of approximately 479 meters. It is assumed that the area to be surveyed is relatively clear of bottom obstructions, which could tangle measuring lines, and that accuracy is not terribly important (the map is less accurate, as one moves away from the center bench mark). Its good for constructing a hasty map of reef scatter and searching for large obstructions, when visibility is a problem.

Data to be Collected

-Precise location of Center Bench Mark (usually Loran C numbers).
-Dive team heading in degrees to or from the center bench mark.
-Distance from center to object to be mapped.
-Description of object (photograph when possible) to be mapped.
-Visibility, depth and current information.
-Date, time of mapping.
-Dive team names.

Data Gathering Equipment

(On Attachment Sheet include drawing.)
-50 meter Fiberglass measuring tape, with snap clip on end.
-Anchor or some bench mark too fasten end of tape to, while on bottom.
-Underwater slate and pencil.
-Compass
-Watch

Minimum Dive Team Description

-Compass and tape bearer (CTB)- makes fast the end of the measuring tape to the anchor and swims the proper compass headings while reeling the measuring tape.
-Recorder- carries slate and describes objects to be mapped by noting distance and heading of the object, from the center bench mark.

Sources of Additional Information

Miller, James N. 1979. NOAA Diving Manual - Diving for Science and Technology - 2nd Edition. U.S. Dept. of Commerce. Superintendent of documents. Stock No. 003-017-0046806.

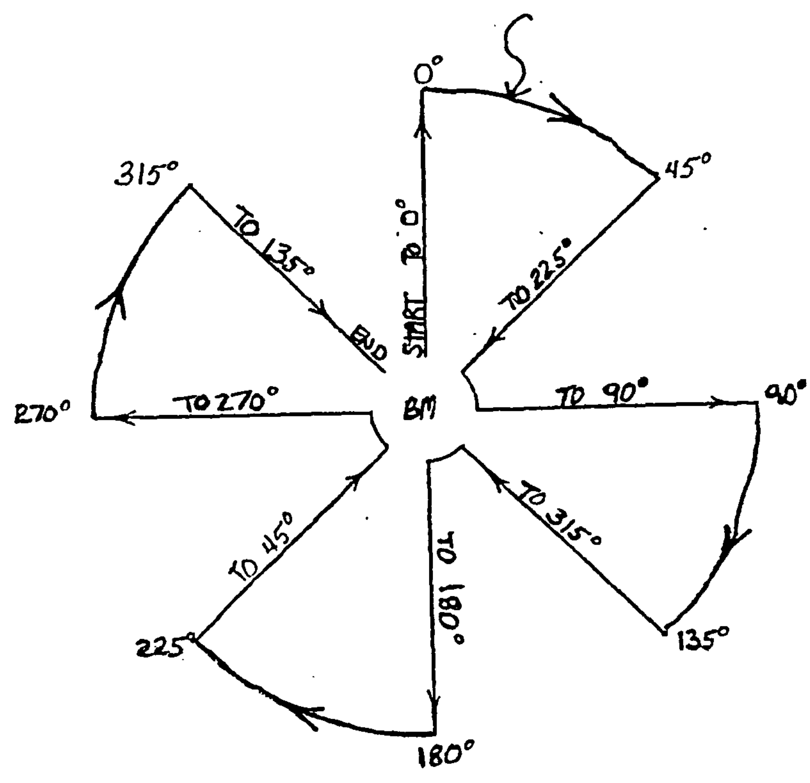
Woods, J.D. & J.N. Lythgoe. 1971. Underwater Science, an introduction to experiments by divers. Oxford Uni versity Press. London.

Outline of Dive Procedure in Sequence by Tasks

1. Establish a Bench Mark (BM) using the support anchor, some anchoring device, or a fixed feature on the bottom which can easily be found again. Record Loran coordinates of the BM, if possible.
2. Compass & Tape Bearer (CTB) attaches end of measuring tape to the BM and begins to swim in a fixed compass direction, away from the BM, while unwinding the tape.
3. Recorder follows the CTB, while recording the compass heading distance, and description of objects found along the bottom, within range of view on either side of the measuring tape.
4. On reaching end of the tape, or previously determined distance from the BM, the CTB stops until Recorder completes sampling, then the two swim an arc until their compass heading back to the BM reaches a previously determined back-azimuth to the BM. (see illustration).
5. Then, the recorder swims ahead of the CTB, along the measuring tape while sampling. The CTB follows, while rewinding the tape, and maintaining the proper compass heading.
6. Upon reaching the BM, the next compass bearing is selected, and steps 1 through 5 are repeated until a full circle is sampled.
7. The rough notes, recorded on the slate, are then later, transcribed onto circular (Polar Co-ordinate) graph paper, from which, a final map is produced. (See example - Attachment 2).

Attachment Sheet

Attachment I



EXAMPLE:

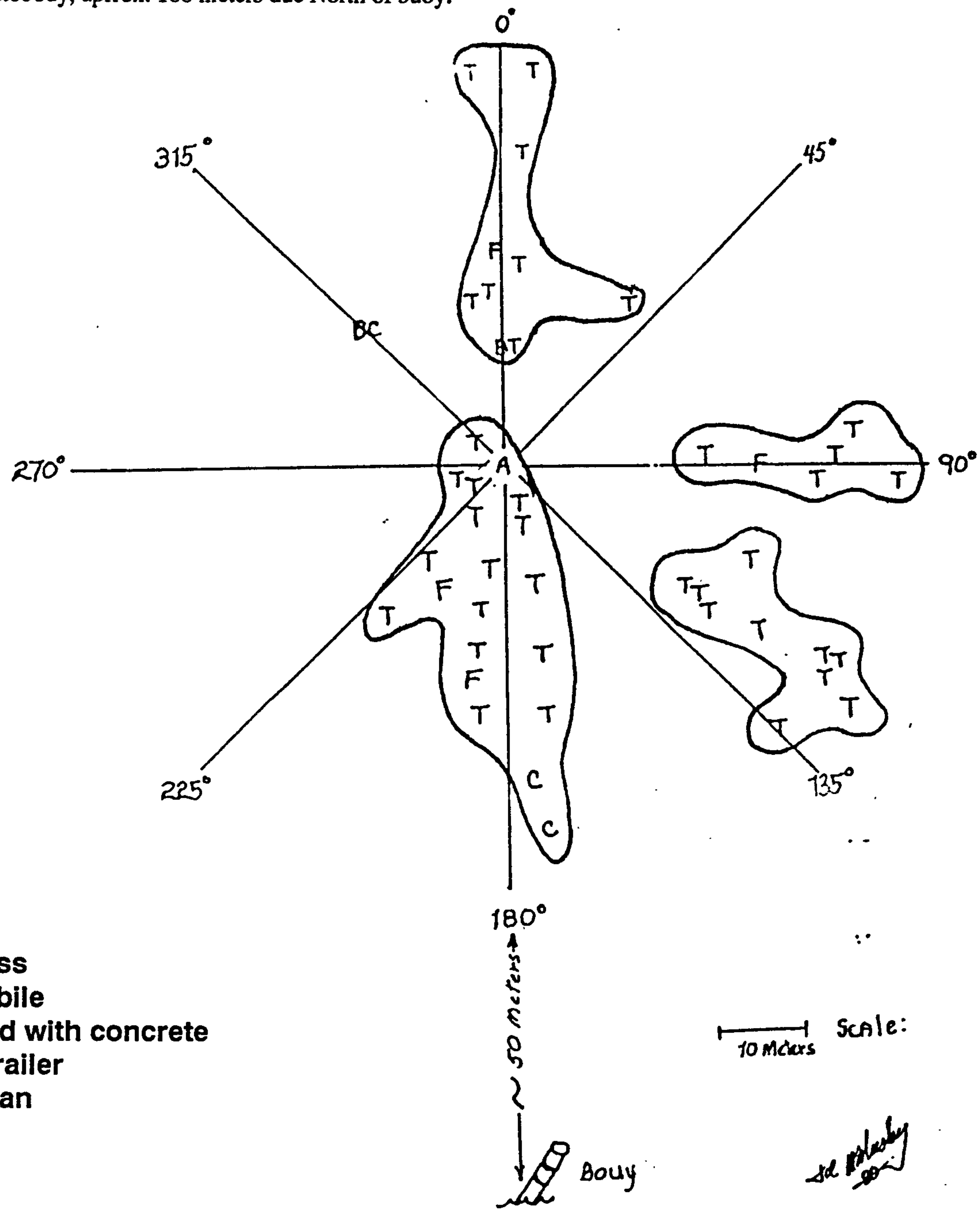
Swim arc until appropriate compass heading back to BM as sighted along the tape is reached. (In this case, it would be to 225°). Then swim towards it, with recorder leading.

The radius of the pattern can be any pre-determined length depending on the area to be surveyed, visibility and current condition. Two dive teams may also work off the same BM simultaneously. Use caution while swimming the arc, since the extended measuring tape may become entangled with obstructions, between the divers and the BM.

Attachment II
Post Deployment Map: POP WARNER REEF
St. Augustine, FL
June 29, 1980 Loran 7980
14585.5
44960.0

Approx. 9mi. at 90° one from Sea Buoy, St. Augustine, FL

This map shows the approximate distribution of artificial reef material as observed by divers, within hour of completion of reef drop. The survey was conducted by teams of divers swimming along a 50 meter tape measure in the direction indicated on the map (azimuth lines). All debris observed in a 10 meter wide path along the azimuth were charted. Bottom flat, with slight current from the south. Center of chart is an autobody, aprrox. 100 meters due North of buoy.



KEY:
T - Tires
F - Fiberglass
A - Automobile
C - Can filled with concrete
BT - Boat Trailer
BC - Beer Can

Mapping - Small Area Survey Grids

Contributed By

Catherine M. Guinon
803 E Park Avenue
Tallahassee, FL 32301
(904) 222-9291
6 April 1986

General Description of the Method & Its Purpose

This method is for mapping a small area such as a small reef. It is done in increments of approximately 25 square feet square grids. The task can be accomplished by a two diver team (speeding up process can be dome with additional divers).

Data to be Collected

-Location of reef (Loran C or lines of position from known marks).
-Degree angles of measurement from center datum.
-Distance of objects along measurement lines.
-Coding of objects type
-Depth and orientation of reef.
-Date and time of sample.
-Description of bottom.

Data Gathering Equipment

-Datum or identifiable Bench Mark. - or Rebar Stake.
-Tape measure
-Data slate
-Compass
-Grid lines or lengths of line, 500 feet.
-Rebar for stakes - need 13.
-Hammer

Minimum Dive Team Description

-Datum recorder
-Tape and slate bearer
-Safety diver
-Boat operator

Sources of Additional Information

None given

Outline of Dive Procedure in Sequence by Tasks

1. Run 100 ft lines with a compass, placing a stake every 25 foot.
2. Establish quadrants by tagging the rebar at each corner of the grid.
3. Set up quadrant 1 datum pt and pound it in.
4. Run tape line at pre-established angles and record.
5. Record finding along tape lines and about 10 feet on either side (depending on visibility) and put on data board.
6. Repeat for each quadrant.

Position Finding

Contributed By

Dennis C.E. Petty

6 April 1986

General Description of the Method & Its Purpose

The responsibility of getting precise location data of a project will be that of the Chief-scientist. Also following a proper grid pattern will be the responsibility of the Chief-scientist; in that he must assure the proper coordinates for each pass are with in the tolerances of the planned procedure.

Accomplishing this task will be dine by balancing several different navigational techniques, to acquire the necessary base information to design a project grid that is reliable. The first procedure is to set out at least four buoys on the boundaries of the planned area to be worked. Taking Loran readings on at least one buoy (to be labeled buoy #1.) and then two compass and radar in line shots on two known permanent navigational objects relative to buoy number one. Radar ranges and bearings will be taken of the other buoys relative to buoy one (#1).

A grid reflecting proportional units will be designed so that entrance points to the operating grid can have radar ranges and bearings relative to buoy one (#1) as a mainstay to the world location; but two other buoys will also be involved in shooting precise angles in locating an entrance to the grid or a object of interest within the grid. Using this method of three buoys (or two buoys and magnetic North) and three angles relative to each other will insure the ability to accurately relocate aspects of a project. All this is to be done with Loran bearings of latitude and longitude, radar ranges and a three arm compass that will fit on the radar's screen.

Data to be Collected

-Precise location of buoy one (#1) relative to known permanent navigational objects.

-Precise location of all other buoys relative to buoy one (#1). Including distance and bearings by radar.

-Designed grid used in the project.

-Names of all persons in each job and the times performing them.

-Any abnormalities seen. (estimated angle to two buoys, with buoy #1 being one of the buoy's sighted on, and the grid line.)

-Visibility, depth and current information.

-Date and time of the project.

Data Gathering Equipment

-Radar, variable distance formatted.

-Loran navigation unit.

-Large plotting board, plastic film covered, and sliding parrell bar.

-Transparent plotting compass with three adjustable arms that will fit on the radar's screen.

-Log book with some blank pages for grid design and information transfer.

-Full set of plotting instruments for the plotting board.

- A good ship compass.

-At least four buoys with six foot (6') aluminum pipe mast, line and anchor.

Minimum Dive Team Description

This method does not involve diving.

Sources of Additional Information

-Lecture on prevenience in 4135 and 4135R classes.

-Lecture specifically on the H.M.S. Foey in 4135.

-Lecture on the survey in Byscane National Park, by the National Park Service.

Outline of Dive Procedure in Sequence by Task

1. Equipment function check out at the shore base.
2. Once the boat is on station the desired spot two anchors will be let out, (fore and aft) the lines drawn taught and secured.
3. Now Loran bearings will be taken and recorded on the big plotting board.
4. Radar ranges will be taken on at least two permanent navigational objects to give distances to the angle legs that the three arm compass will give relating the boat to the navigational objects, and the third leg will be placed on the ship's compass reading. All this data will be recorded and labeled buoy one (#1).
5. Now buoy #1 will be placed over the stern and as close to the stern of the boat as seas will allow.
6. Anchors will be brought in and the boat turned ninety degrees (90) to proceed to buoy #2's position. This will be done by following the new compass heading or plotting the heading into the Loran unit and then watching the compass for insurance.
7. By using the radar's range finding ability the distance can be determined fairly close to exact. Once on station the same procedure for buoy #1 will be followed with the exception that one the angles that the adjustable arm compass will be set on will be that of buoy #1.
8. Buoy two (2) will now be placed over the stern and the position by bearing and distance to buoy one will be recorded. The boat will then make a ninety degree (90) turn and run in that heading until the preplanned distance to buoy three is achieved, then a bearing will be taken relative to buoy one and two. Proof of proper position for buoy three will be attained be trigonometric (see figure 3a) using data from the radar set-up. After proper positioning is achieved buoy three will be placed over the stern. This procedure will be repeated for buoy four except that the buoy will parallel to buoy three and one, making sure a ninety degree angle (90) exists between legs 3-4 and 4-1. Also recorded will be the angles made by the three arm compass relative to the other three buoys.
9. After the buoys are set and recorded a grid must be designed relative too the size and needs of the project. While a grid one meter is desirable it may not be practical or necessary. Once a grid is designed the decision to saturate only portions on the design grid may prove a solution to an old problem: too much ground to cover in too little time.
10. In the case that only portions will be studied it would be necessary to plot angles trigonometrically relative to three of the four buoys. Also radar ranges will provide the distances that will help to prove correct location within the grid pattern.
11. All entrances will have a three way angle code related to a distance from the grid border (see figure 5a) to give conformation that the approach is correct.

Sediment - Bioturbation Rate

Contributed By

James Grace
533 Bryan Street
Tallahassee, FL 32304
(904) 224-9532
3 April 1986

General Description of the Method & Its Purpose

This is a method for measuring the rates and amounts at which newly deposited sediment is reworked by bioturbators. It should be located in a bay or lagoonal area which is currently depositing very fine sand, silt or clay. Two divers could set up this experiment in one hour bottom time. Setting up would consist of placing a layer 10' by 10' square area of fine colored sand gridded every two feet. Core samples taken every one to two days will be used to determine the time it takes bioturbators to convert regular layered sediment into irregular layered sediment, mottles or homogeneous sediment.

Data to be Collected

-Date and time of sampling.
-4 core samples from one square on the grid each time sampled.
-Examination of cores at the lab to determine the amount of movement sand has undergone, based on the amount of mixing.

Data Gathering Equipment

-a ten foot measuring tape
-4 stakes to secure the square
-130 feet of line
-20 to 30 pounds of colored sand or fluorescing mineral sand
-soft sediment coring device (vibracore)
-one floating marker
-low powered microscope for examining the cores in the lab
-slate and pencil and a fine screen sieve

Minimum Dive Team Description

Two divers are needed to set up the experiment. One diver is needed to take cores and record location.

Sources of Additional Information

None given

Outline of Dive Procedure in Sequence by Tasks

1. Measure a 10' by 10' area and rope it off. Grid the area in increments of 2'. Secure a flotation buoy to make the site visible from the surface.
2. Wait 24 to 48 hours to allow the biological activity to return too normal. Using a fine screen sieve, evenly distribute a layer of colored sand over the gridded area approximately 1/4 to 1/2 centimeter thick.
3. Return to the site every 2 days taking 4 core samples from one square marking the squares that have been cored.
4. The core samples should be taken to the lab and examined under a microscope closely noting the lateral and vertical displacement of the sand.

Sediment - Sand Transport

Contributed By

Catherine M. Guinon
803 E. Park Avenue
Tallahassee, FL 32301
(904) 222-9291
12 April 1986

General Description of the Method & Its Purpose

This is a method for determining the rate and direction of sand transport in a given area. Its purpose is to record the erosion factors of the area for future reference.

Data to be Collected

-Location of study site - coordinates or Loran C.
-Rate at which sand is moving, based on date and time from initial placement.
-Direction of transport in degrees.
-Amount of sand deposited.
-Surface area covered by initial placement.

Data Gathering Equipment

(On Attachment Sheet include drawing.)
-Survey sled or Diver Tow device.
-KMB with communication
-Record slate
-Load of colored sand
-Measuring tapes
-Compass

Minimum Dive Team Description

-Sled operator
-Tender
-Boat operator
-Communications/data recorder

Sources of Additional Information

None given

Outline of Dive Procedure in Sequence by Tasks

1. Run initial survey of area to document existing environmental conditions.
2. Deposit sand at dump site and measure area covered.
3. Run survey along coast on the next day (depending on current rate, it may need to be within a few hours).
4. Record sand transport distances and direction for deposit site and time.
5. Map in areas of deposition.
6. Repeat process at appropriate time intervals, continuing to also run the sled survey further off the coast.

Sediment - Settlement Rate

Contributed By

Jim Grace
Florida State University
Tallahassee, Florida
April 1986

General Description of the Method & Its Purpose

This is a method designed for measuring the rate at which sediments (mostly silts and clays) are deposited. It consists of securing a sediment collecting tray calibrated in mm to the bottom and periodically checking the amount of sediment that has accumulated.

Data to be Collected

-Date, time, depth, location and millimeters of sediments accumulated per unit of time.

-At termination of project, sediment sample is take from the collecting tray for later lab analysis.

Data Gathering Equipment

-Sediment collecting tray (old wash tub, sink, etc.)

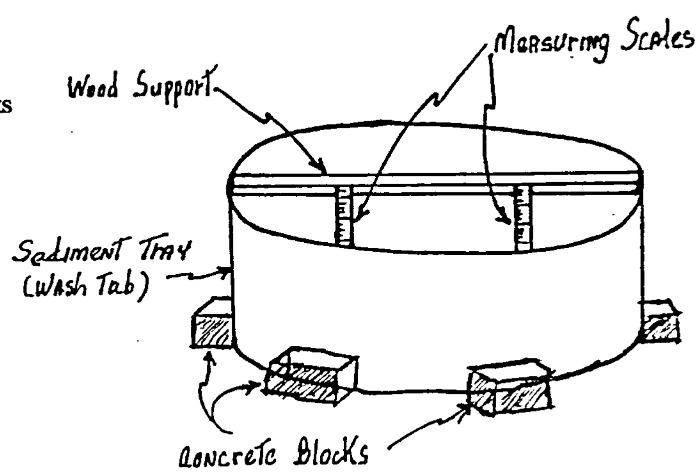
-Two rulers or measuring scales (mm)

-Piece of wood or wire to support the measuring sticks

-Concrete blocks or brick to secure the sediment tray

-Weight (concrete block) and marker buoy

-Pencil and slate



Minimum Dive Team Description

-Two divers could easily preform all operations

Sources of Additional Information

None given

Outline of Dive Procedure in Sequence by Tasks

1. Find a suitable location. Somewhere in the bay away from heavy boat traffic and at least one meter below mean low tide. Be sure to check and monitor compass heading on the way out or record Loran C readings to make relocation easier.
2. Two divers carry down the collecting tray sinking it into the bottom until it is stable and making sure it is horizontal. Secure the tray by placing bricks around the outside.
3. Secure a marker buoy so site can be found easily
4. Visit the site on a regular basis to measure the amount of sediment accumulation. Measurement is made by observing the level of sediment deposit against the scale.

Stone Crab Reef Module - Current

Contributed By

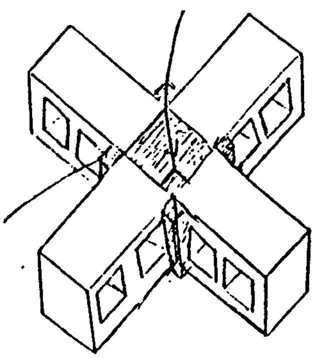
Catherine M Guinon
803 E. Park Avenue
Tallahassee, FL 32301
(904) 222-9291
DATE: 8 April 1986

General Description of the Method & Its Purpose

This is a method for developing a modified version of a stone crab module. Its purpose is to study the variables of current on the individual module and how this variable effects the stone crab.

Data to be Collected

Orientation of module
Direction of current
Hole in which crab is habituating
Size of crab
Sex of crab
Date and time
Water depth and temperature
Location coordinated of test site



Data Gathering Equipment

(On Attachment Sheet include drawing.)
Stone crab module
Current meter
Compass
Data Slate
Ruler

Minimum Dive Team Description

Current and direction recorder
Crab data recorder
Surface support

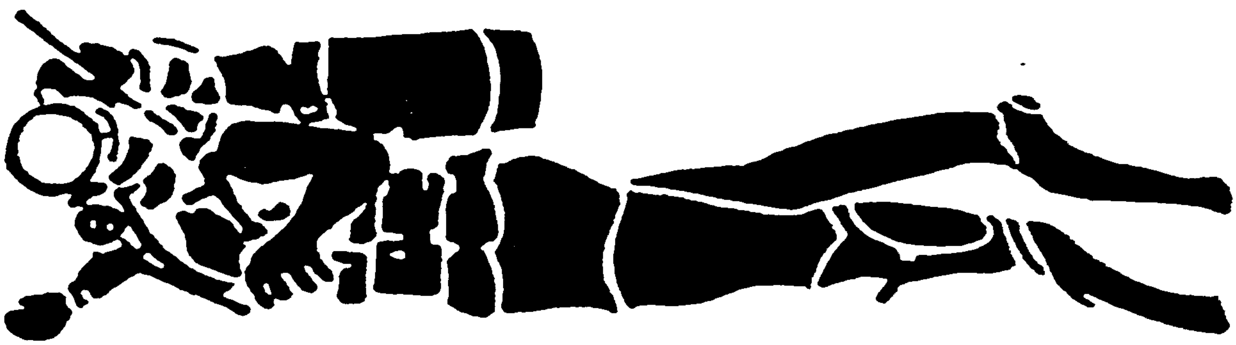
Sources of Additional Information

None given

Outline of Dive Procedure in Sequence by Tasks

(after modules have been deployed).

1. Find pre-recorded drop sight.
2. Dive on modules and record their orientation on a grid slate.
3. Record current direction to and velocity.
4. Measure carapace of each crab.
5. Record which hole the crab inhabited, with respect to direction.
6. Record sex of crab.
7. Record process for each individual module.



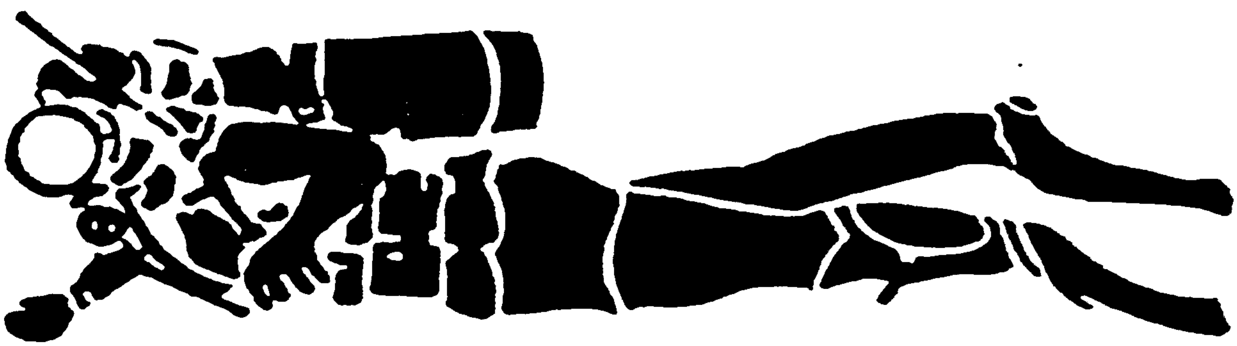
Appendix A

For more information on scientific diving write to:

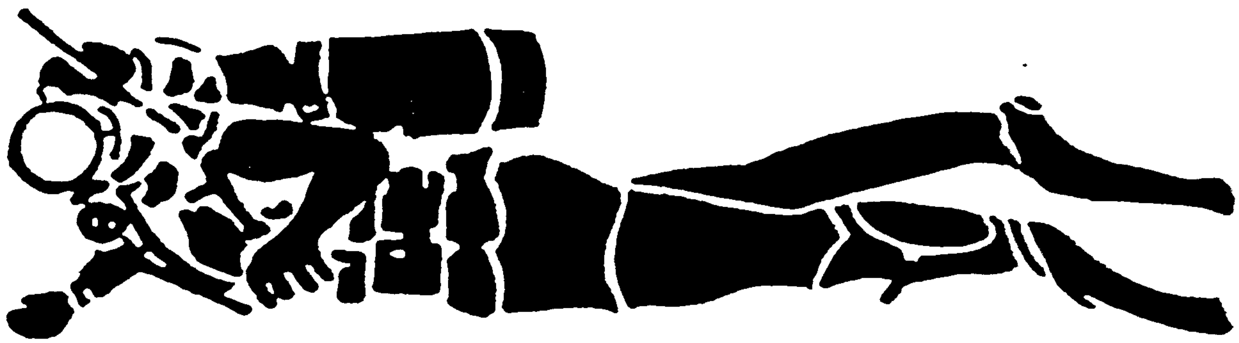
American Academy of Underwater Sciences
947 Newhall Street
Costa Mesa, California 92627

For a copy of "Scientific Diving: a general code of practice", a book published by the Florida Sea Grant College Program, write to:

Florida Sea Grant College Program
Building 803
University of Florida
Gainesville, Florida 32611



Appendix B



REEF RESEARCH TEAM
TIME AND EXPENSE LOG

Name ____________________

Time Period ____________ thru ____________

DATE/ PERSONAL DIVE LOG #	PROJECT					ACTUAL EXPENSES			
	Description	Volunteer Hours	Travel Hours	Boat Hours	Odometer STOP/START	Meals, Lodging	Gas	Boat	Other
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
/ #	☐ Dive ☐ Other ____ Site Desig.								
	TOTALS								

SCUBANAUTS NOT FOR PROFIT, INC.

REEF RESEARCH TEAM

DIVE LOG

Project ____________________

Date ____________ Dive No. ________

Project Leader ____________________

Boat Name ____________________

DIVERS: (author) ____________________ Team Role ____________________

(buddy) ____________________ Team Role ____________________

DIVE: Time IN ________ OUT ________ Bottom ________ Max. Depth ________ Safety Stop ________ ft.

Site Designator: ____________ Placement Name: ____________________

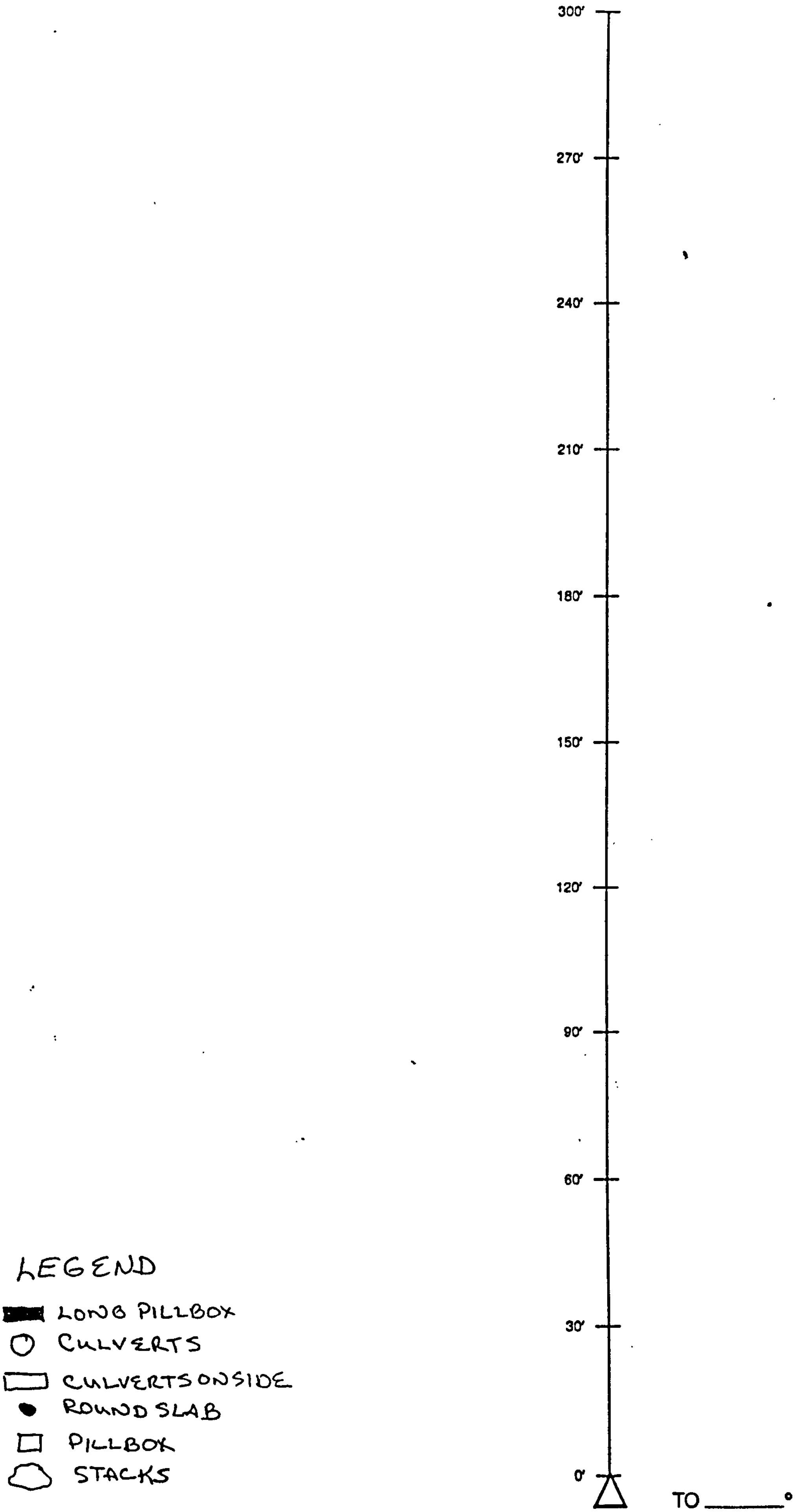
PURPOSE: ☐ Photo ☐ Map ☐ Sediment ☐ Survey ☐ Fish Counting ☐ Other ____________

TERRAIN: ☐ Ledge ☐ Culverts ☐ Wreck, ____________ ☐ Other ____________

TEMPERATURE	CURRENT	VISIBILITY
Air ______° Surface ______° Bottom ______°	(TOWARD) ________°	________ ft.
Thermocline ________° at ________ depth (ft.)	☐ Nil ☐ Slight ☐ Moderate ☐ Strong	☐ Measured ☐ Estimated

AUTHOR'S NOTES	BUDDY'S NOTES

ADDITIONAL DATA ON REVERSE


300'
270'
240'
210'
180'
150'
120'
90'
60'
30'
0'
TO ______°
LEGEND
LONG PILLBOX
CULVERTS
CULVERTS ON SIDE
ROUND SLAB
PILLBOX
STACKS

SCUBANAUTS NOT FOR PROFIT, INC.
REEF RESEARCH TEAM

WATER QUALITY DIVE LOG

Project ______
Date ______ Dive No. ______
Project Leader ______
Boat Name ______

DIVERS: (author) ______ Team Role ______

(buddy) ______ Team Role ______

DIVE: Time IN ______ OUT ______ Bottom ______ Max. Depth ______ Safety Stop ______ ft.

Site Designator: ______ Placement Name: ______

PURPOSE: ☐ Photo ☐ Map ☐ Sediment ☐ Survey ☐ Fish Counting ☐ Other ______

TERRAIN: ☐ Ledge ☐ Culverts ☐ Wreck, ______ ☐ Other ______

I. Water Sample Thermometer No. ______

A. Fifteen (15) feet below surface ______ °F

B. Three (3) feet above bottom ______ °F

C. Thermocline
Depth ______ to ______ Temp ______ °F
Time of Day ______

II. Current

Direction to: ______ °

Speed ft./sec. ______

III. Salinity

☐ Refractrometer
☐ Hydrometer

	Surface Sample	Bottom Sample
Specific gravity	______	______
Temperature of sample*	______ ° F	______ ° F

*Temperature recorded if using a hydrometer

IV. Visibility

	Diver 1 White/Black	Diver 2 White/Black
A. Distance in feet from secchi	______	______
B. 180° d. in feet from secchi	______	______

Calculated: $\frac{(1 \text{ white} + 2 \text{ white}) + (1 \text{ black} + 2 \text{ black})}{4}$ = Reported vis. ______ ft.

AUTHOR'S NOTES	BUDDY'S NOTES

DIVE LOG & DATA SHEET

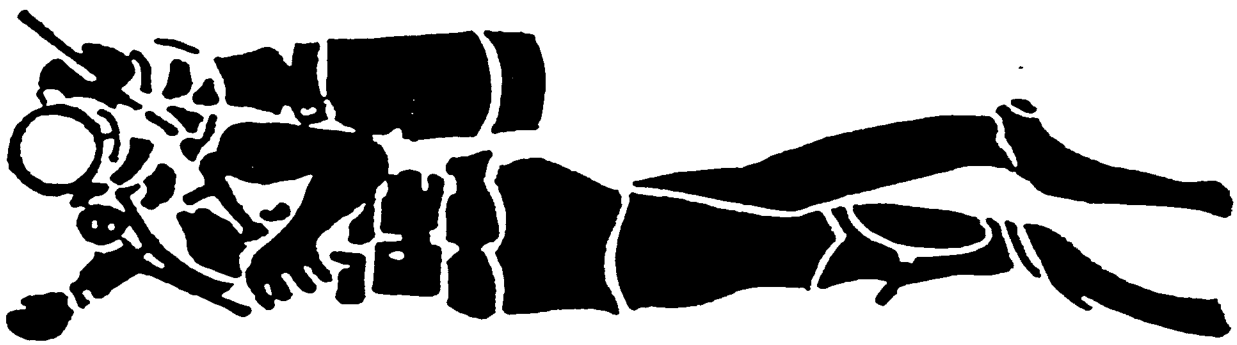
EXACT LOCATION & PURPOSE: DATE:________________

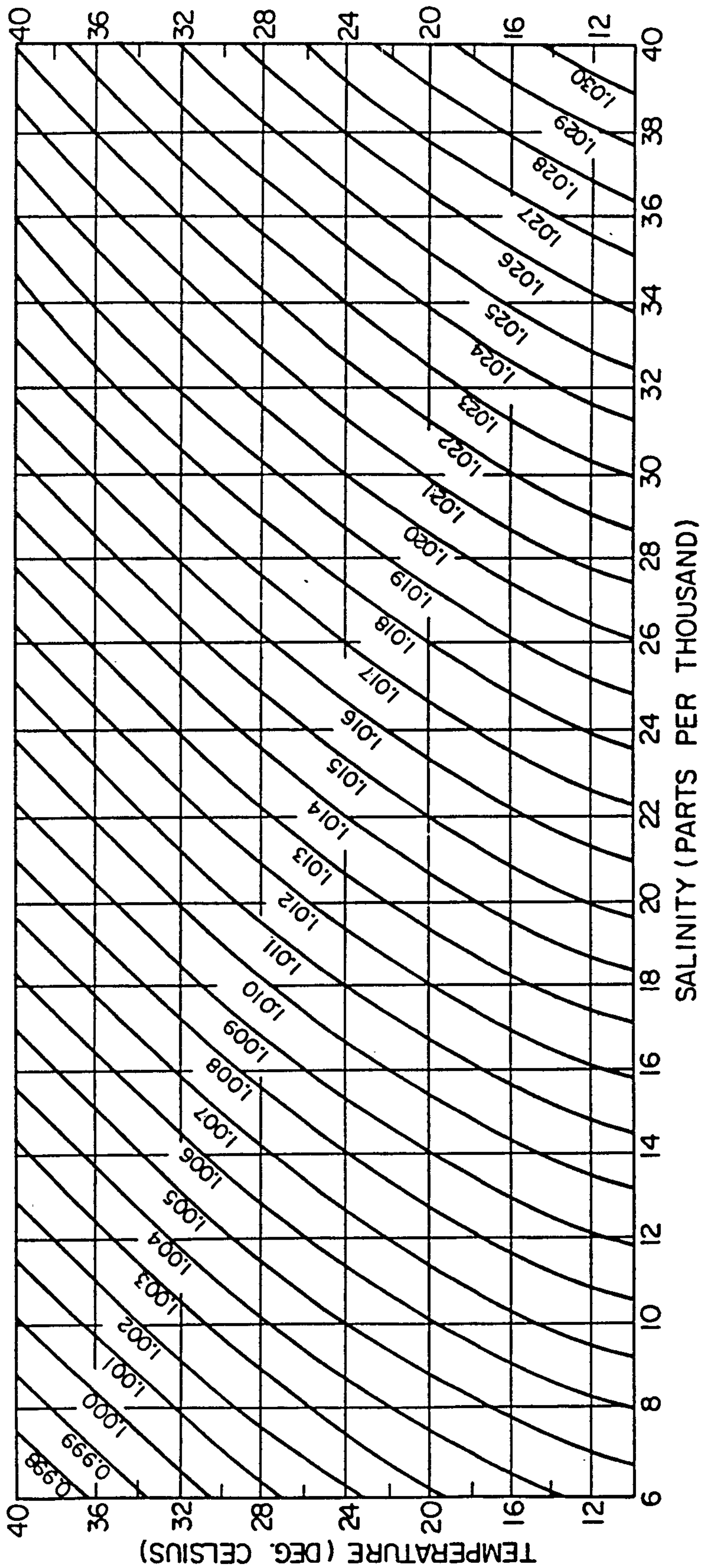
					OBSERVATIONS
NAME(S)					
PLAN ENTRY TIME					
SURFACE INTERVAL					
NEW REPET. GROUP					
INTENDED MAX. DEPTH					
RES. N_2 TIME(RNT)					
PLAN BOT. TIME					
B. TIME END DIVE					
A. TIME BEGIN DIVE					
IN WATER TIME(B-A)					
PHYSIOLOGICAL BOT. TIME (+RNT)					
ACTUAL MAX. DEPTH					
REPET. GROUP					
DECOMPRESS STOPS					

UNDERWATER COMPASS SKILLS TRAINING

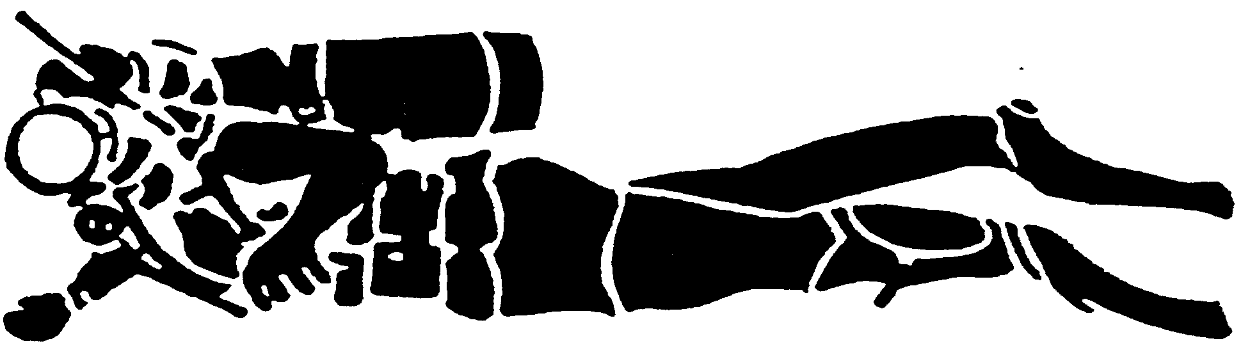
TRIAL NUMBER	1	2	3	4	5	6	7	8	9	10	
START TIME											
START PRESSURE											
HEADING											
ARRIVAL TIME											
ARRIVAL PRESSURE											
POINT OF ARRIVAL											
# OF RIGHT LEG STROKES											
SWIM TIME											
SWIM RATE METERS/SEC.											
PRESSURE CHANGE											
PRESSURE RATE LBS/MIN.											
DEVIATION FROM TARGET (+ OR -)											
METERS/ LEG STROKE											

Appendix C





SALINITY (PARTS PER THOUSAND)
TEMPERATURE (DEG. CELSIUS)
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
12
16
20
24
28
32
36
40
0.998
0.999
1.000
1.001
1.002
1.003
1.004
1.005
1.006
1.007
1.008
1.009
1.010
1.011
1.012
1.013
1.014
1.015
1.016
1.017
1.018
1.019
1.020
1.021
1.022
1.023
1.024
1.025
1.026
1.027
1.028
1.029
1.030



Appendix D

Nitty-Gritty Sand Facts

Sand size:

GRAVEL--------------------------above 2mm
SAND------------------------------0.05 - 2mm
SILT---------------------------------0.004 - 0.05mm
CLAY-------------------------------less than 0.004mm

Sand shape:

Angular:
The result of mechanical (physical) action.
Rounded:
The result of water and/or chemical action.

Causes of shape:

__Water:__
Rocks worn down by the force of the water against them.

__Chemical:__

1. The slow dissolving of certain rocks such as coquina and limestone which react with the normally slightly acidic rain.
2. The more rapid destruction of rocks which occurs in acid rain conditions and/or industrial pollutant environments.

__Wind:__
500 - 1,000 times more effective in wearing down rocks and sand than is water.

__Abrasion:__
The action and movement of rock and sand grains tumbling and crushing against each other.

Color and content:

QUARTZ---------------------clear or glassy grains
FELDSPARS-----------------milky grains, many colors
MICAS------------------------flakes, shiny, not rounded;
Muscovite----------white mica
Biotite------------black mica
HORNEBLENDE----------dark minerals
SHELLS, BROKEN-------milky or light tinted pieces

Origin of Florida East Coast sand:

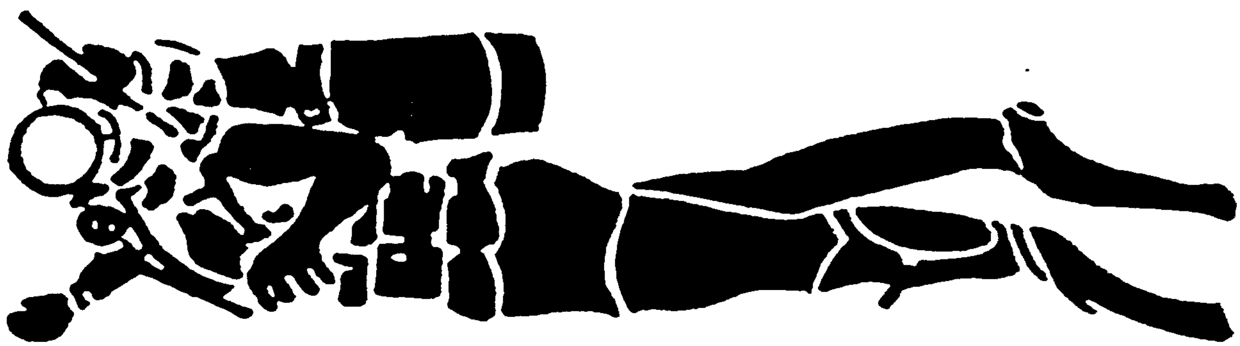
Virginia and the Carolinas. 500,000 cubic yards a year are transported by wave and current action from the above states and into our area.

Loss of sand grain size (water action and abrasion):
0.02% weight/100 miles/in water/per. medium grain

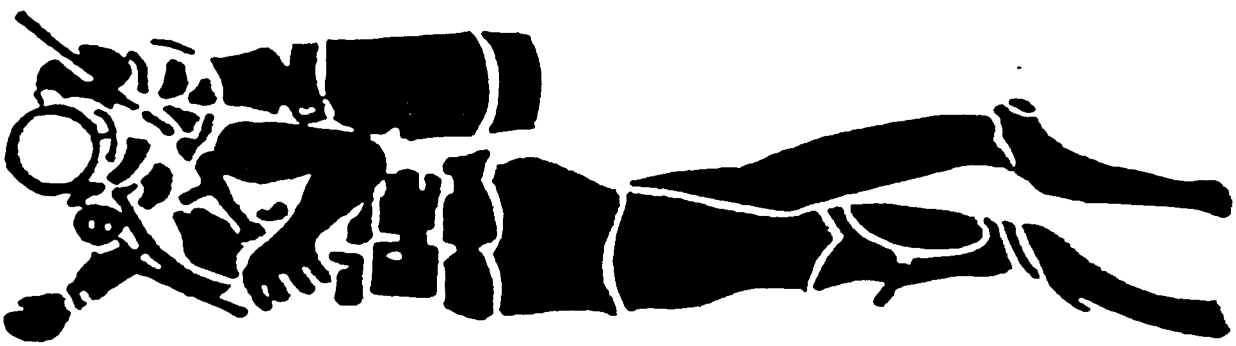
Moh Hardness Scale:

1. talc	4. fluorite	7. quartz
2. gypsum	5. apatite	8. topaz
3. calcite	6. feldspar	9. corundum
		10. diamond

(a fingernail = #2 hardness, a penny = #3, a pocket-knife = #5 1/2)



Appendix E



NCEL Techdata Sheet

Determine Seafloor Soil Properties With Diver Operated Geotechnical Tools

This Techdata Sheet is primarily directed to ocean engineers who are tasked with determining the geotechnical properties of seafloor soils. It reports the development and stocking of six new diver operated tools: an Impact Corer, a Miniature Standard Penetration Test tool, a Vane Shear device, a Rock Classifier, a Jet Probe, and a Vacuum Corer.

A set of six geotechnical diver tools has been developed to provide military divers with the capability to gather marine geotechnical (seafloor soil) data. Up to now, divers have had to use makeshift methods to try to gather information on seafloor soils. The data that can be gathered with this new set of tools can be used by military divers and engineers for site selection; calculating object embedment depths and breakout forces; designing anchoring systems and calculating anchor holding capacities; designing foundations for structures in the marine environment such as piers, sewer outfalls, pipelines, and various other structures; and the design of any device that will interact with the seafloor.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

The set of geotechnical diver tools is a self-contained system consisting of the following six tools packaged in four kit boxes:

Box 1:	impact corer kit (265 lb, 16 ft^3)
Box 2:	MSPT (Miniature Standard Penetration Test) tool kit vane shear tool kit (146 lb, 11.3 ft^3)
Box 3:	rock classifier kit (147 lb, 11.3 ft^3)
Box 4:	jet probe kit vacuum corer kit (450 lb, 32 ft^3)

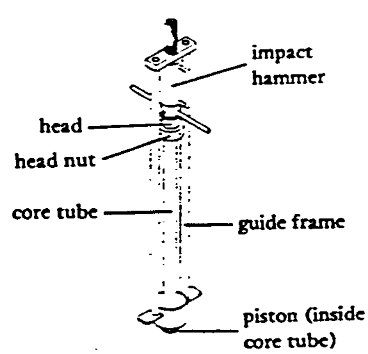
These kit boxes can be transported by military or commerical aircraft, truck, or ship.

The kits contain spare and repair parts, support equipment, and an operation and maintenance manual. Only gasoline (fuel for the jet probe/vacuum corer pump) and a source of fresh water for after use tool cleanup are needed at the site. Two complete sets of the geotechnical diver tools are available for check-out from the Ocean Construction Equipment Inventory (OCEI) maintained by Chesapeake Division of NAVFAC.

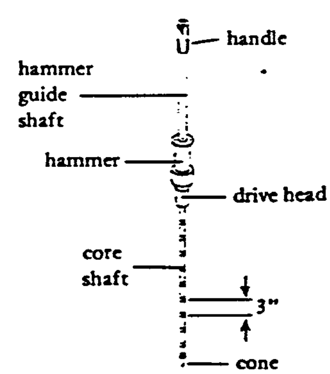
The geotechnical diver tools are designed to be hand-operated by divers wearing wetsuits and three-fingered wetsuit gloves. The tools can be operated from a beach, pier, or diving support craft. The tools are constructed of materials that are compatible with the seawater environment and they can be operated in water depths from 0 to 130 feet and water temperatures from 28 to 90°F.

Each tool is briefly described below.

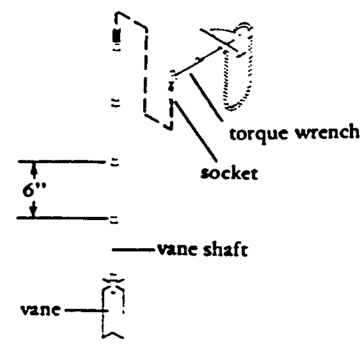
IMPACT CORER – This tool takes a soil sample (core) up to 30 inches long and 1.5 inches in diameter in a clear Lexan plastic core tube. This core tube is supported by a frame which also contains a built-in impact hammer to drive the core tube into the soil. This corer has a piston in the core tube designed to stay at the seafloor surface and create a suction in the tube to help retrieve a relatively undisturbed soil sample. The core is sealed in the core tube and can be shipped to a geotechnical laboratory for testing. The tool is 47 inches long and weighs 16 pounds in seawater.



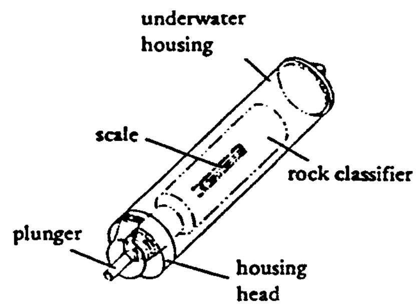
MSPT (Miniature Standard Penetration Test) – This tool takes in-situ geotechnical data in cohesionless soils (sands). The tool consists of a shaft with a cone tip at the bottom and a hammer on a guide shaft on the top. The cone tip is set on the seafloor and the hammer raised to the top of the guide shaft. The hammer is then allowed to free-fall. The number of such hammer blows per 3-inch increment of penetration is counted. The hammer blow counts can be related to relative density. Data can be taken to a depth of 30 inches. The tool is 39 inches long (stored), 68 inches long extended, and weighs 14 pounds in seawater.



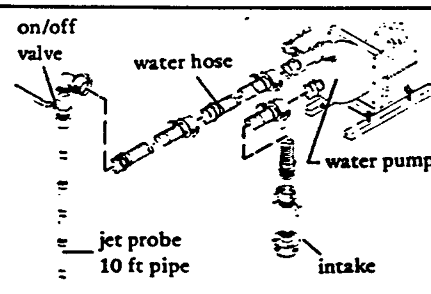
VANE SHEAR – This tool takes in-situ data in cohesive (clay-like) soils. The tool consists of three sizes of vanes attached to 30-inch shafts and a torque wrench that attaches to the top of the vane shafts. The torque wrench is used to rotate the vane in the soil until the soil fails in shear. The torque (in.-lb) required to cause this failure is measured and converted to vane shear strength (psi) through an equation. Data can be taken to a depth of 30 inches. The tool is 34 inches long and weighs 10 pounds in seawater.



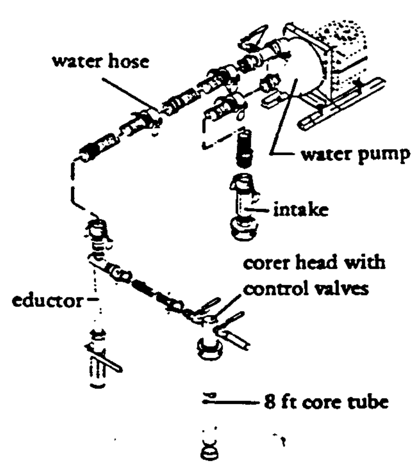
ROCK CLASSIFIER – This tool produces data on the surficial strength of rock. The tool is a standard rock classifier used on land that has been fitted into an underwater housing. The rock classifier works by pressing a plunger against the rock surface; an internal hammer strikes and rebounds from the plunger. A rebound number is read off the classifier's scale and is related to axial compressive strength and the tangent modulus of the rock through charts. The tool is 19 inches long and weighs 3 pounds in seawater.

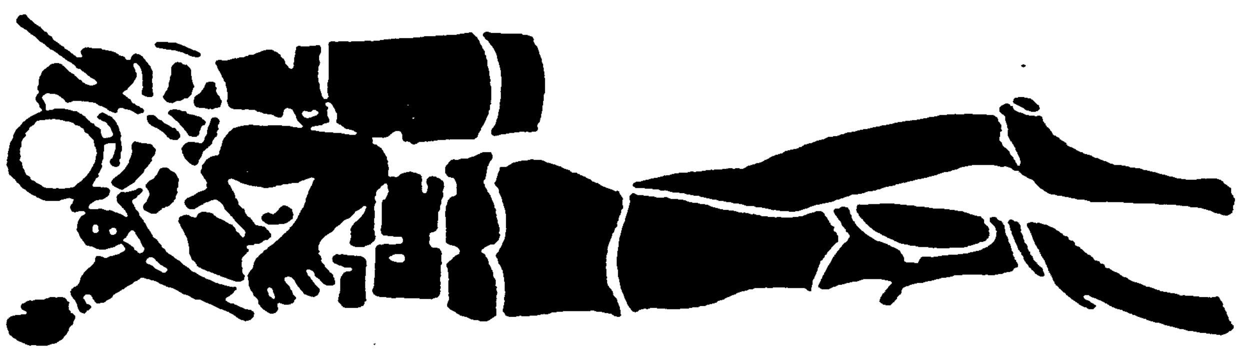


JET PROBE – This tool is used to determine sediment thickness by probing the seafloor to locate bedrock or other hard layers. It can also be used to verify subbottom profiler data. The tool consists of a 10-foot length of pipe with an on/off valve attached to a waterpump by 150 feet of waterhose. The tool is 11 feet long and weighs 15 pounds in seawater. The waterpump weighs 43 pounds.

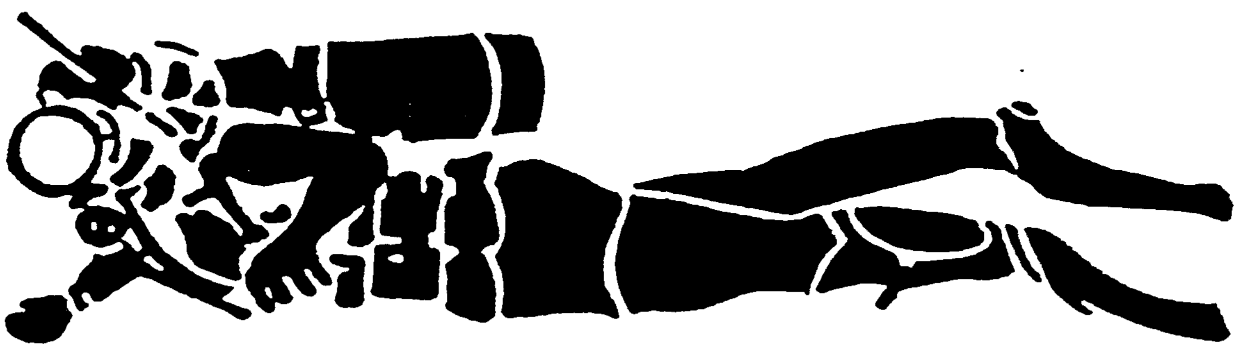


VACUUM CORER – This tool takes an 8-foot core, 1.5 inches in diameter, that is fairly disturbed (due to the effect of the vacuum). The tool consists of an 8-foot clear Lexan plastic core tube and corer head attached to an eductor by a vacuum hose. Water is pumped through the eductor to create a suction in the vacuum hose and core tube. The vacuum helps the core tube penetrate the seafloor and allows divers to take an 8-foot core. The core can be sealed in the core tube and sent to a geotechnical laboratory for analysis. The type of analysis that can be done is limited by the amount of disturbance. The tool is 9 feet long and weighs 18 pounds in seawater.





Appendix F



FLORIDA COOPERATIVE EXTENSION SERVICE
Marine Advisory Program
A FLORIDA SEA GRANT PUBLICATION AUGUST 1979 MAFS-20

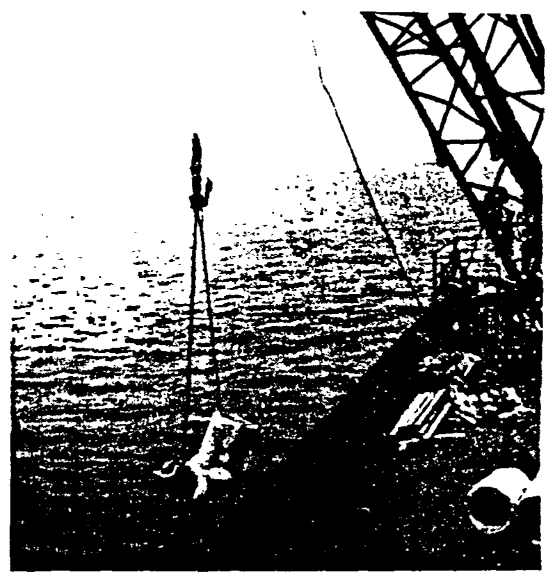
ARTIFICIAL REEF SITE SELECTION AND EVALUATION

By: Heyward Mathews*

INTRODUCTION

One of the most exciting marine fishery management tools in the last few decades is the artificial reef. When properly built in optimum locations, these reefs can create an oasis of fish on what was formerly a biological desert.

In recent years coastal communities around the country have started artificial reef building projects. Unfortunately, some of these projects were failures or did not realize their full fish habitat potential due to improper site selection at the beginning of the project. With proper site selection an artificial reef can last indefinitely. Improperly sited it may last less than six months.



PHYSICAL LOCATION

One of the main reasons for building an artificial reef is to attract food and game fish to a location easily accessible to fishermen and sport divers. With this in mind, planners should find a site that is easily located, with a minimum of travel time and fuel consumption.

Wherever possible, a reef should be located directly offshore from the channel or inlet where most fishermen will be departing. Many anglers utilizing an artificial reef will have small inexpensive compasses, seldom corrected or even checked. For this type of angler, a compass course such as 147° or 219° will decrease the likelihood of his finding the reef if it is more than a few miles offshore. A reef that is due south, east, or west from a sea buoy is usually best. However, a bearing like southwest or other major compass point is still much easier for small boaters than some odd number.

In locating an artificial reef directly offshore from the channel or inlet, care must be taken to avoid interference with navigation. If the area is frequented by large ocean-going vessels, there is the hazard of small boat anglers being run down by a large ship during fog or on a dark night. Such a location requires a lighted buoy greatly increasing the original cost and maintenance. Once the reef is constructed it probably will have many small boats anchored over it both day and night.

Another important consideration is the commercial fishing activity in the area. It is best to avoid an area used for purse seining, drift netting, or trawling to avoid conflict with commercial fishing interests and possible net damage. In most areas the local commercial fishing interests will cooperate and point out which areas they do not fish. Many areas will already have some existing obstructions that prevent net use anyway, and such

*Professor of Oceanography, St. Petersburg Junior College obstruction areas make ideal reef locations (assuming the substrate is firm).

A final consideration is to avoid areas with strong tidal currents. A tidal current will cause erosion along alternate sides of the reef. This can cause reef materials to slowly work down into the substrate. A constant current from the same direction is usually not a serious problem. Since many of the benthic invertebrates on an artificial reef are filter feeders, a reef with its long axis running at right angles to the prevailing current would be more productive.

DEPTH VS DISTANCE OFFSHORE

A very important consideration in reef site selection is water depth. In coastal areas water depth is normally a function of the distance offshore. Therefore, water depth and distance offshore must be considered together.

As a general rule, a shallow water reef in depths of 10 to 15 meters* will not attract the large benthic species common to reefs in 20 to 40 meter depths. Shallow reefs will often support a larger total fish biomass, but most anglers are more interested in catching a single ten pound fish than ten one pounders.

An ideal site is one with 30 to 40 meter depths only a few miles offshore from the inlet or harbor. However, in areas with a wide continental shelf, 30 to 40 meters of depth is seldom found less than 75 to 100 miles offshore. For that reason, some type of compromise between depth and distance offshore is required. This is best solved by building several reefs to accommodate different user groups. Deeper reefs farther offshore provide larger individual fish for larger boats. Shallower reefs closer to shore attract smaller fish for smaller boats. Wherever possible the small boat reef should be in sight of land.

The depth of the reef site is also important in the choice of reef building materials. In this respect, however, the average wave energy as a function of water depth is of primary importance.

In the open ocean a wave travels free of the bottom when the depth of the water is greater than one half the wave length. Once a wave enters water less than ½ the wave length it begins to interact with the bottom and any structure on the bottom. For example, a wave with a 20 meter length will begin to "drag" the bottom at a depth of approximately ten meters. This not only stirs up the bottom sediment around the reef but can actually shift low density reef materials about and even move them off the reef site entirely. Several artificial reefs have been built, only to discover a year later that the entire reef was scattered out of the original drop site and, in one case part of the reef ended up on a public beach. This type of failure could seriously hamper future reef building projects in a given area and elsewhere.

Early in the project, planners should determine the average wave length for a range of storm waves, and some estimate should be made of what length waves probably would occur during a ten year storm cycle. This information can be obtained from the National Oceanic and Atmospheric Administration (NOAA) hydrographic offices. If the average wave length in such a storm is 50 meters, high density reef materials such as concrete and steel hulls should be used since the reef would be only 25 meters deep or less.

With high density reef materials, the wave energy problem is not as serious, and in most coastal areas, depths as shallow as ten meters are safe. An exception might be some exposed Pacific coastal areas like in California or Hawaii.

Auto bodies would normally be considered low density reef materials because the major portion of the car body is very thin metal. The auto frame itself is high density, but tends to separate from the body sections after a few years in sea water. P.V.C. tubing used in structures such as the "Prentiss" reef is also considered low density material as well as automobile tires and wooden hulls. One way to utilize a variety of reef materials is to build several reefs at varying depths simultaneously. On the deeper water reef (30-40 meters) use low density materials like auto tires, and on shallower reefs use high density materials like culvert and concrete rubble.

SUBSTRATE

Once the above factors have been considered the next step is to go out to the selected area and make an underwater survey of the bottom. A diver/biologist can make a general biological assessment of the benthic communities present, but if a biologist is not available, then an experienced diver would be the next best choice.

The types of substrate to avoid are mainly soft sediments (clay or silt size particles) and bottoms that are already biologically productive.

*1 meter = 39.37 inches or 3.208 feet

To determine the bearing capacity of the bottom a diver should probe the substrate either by hand or with a metal rod. As a general rule, a suitable bottom is one where the hand will not push down into the bottom past the wrist in a single push. If the hand penetrates beyond the wrist (with fingers extended) the bottom is probably too soft and will result in much of your reef effectiveness being lost soon after construction. In one case off the Florida east coast, a group built a reef in such a soft substrate that one year later no trace of the materials remained about the bottom. In most areas the bottom will be fairly firm for long distances with only an occasional soft spot. In other locations one may spend several days locating a suitably firm bottom.

The idea of selecting a site without existing productive benthic communities may seem strange. It would seem logical to try to improve on a productive area. However, while an artificial reef can provide more niches and habitat than a natural reef, the improvement will not be that significant in most locations. If a bottom area is already productive, then leave it alone, and select a barren sand or shell bottom where the improvement and additional habitat will add to the existing situation. A grass bed or rock outcrop already provides habitat, while a barren sand bottom has almost none at all. So the total habitat and, therefore, the total fish biomass of a given bottom area can be improved best by adding habitat where it does not exist or is scarce, rather that slightly improving an already productive location.

In many areas there may be rock or hardpan strata that will intersect the bottom surface at given points offshore. Where this occurs, a good practice is to move up slope from such an outcrop and locate a site with 10 to 30 centimeters of sand or shell over a rock foundation. This will assure that reef materials can sink no more than a short distance into the bottom, and often the current action around the reef materials will expose the rock itself, making additional habitat.

In one case of poor site selection in the Florida Keys, a tire reef was dropped on a grass bed adjacent to a coral reef. The unsecured tires not only damaged the grass beds, but some shifted and began to batter down the coral heads.

Firm sand or sand/shell combinations are the most suitable substrates for high and low density reef materials. Low density materials like car tires often only become relatively stable on the bottom when they become imbedded in the sand.

EXACT LOCATION

Once a suitable reef site has been selected it is vital that the spot be precisely fixed. All the careful steps in site selection can be totally negated by being a few hundred yards off when actual construction begins. In most states the necessary construction permits must show the exact location, as do permits from the U. S. Army Corps of Engineers and Coast Guard.

Time and distance runs from a known location are never accurate enough for reef site selection, nor are Loran A coordinates. If the reef site is within site of land with prominent landmarks, then horizontal sextant angles will give enough accuracy for site location. If the site is farther offshore, then Loran C is the only alternative. The same Loran C set should be used for the original site selection dives and the actual buoy placement prior to the first drop.

REEF PERMITTING

Permission must be received from both the U.S. Army Corps of Engineers and the appropriate state permitting agency to construct a marine reef. Regulations of each agency are available upon request.

INITIAL BIOLOGICAL REPORTS

Most permitting agencies will expect a biological report on the reef site as a part of the original permit application. This report also provides a good record of productivity of the site prior to reef construction for later comparison.

The initial survey should include a list of both invertebrates and fish species and some measure of abundance. If the above suggestions are followed, the initial biological report should be simple because the ideal reef site will have only a minimal plant and animal population prior to construction.

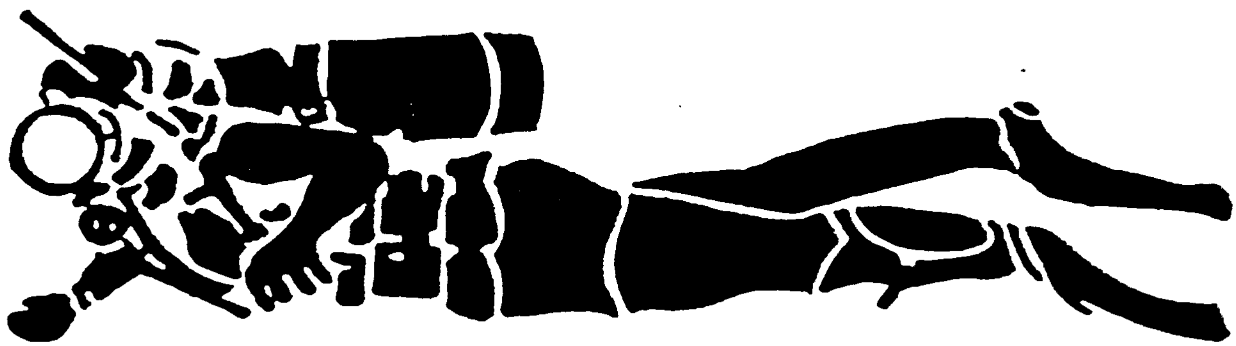
Once the reef is built, a series of fish counts should be conducted to evaluate the reef's effectiveness, and if personnel and funds are available, primary production and invertebrate populations should also be measured. If the reef is sited and built properly, the "before" and "after" comparisons should be so impressive as to warrant additional reef building projects.

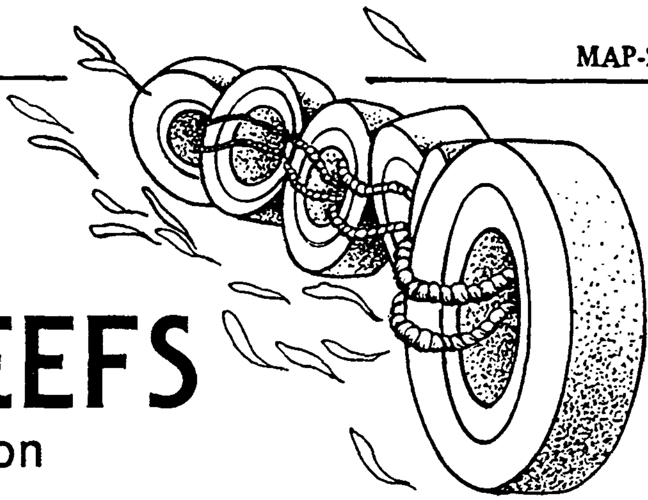
The State University System of Florida Sea Grant College Program is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number 04-8-M01-76 under provisions of the National Sea Grant College and Programs Act of 1966. This information is published in cooperation with the Florida Cooperative Extension Service, John T. Woeste, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners cooperating. Printed and distributed in furtherance of the Acts of May 8 and June 14, 1914. The Florida Sea Grant College Program is an Equal Employment Opportunity-Affirmative Action Employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex or national origin.

Copies available from: Marine Advisory Program, G022 McCarty Hall
University of Florida, Gainesville, FL 32611

This public document was promulgated at a cost of $22.05, or 4.4 cents per copy, to provide information concerning artificial reef site selection and evaluation. Cost does not include postage and handling.

Appendix G





ARTIFICIAL FISHING REEFS

Materials And Construction

Dr. Heyward Mathews

INTRODUCTION

Artificial reefs, when sited and built correctly, have long been known to attract food and game fishes into areas easily accessible to fishermen. The effectiveness of reefs, however, depends greatly on the site, the type of materials used, depth, configuration, and local oceanographic conditions. In some instances, considerable amounts of time and money have been spent only to have the reef later destroyed or become less useful than expected.

The purpose of this publication is to survey the more common types of artificial reef materials in use today and to discuss some of the advantages and disadvantages.

Artificial reefs can be divided into three general categories: 1) Bottom reefs; 2) Mid-water reefs; and 3) Surface attractors.

Bottom Reefs

Artificial reefs built directly on the sea floor are by far the most common type of reefs built in the United States today. These reefs can be subdivided into two main categories: low density and high density materials.

Low density materials, have low mass to volume ratio such as scrap tires; white goods, such as old stoves and refrigerators; and car bodies. High density materials include concrete, heavy fiberglass, steel, and other dense materials that generally do not need additional ballast to remain in place on the sea floor.

Low Density Materials

Scrap Tires: The use of scrap car and truck tires for artificial reef building in this country probably began in the late 1950's and early 1960's. Tires once worn past the recapping point are readily available and generally can be obtained in large quantities at no cost other than transportation and preparation. They are almost impervious to decay in sea water, so the life expectancy of a tire in sea water is probably hundreds of years.

Scrap tires have been used in a wide variety of configurations throughout the country, but they have become probably the most troublesome of reef materials. A car tire weighing some thirty pounds in air will often weigh only five to eight pounds in water. Consequently no matter how many tires are put together in a bundle, the whole structure will still be very easily moved by wave surge or bottom currents. As a result, tire reefs have caused some problems in Florida and on the Pacific Coast when built where storm surges can dislodge the units.

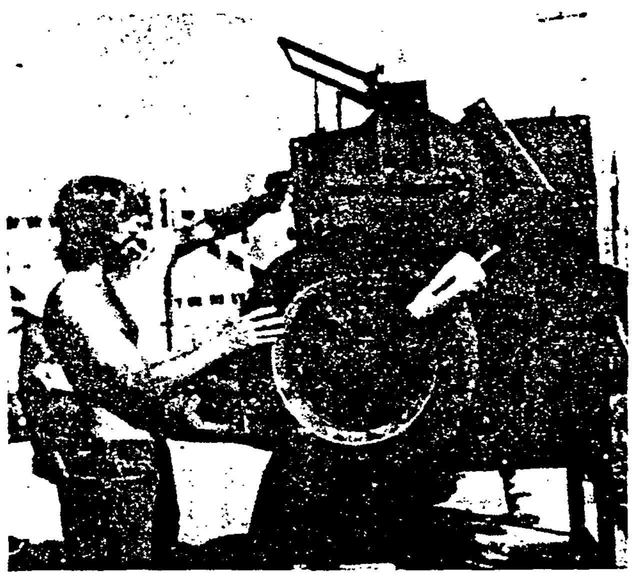


Fig. 1 Tire Cutter

Florida Cooperative Extension
Marine Advisory Bulletin

September 1983

In addition, a single passenger car tire will trap enough air to hold up to twenty-five pounds of concrete if some type of vent is not cut into the top. Venting of trapped air has been done by using a hole saw, chain saw, hydraulic or pneumatic punch, or by splitting the tire completely in half with a tire cutter (Fig. 1).

Once all air is allowed to escape, the tires must then be bound to provide a profile up off the bottom as well as inside hiding places. Single tires produce very poor results. On a hard bottom, single tires will not remain in place during periods of heavy bottom surge or strong currents.

One of the earliest and most common tire units consists of three or four tires standing upright with a reinforcing rod through the bottom and concrete poured into the bottom to cover the rod completely (Fig. 2).

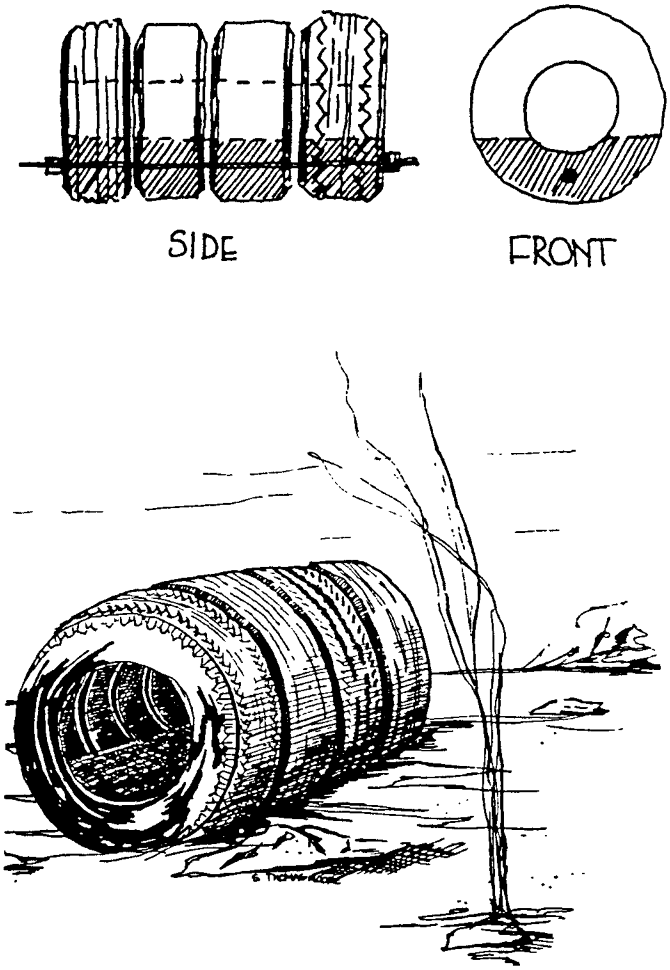


Fig. 2 Typical 4-Tire Unit (Drawing: S. Thomas Moore)

Two people can easily load it onto a barge or similar vessel using a 4-foot section of 1-inch pipe as a handle. This type of tire unit requires a considerable amount of time and labor as well as the cost of the concrete and reinforcing rods. Also, since these units do not pile up well, they offer only a low profile habitat which is not as effective as one with a higher profile. To achieve maximum effectiveness, these units should be dropped as close together as possible. The dropping vessel should be anchored, or a float dropped, and all units dropped around the float. If possible, the vessel should be anchored fore and aft to avoid scattering the units. This type is most stable when positioned on sand bottom so it can sink six to ten inches into the substrate.

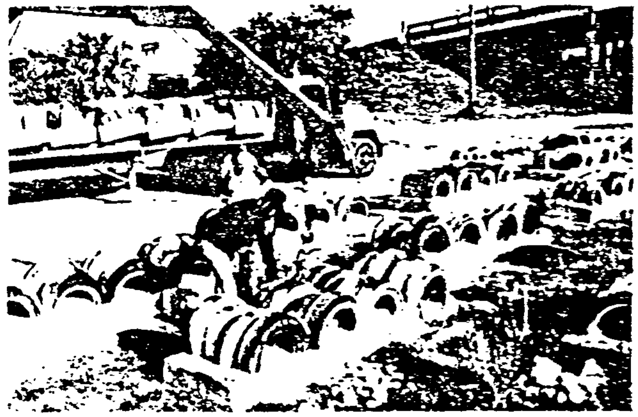


Fig. 3 Ft. Pierce Tire-Concrete Unit

An effective modification is one developed by the Ft. Pierce Recreation Department, Ft. Pierce, Florida. Twelve tires were positioned upright in a wooden form. Approximately one-half cubic yard of concrete was poured around and inside the tires to form a 3-by 9-foot concrete slab from which the tires project upward (Fig. 3). Individually, this unit does not offer much advantage over the single four-tire unit, but it does lend itself well to multi-unit structures. In depths of 50 feet or more, this type of multi-unit appears to be rather effective. It would probably not be very cost-effective, however, if the concrete had to be purchased.

The cost of this particular unit was kept down by placing the forms at a concrete plant and filling them with leftover concrete from returning trucks. Pinellas County, Florida, has obtained numerous buoy sinkers in a similar way by placing a mold at a concrete plant.

Other multi-tire units have been used around the country, some standing up three and four tires high. These have had limited success in fresh water lakes without long wave action but tend to fall over in coastal waters and lose much of their effectiveness. They are not very cost effective when the labor costs are added and have a limited life span when reinforcing rods are used to hold the structure upright because the rods eventually rust and the unit falls apart.

White Goods: Discarded stoves, refrigerators, bath tubs, commodes, washing machines, and similar appliances, at first seem like good reef materials because they are readily available in moderate quantities and the porcelain does slow down the destruction by rusting in sea water.

The problem is, however, that stoves and refrigerators have large amounts of insulation that provide air traps. If concrete ballast is used, then much of the inside space is filled. White goods also provide rather limited hiding spaces for fish, even when the doors are removed, because fish will generally avoid "dead-ends." At one time, it was thought that the encrusting organisms would establish a firm base that would remain even after the metal rusted away. This may be true in tropical areas where coral growth is very rapid, but even in south Florida, the entire profile is lost in two to four years when the thin metal deteriorates. Experience has shown that white goods are not worth the labor involved in their collection, preparation, and transportation to the site in terms of years of use and fish habitat produced. Some states, like Florida, have simply refused to permit white goods for artificial reefs.

Car Bodies: Some of the first artificial reefs in the United States were made using old car bodies. Alabama and Florida once had several large car body reefs that for some years were very effective fish attractors. Unfortunately, the metal in these car bodies was thin and often already badly rusted even before they were placed in the ocean. These reefs soon rusted away to small sections that sank into the substrate, often leaving no trace whatsoever after five to seven years.

Recent changes in the pollution laws require that prior to dumping, the rear ends, transmissions, and engines be de-greased. In addition, all seats and headliners must be removed, so the labor cost soon becomes excessive. Also, car bodies have thinner metal than in the early 1960's, so modern car bodies have an even shorter life span in sea water.

As with white goods, it has been proven that the idea that marine growth over the metal prolongs the life of car bodies is in error. Car body reefs are simply not cost effective and are very short lived.

High Density Materials

Concrete Culvert: The use of concrete culvert probably began in the mid and late 1960's. It can be obtained in most urban areas where road construction is common, and broken or chipped sections of concrete pipe can often be obtained at no cost from manufacturing plants.

Concrete culvert has a very long life span in sea water. So, if properly sited, a culvert reef will remain effective for several thousand years at least. For best results, the culvert should be piled up as high as possible, preferably 8 to 12 feet above the bottom. Often the effectiveness of culvert can be increased by placing a smaller diameter culvert inside a larger one. Care must be taken to avoid placing solid culvert up on end; this will provide a stagnant water area that will collect only silt. Additionally, fish tend not to go down into such a blind alley. Consequently, when culvert is dropped from a barge, it should be released so it will land at an angle or horizontal. This is particularly a problem with short sections of 48-inch and larger diameter pipe.

If the unloading vessel cannot be anchored fore and aft, then a marker buoy should be used to insure the entire load is placed in a pile. Even a small swing of the vessel at anchor will result in considerable scatter and a drop in effectiveness. A successful configuration built in Pinellas County, consists of circular clusters 30 to 50 feet in diameter spaced 50 to 70 feet apart. Culvert reefs are permanent and require relatively limited amounts of labor; however, they do require heavy equipment to load and unload.

In Pinellas County, an artificial reef construction program has become a permanent municipal function. New road construction bid specifications require that all old culvert removed be made available to the reef project. The contractor provides the loading at the construction site, and county trucks transport the culvert to the waterside staging area. In heavily urbanized areas where landfill space is limited, construction companies are often willing to transport old culvert to a staging area free of charge. Concrete culvert is probably one of the most effective reef materials in use throughout Florida and elsewhere around the country.

Bridge Rubble: One of the least expensive types of artificial reef material is concrete and steel rubble from bridges. This material is not always available but whenever a large bridge is slated for removal high priority should be given to making a reef from the rubble. Often building a reef from the old bridge is the most economical means of disposal because it can be removed directly from the bridge site and dumped by barges in larger sections than would be possible with truck transported land disposal. As with culvert, the key is to achieve a high profile by careful off-loading on the reef site. When possible, it is advantageous to have reef building personnel on board the vessel to insure that the material is off-loaded in a way that insures maximum profile. If the materials are scattered on the bottom, then most of its effectiveness as a fish habitat will be lost.

With concrete materials, this type of reef has an infinite life span when built on an appropriate site. It can be built off high energy shorelines, but should not be combined with any breakwater or erosion control structures because the shallow depths required for erosion control are less than optimum for fishing reefs. Steel bridge structures are also very effective as reefs but have a shorter life span in sea water. The heavy steel used in bridges generally has a life span of twenty to thirty years, long enough to justify its transport cost in most locations. Wooden bridge pilings, however, are normally not recommended for reefs because of their low density on the bottom and a tendency to shift during periods of heavy wave surge.

Pre-formed Designs: Several pre-formed concrete reef structures have been used with some success around the country. Back in the mid-1960's, a common reef structure was the "Japanese Pill Box" design. This structure was a copy of some early designed units built in Japan and consisted of a concrete box 4 feet wide, 10 feet long, and 3 feet high with large diameter holes in all sides (Fig. 4).

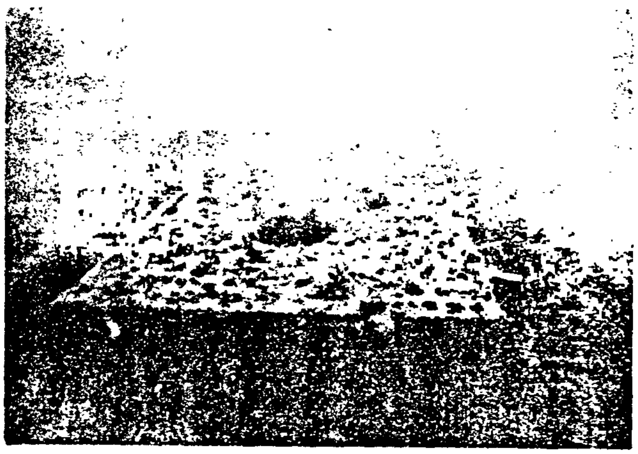


Fig. 4 Japanese "Pill Box" Unit (Photo courtesy Dr. Dan Sheehy) Copyright - Aquabio Inc. 1981.

These units were not only rather expensive to construct, but they also required careful handling in both on-loading and off-loading at the reef site. Since they were rectangular in shape, they could, in theory, be stacked up to provide excellent profile. In actual practice, however, this ideal configuration was seldom achieved. Modern equivalents to these custom built units can often be found at a construction site as junction boxes for large diameter culvert. Similar units have been used with pyramid or dome shapes. At present prices for concrete and labor, these units are expensive and probably not cost-effective when compared with other materials.

A six-pointed concrete unit, similar to a child's jack, has been used off south Florida. However, this unit was only effective when interlocked into some type of structure that extends some distance off the sea floor. Actually placing these on the bottom into such a configuration requires careful planning and specialized equipment.

In Japan, where most of these designs originated, very large barges are used with enormous cranes capable of placing whole structures on the bottom in one lift.

Mineral Waste Aggregates: This is a relatively new type of reef material utilizing fly-ash from coal fired power plants. Using a patented process, chemicals are mixed with the fly-ash to produce a substance that hardens much like concrete. This material appears to be stable in sea water and can probably be formed into a variety of structures; however, the initial tests have been with solid square and rectangular shapes (Woodhead, 1979). This material offers some exciting possibilities for the future because construction costs can be kept down and a waste product recycled.

Fiberglass/Reinforced Plastic: This material has been used extensively in Japan and was recently introduced into the United States by Aquabio, Inc. Presently it is being evaluated by Aquabio, Inc. under a grant from the National Marine Fisheries Service.

The fiberglass reinforced plastic (FRP) material has the advantage of being impervious to sea water and possesses very high strength. A variety of designs use this material. The most common is a series of open weave cylinders stacked up in a pyramid structure four cylinders high (Fig. 5). The whole pyramid is fiberglassed together into a single unit and then concrete is poured into the bottom cylinder for ballast. Air bags are used to provide flotation for the units during towing out to the site where the air is released and the whole unit sinks to its place on the sea floor. The "open space" aspect of this unit makes it very effective as a fish attractor and apparently will have an infinite life span when sited correctly. Since it is presently only manufactured in Japan, it is not yet readily available in Florida.

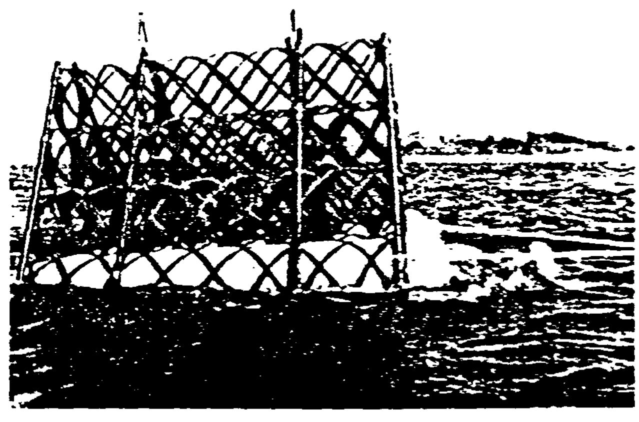


Fig. 5 Fiberglass Reinforced Plastic Reef Unit (Photo courtesy Dr. Dan Sheehy) Copyright - Aquabio Inc. 1982.

Discarded Fiberglass Structures: In Florida, there are numerous boat building firms that construct fiberglass hulls. One part of this industry involves large fiberglass molds to cast the hulls. When the hull design is changed, the old mold is disposed of, and can often be obtained free for reef materials. These have been used very effectively in Pinellas County and, again, they should have a very long life span in sea water. Often these hull molds, and used or damaged fiberglass hulls, can be greatly improved by cutting various size holes all along the structures while maintaining their overall strength.

P.V.C. Reefs: The use of polyvinylchloride pipe is not a new idea. In Destin, Florida, commercial fishermen collect scrap plastic pipe sections which they put together in the form of "Christmas trees" and set into concrete bases. These units can be easily transported by small boats, and, if they are arranged properly in water deep enough to avoid wave action, they can be very effective fish attractors.

Another design, the "Prentis Reef," has been patented but as yet, not adequately tested. It involves a six-sided PVC junction in the 3-4 inch diameter range from which a large "tinker toy" design can be constructed above water and then placed on the bottom. This "open space" design has worked well in Japan, but so far, this particular unit has not been tested regarding its durability. A small PVC unit has been used off Destin, consisting of a 6 to 10-foot tall "Christmas tree" of scrap PVC pipe set in a 5 gallon bucket of cement. These units can be easily dropped from small boats and, if dropped close together in a cluster, can be very effective. They can, however, be easily damaged by boat anchors.

Ships and Barges: These are undoubtedly the oldest type of artificial reef material and still very effective and popular. Steel and fiberglass hulls are the most durable and effective, while wooden hulls have a shortened life span and require more ballast to remain in place on the sea floor.

Surplus Liberty ships were once readily available but that source appears to be nearing an end. Early use of Liberty ships, however, were not all successes although these experiences contributed to better reefs later on. For example, the Florida Department of Natural Resources (DNR) was in charge of sinking five Liberty ships in the mid 1970's. They contracted with salvage firms to cut the hulls down to 12 feet above the keel prior to sinking. The result was a "400+ foot long steel bathtub." Once the ship hulls had collected sand, they resembled low steel walls in a sea of bare sand. The fish attraction effectiveness from these early sinkings is minimal. Later in the 1970's, Florida DNR sank a single Liberty ship with the hull intact and with some holes cut in the sides for open space. While this was not as effective as several Liberty ships sunk by the Texas Game and Fish Commission, it was a great improvement over those first failures.

Most fish species will not venture into a dark closed compartment, particularly one with only a single exit. For this reason, all ships and vessels should be opened up prior to sinking. If possible, all compartments should have as many holes cut as possible without removing the structural strength members to allow free movement of water and light into the hull. The location of the stringers and support beams will determine the size and shape of such openings. Where possible, the entire superstructure should be left intact. If this is not possible, then often a superstructure can be constructed using tires on chains extending up from the deck, much like the mid-water attractors discussed in the next section.

If the drop site has a strong current, tidal or otherwise, the hull should be oriented at right angles to this current. This positioning allows the reef to provide some shelter for smaller fish in the lee of the hull; and, since most of the fouling organisms are filter feeders, allows maximum exposure to plankton drifting past the site.

Sinking of hulls by explosives has, in the past, provided a spectacular show for the press and TV reporters and does have the advantage of opening up hulls below the water line. The disadvantage is that liberal use of explosives can often damage a hull structurally to the extent that it soon falls apart. Explosives should be used sparingly. If a hull can be opened up with cutting torches prior to sinking, it can be sunk by pumping or opening up the sea cocks.

Coast Guard regulations require all oil and other hydrocarbons be removed and inspected prior to the actual sinking. The hull should be anchored securely at the site to prevent its moving during the sinking, which often takes longer than expected.

Oil Platforms: Oil companies have long advertised their offshore platforms as great fish attractors, and they do attract fish because they have the "open space" aspect that the Japanese have long ago proved to be best for most food and game fish species.

These steel platforms will probably last thirty to fifty years, but are rather large, so they must be used in waters with depths in excess of 100 feet, which may exclude some areas of Florida's gulf coast. Once they have become obsolete, they must be removed from the sea floor. The first of these was sunk in 170 feet of water off the Florida panhandle in September, 1982 (Fig. 6).

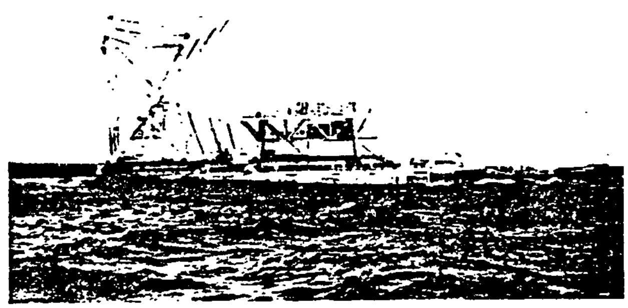


Fig. 6 Tenneco Oil Platform Offloading off Pensacola, FL. (Photo courtesy Dr. Dan Sheehy) Copyright - Aquabio Inc. 1982.

Mid-Water Attractors

This type of artificial reef is a relatively new idea pioneered along the Atlantic Coast by the South Carolina Wildlife and Marine Resources Department.

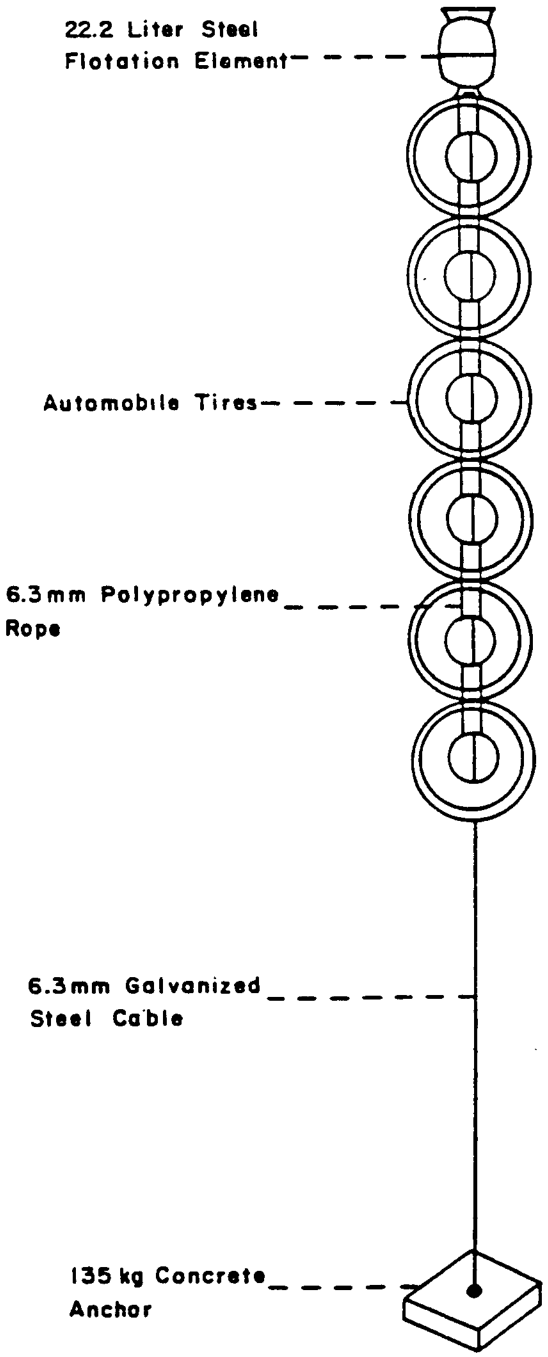


Fig. 7 Tire Mid-water Reef (Hammond, 1977)

The main purpose is to attract schools of bait fish, mainly sardine-like fish, which in turn attract large numbers of pelagic fish. The original design used off South Carolina was a series of passenger car tires suspended on a stainless steel cable. A concrete anchor at the base of the string held it in place, and a float at the other end held the five-tire unit upright off the bottom (Fig.7). These units were then placed approximately 50 to 100 feet apart in a long line or "trolling alley" (Fig. 8). Fishermen could then troll down the line of attractors by lining up the two buoys at each end of the line (Hammond, 1977).

Later modifications of this design used scrap dragline cable obtained free from construction contractors and crane companies. A car tire filled with concrete makes an excellent anchor with a ring or reinforcing bar loop protruding up from the center. The use of a car tire for the mold of the sinker allows it to be rolled up a plank onto the deck of the barge or even a small boat. The cable is then clamped to the sinker and three to seven tires are strung along the cable using holes cut in top and bottom with a hole saw or knife. The float at the top is a pair of old 20-pound freon bottles obtained free of charge from air conditioning contractors (they cannot be reused). These metal containers, when painted, will last from 18 months to two years in sea water. This is a deliberate "weak link" in the system to prevent the tires from ever floating to the surface and becoming a navigation hazard. Long before the cable rusts through, the freon bottles will rust enough to let out the air and sink to the bottom. Once on the bottom, the unit becomes a benthic fish attractor. Relatively inexpensive to build, they can be replaced every two years.

When used in a "trolling alley" these units have had great success in offshore waters, particularly for such species as mackerel, amberjack, cobia, barracuda, and other pelagic species. The number of tires used and the length of the cable depends upon the depths of water available. In general, they should extend up off the bottom approximately one-half the depth, if possible, without creating a hazard to navigation.

Often ship hulls or other types of bottom reefs can be greatly enhanced by addition of several dozen mid-water units.

"Fish Aggregating Devices" (FADs): This type of mid-water attractor is made of light-weight structures suspended up from the bottom on nylon ropes. These devices have been successful in Japan and are presently being tested in this country. Like the mid-water units used off South Carolina, these reefs attract large schools of bait fish; in turn, pelagic fish feed on these large concentrations of bait fish. FADs probably do not have the long life spans of bottom reefs, but they are cheaper and easier to deploy.

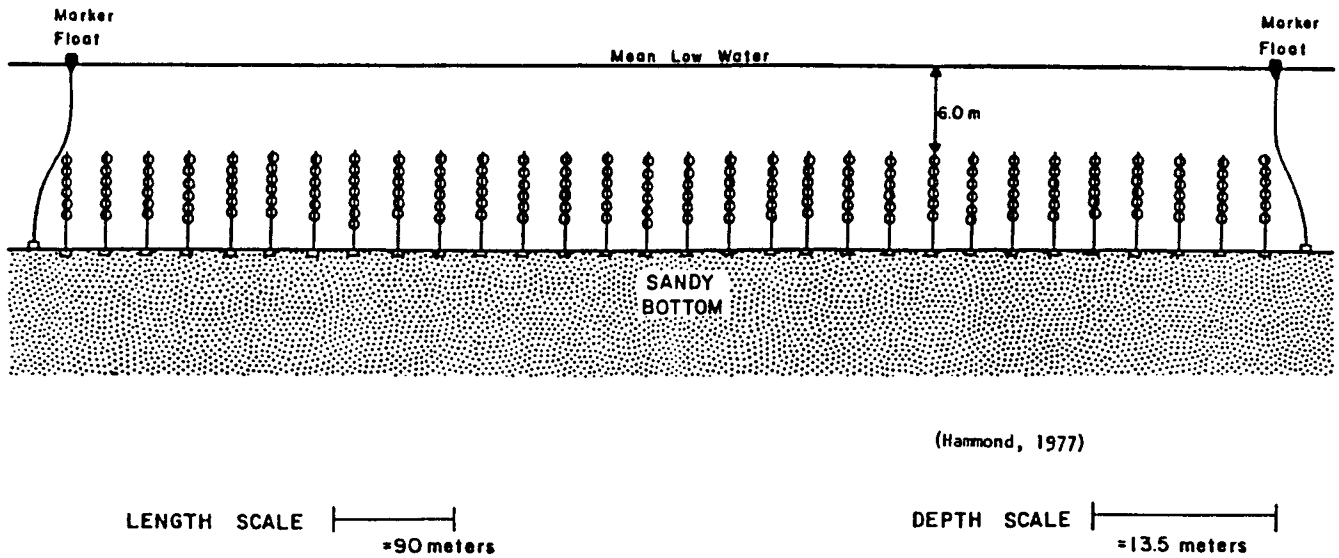


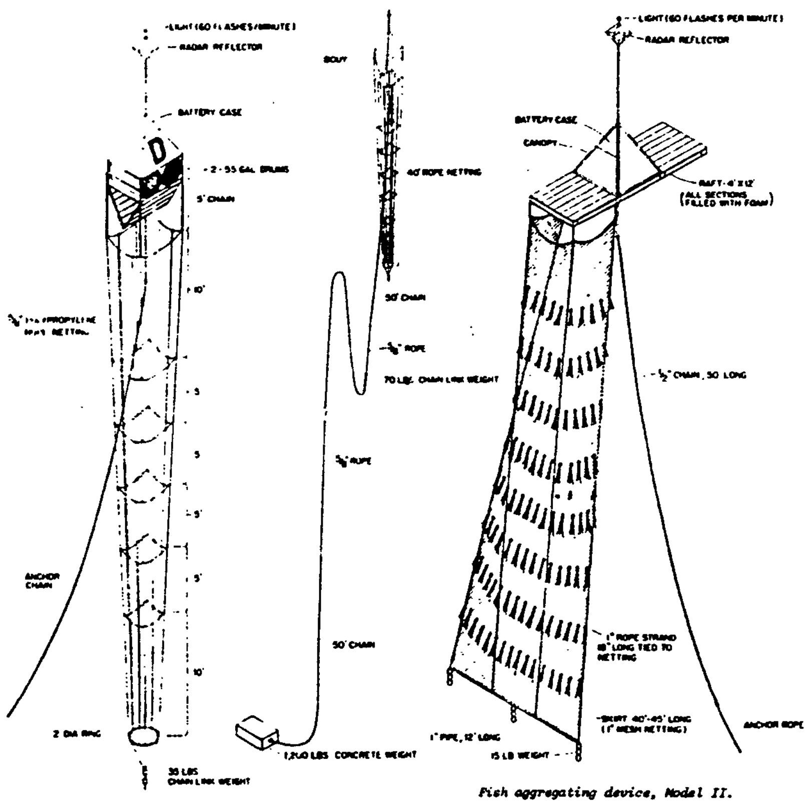
Fig. 8 Mid-water Trolling Alley

Surface Attractors

In areas where the lack of a substantial continental shelf limits the use of bottom and mid-water reefs, surface aggregating devices have been used. Hawaii has experimented with several types of these units. (Those pictured in Fig. 9 were developed by the National Marine Fisheries Service.) These units do not have the long life spans of most bottom reefs, but have proven very effective in attracting bait fish and pelagic game and food fish (Matsumoto, 1981).

One maintenance problem with surface attractors is that they must have both lights and radar reflectors. They are also more vulnerable to storm damage. Florida waters generally have adequate shelf areas so the surface attractors may prove

The aggregating devices consisted of a buoy made of two 55-gal oil drums which supported a canopy above to house the battery pack, a radar reflector and light, and a 45-ft long rope netting suspended beneath the buoy. Later improvements included the use of a raft in place of the 55-gal drums. The mooring system consisted of 50-ft chain lengths at the anchor and buoy, a 1,200-lb concrete block anchor, an anchor line of 5/8-inch polypropylene rope, and sufficient weight at the top third of the anchor line to keep the line submerged at all times.



Fish aggregating device, Model I.

Fish aggregating device, Model II.

(Matsumoto, 1981)

Fig. 9

more expensive to maintain and not as cost effective when compared with bottom and mid-water reefs.

Inshore Reefs: Most artificial reefs in Florida waters have been located offshore in areas accessible only to medium and larger size pleasure craft. Inshore reefs to provide benthic fishing for small boat and pier fishermen have been constructed in several parts of Florida with limited success. Inshore reefs attract smaller individual fish than an offshore reef, and the total fish populations attracted to these shallow estuarine reefs do not equal those offshore.

In areas where a large user group does not have the type of boats necessary to venture offshore, inshore reefs may provide an important addition to existing fishing resources. In Miami's Biscayne Bay, for example, a fishing pier was constructed and then an artificial reef of old culvert was added around the end of the pier. Due to poor site selection, this particular project was not a great success; but, if done properly, this can be an effective way to return some limited fish habitats to an estuary already damaged by dredge and fill activity.

Due to the lack of wave surge, car tires can often be utilized in these inshore reefs if adequate ballast is used. These reefs can be built in waters as shallow as 5 to 7 feet when not adjacent to boat channels and if well-marked. These shallow reefs have less maintenance cost because they can be marked with permanent concrete pilings rather than buoys that must be repaired and replaced every few years. Great care, however, must be used in site selection on these shallow water inshore reefs to avoid disruption of existing estuarine communities.

* * *

LITERATURE CITED

Hammond, Donald L., Dewitt O. Myatt, and David M. Cupka. *Evolution of Midwater Structures as a Potential Tool in the Management of the Fisheries Resources of South Carolina's Artificial Fishing Reefs.* South Carolina Marine Resources Center Technical Report Series Number 15, February 1977.

Matsumoto, Walter M., Thomas K. Kazama, and Donald C. Aasted. *Anchored Fish Aggregating Devices in Hawaiian Waters.* Marine Fisheries Review, Vol. 43, #9, September 1981, pp. 1-13.

Woodhead, Peter M.J., Iver W. Duedull and Neal F. Lansing. *Coal Waste Artificial Reef Program, Phase I.* Project #1341-1 Interim Report, Electric Power Research Institute, November 1979.

Dr. Heyward Mathews is a Professor of Oceanography, St. Petersburg Junior College, Clearwater, FL.

Project No. M/PM-2
Grant No. NA80AA-D-00038

SEA GRANT

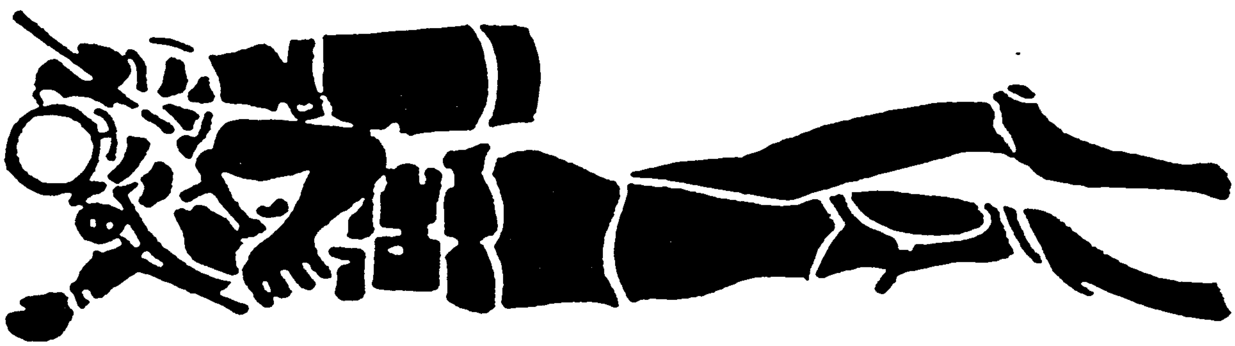
Copies available at:

Sea Grant Marine Advisory Program
G022 McCarty Hall
University of Florida
Gainesville, FL 32611

The State University System of Florida Sea Grant College is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, grant number NA80AA-D-00038, under provisions of the National Sea Grant Collge and Programs Act of 1966. This information is published by the Marine Advisory Program which functions as a component of the Florida Cooperative Extension Service, John T. Woeste, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U. S. Department of Agriculture, U. S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914. The Florida Sea Grant College is an Equal Employment Opportunity-Affirmative Action employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.

This public document is promulgated at a cost of $560.75, or 22.4 cents per copy, to provide information on the materials and construction of artificial reefs. Cost does not include postage or handling.

Appendix H



SGEB-4

FLORIDA COOPERATIVE EXTENSION SERVICE

SEA GRANT EXTENSION PROGRAM

A FLORIDA SEA GRANT PUBLICATION October 1984

ARTIFICIAL REEFS: Permit Application Guidelines

By: Dr. Heyward Mathews

INTRODUCTION

Back in 1977, the artificial reef permitting process in Florida was still quite complicated, but a comprehensive conference on Florida reefs was held June 10-11, 1977, at which time this problem was addressed. Organized by Florida Sea Grant, every major agency, academic and private group having any interest in, or responsibility for administering artificial reefs, were involved. Following this Conference, a single inter-agency permitting process was established. This publication is written to aid those interested in obtaining the forms and following the proper procedures to secure such a permit.

Site Selection

The first, and probably most important, step in any artificial reef building project is selecting a suitable site (see Florida Sea Grant publication, MAFS-20, *Artificial Reefs: Site Selection and Evaluation*). Factors to consider include the location, the reef material to be used, local oceanographic conditions, and expected user groups. Because of these special considerations, any person or group interested in building an artificial reef is required to obtain a permit from the U.S. Army Corps of Engineers and the Florida Department of Environmental Regulation (DER). (See *Appendices C & D* for locations).

Guidelines toward expediting the permitting process include attention to the following details:

(1) Navigation Channels and Fairways: Artificial reefs should not be located in or adjacent to navigation channels. Reefs in these areas could create a hazard and cause conflicts between shipping interests and fishermen anchored on a reef.

(2) Shallow Reefs: There is actually no set minimum depth for an artificial reef, but the general rule has been to allow reefs to extend up to depths equal to shoals or reefs found in the area. For example, if a coastline has shoals that project up to within 20 feet of the surface in an area, then the artificial reef could be allowed with only a 20-foot clearance over the top. In general, the U.S. Army Corps of Engineers would prefer a minimum clearance of 55 feet over the top of artificial reefs in most Florida waters. However, the location and type of reef is the determining factor. More or less clearance may be required depending on water depth and the type of reef being constructed.

(3) Unstable Materials: Unfortunately, car tires and car bodies have created some problems along high energy coastlines and, the U.S. Army Corps of Engineers has stopped permitting tire reefs altogether. Also, the use of wooden vessels, or other structures containing wood, is discouraged because of eventual navigation hazards and beach littering caused by distintegration due to decomposition and storms.

(4) **Commercial Fishing Conflicts**: All U.S. Army Corps permits provide a period of not less than 21 days for interested parties to comment on a new reef site. If the site selected causes a serious conflict with commercial fishing interests, the permit could be denied or held up by lengthy public hearings. In most instances, this can be avoided by proper site selection *prior* to filing the permit application.

Biological Reports - Initial Site Survey

The U.S. Army Corps of Engineers regulations does not actually *require* but highly recommends a biological and/or bottom survey report as a part of the permit application. However, if a biological report is not included with the application, a delay in permitting may result because governmental agencies may desire additional information before making recommendations. In most districts of Florida, the Florida Department of Environmental Regulation (DER) does not have diver-biologists available to make site studies, but the Florida Sea Grant Artificial Reef Resource Team has provided such reports upon request through the Marine Advisory Program agents. The Corps does not perform diving to obtain this information.

Two biological reports are included as *Appendix A* and *Appendix B. Appendix A* is a typical report for a new application, while *Appendix B* is a report for an existing artificial reef that needs rehabilitation for which the permit has expired. An existing permitted artificial reef can be renourished under the authority of a nationwide permit.

In preparing these reports, the exact location is of prime importance. If out of sight of land, the site should be fixed by two Loran C readings plotted on a current U.S. Coast & Geodetic Survey chart; and the latitude and longitude should be carefully determined and placed at the top of the Biological Report-Site Survey. A drawing showing two lines of position from fixed shore sites should be prepared for the permit application also.

The bottom survey states the type and composition of the bottom substrate, while the biological report-site survey discusses the existing marine communities on the site. If the site is a new one, no significant benthic plant or animal communities should exist on the bottom, and this should be noted. If the site is an existing reef, then a brief summary of the dominant species should be included as well as a description of its condition and, if possible, some estimate of its remaining effective life span.

Finally, the report should conclude with a statement declaring the site suitable for artificial reef construction of the type planned. However, if the diver doing the biological report finds any conditions that would restrict the use of the site, these should be stated. It is the responsibility of the biologist doing the report to consider all the above factors or face the possibility of being responsible, at least partially, if the site later proves to be unsuitable.

Joint U.S. Army Corps and Florida D.E.R. Application Form

For artificial reef permits, the *Joint Permit Application for Dredge and Fill Structures* is used. This form can be obtained at regional field offices of either the U.S. Army Corps of Engineers or the Florida Department of Environmental Regulation. A list of these offices appears as *Appendices C & D.*

Although the State of Florida has no jurisdiction beyond three nautical miles offshore along the Atlantic coast or 9½ miles (3 leagues) into the Gulf of Mexico, an application is still required and must be completed and processed. The main part of the application is relatively simple to complete; however, the drawings that must accompany the application often cause some problems and delays.

The first drawing, using a U.S. Coast and Geodetic Survey map, must show the location of the artificial reef site. Normally an 8½ x 11 inch copy of the portion of the coast involved is adequate. The map scale should include the shoreline and several fixed reference points on land (*Appendix E*), and the distance to the nearest shoreline should be included so state jurisdiction can be determined at a glance. In addition, two position lines to the site from fixed landmarks showing the bearing and the distance in nautical miles are also required. Loran C readings at the reef site center must also be included on the drawing.

A second, cross-section drawing, should show the distance from the surface to the bottom at mean low water, and the maximum height that the reef will extend up from the bottom. This same drawing should show a typical buoy chain and sinker if the site is to have a buoy. Although buoys are not required by the Army Corps, the U.S. Coast Guard may require some types of reefs to have buoys. Consequently, it is a good idea to contact the Coast Guard prior to final selection of a site to determine what buoys, if any, will be required.

In some locations a lighted buoy may be called for, and the expense and maintenance of such a buoy may exceed the budget of a small project. In this case, a site change might be in order. Generally, however, lighted buoys are only required on a site close to major shipping lanes where a reef could possibly become a hazard. In selecting a site, these areas should be avoided whenever possible.

Completed Application

Once completed, the application should be sent to the Florida Department of Environmental Regulation in your area along with the required fee. A diagram showing the locations of these offices, and the counties served, appears in *Appendix D.* The DER then sends a copy of the application to the Corps in order that the application processing can occur concurrently.

APPENDIX A

BIOLOGICAL REPORT - TAYLOR COUNTY ARTIFICIAL REEF SITE #3

Prepared by: Dr. Heyward Mathews*

Loran C. Coordinates:	14449.8	Longitude:	29° 43' 5"
(Center of site)	46152.0	Latitude:	83° 51' 3"

This artificial reef site is located approximately 18 miles off Taylor County midway between Steinhatchee and Keyton Beach in some 35 feet of water at low tide. The bottom is a firm sand substrate with limestone just under the surface.

There are no marine grasses or benthic algae on this site, nor are there any "hard bottom communities" in the actual site. However, hard bottom communities are located approximately 1/2 to 1 mile inshore from this site. Several starfish in the genus, Echinaster, and several black urchins, Arbacia punctulata, were observed along the bottom. No fish were seen during this cold water survey dive.

This firm substrate bottom will make an excellent artificial reef site for high density reef materials such as concrete culvert, steel and fiberglass hulls, and bridge rubble. However, the depth of 35 feet is not sufficient for low density materials such as car tires or truck tires. Once the reef is constructed, the fish populations should increase greatly.

* Florida Sea Grant Artificial Reef Resource Team

APPENDIX B

BIOLOGICAL REPORT - FERNANDINA BEACH ARTIFICIAL REEF SITE #1

Prepared by: Dr. Heyward Mathews*

Loran C. Coordinates:	45314.4	Longitude: 30^{0} 38' 0"
(Center of site)	61907.1	Latitude: 81^{0} 09" 0"

This is the site of an existing artificial reef approximately 10 miles southeast of Fernandina Beach. The site is in 55 feet of water. It is a large steel hull barge that has been on the bottom for some years. The bottom is a firm sand/shell mixture with well developed ripple marks. The barge has moved into the bottom 10 to 15 inches and exposed some limestone layers underneath.

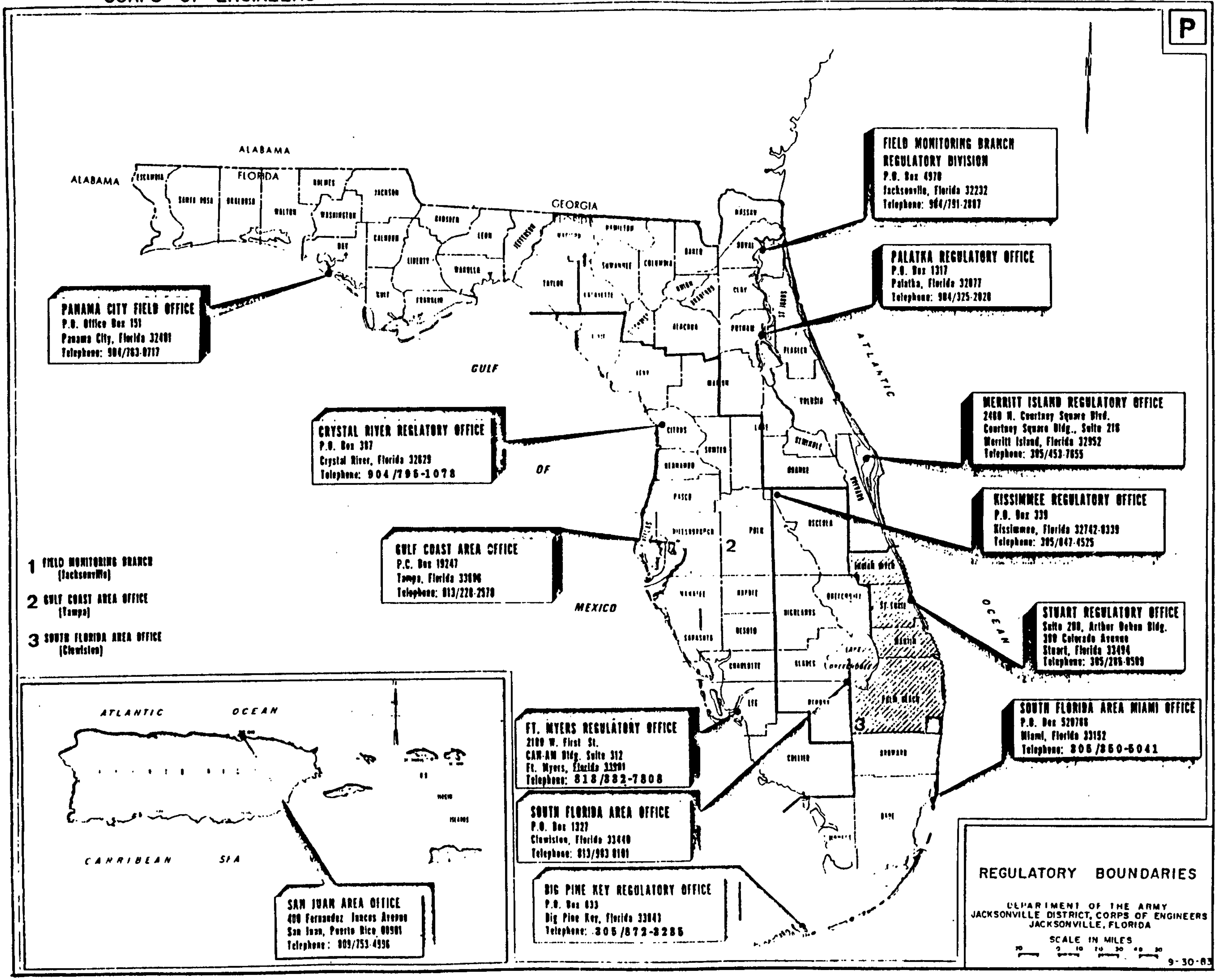
The fish population on the reef is well established with large numbers of sheephead, Archosargus probatocephalus; Black Sea Bass, Centropristis striata; Black Grouper, Mycteroperca bonaci (several up to 30 pounds); Spadefish, Chaetodipterus faber; Porgy, Calamus spp.; and large schools of Menhaden, Rough Scad and Tomtate Grunts. The metal of the barge is well-covered with fouling organisms, barnacles, algae, corals, worm tubes and numerous others.

This is an excellent existing artificial reef site and will support almost any type of reef materials; however, the depth is too shallow for car tires to remain stable without great amounts of ballast.

* Florida Sea Grant Artificial Reef Resource Team.

CORPS OF ENGINEERS

U. S. ARMY



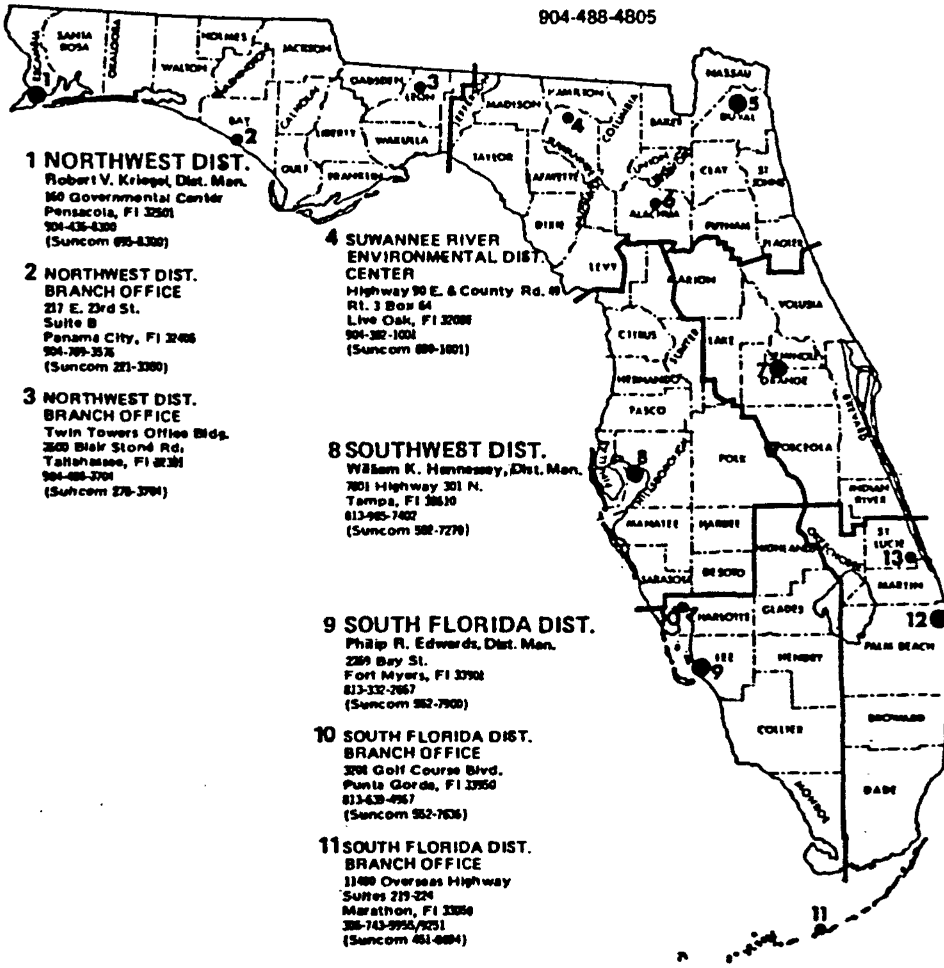
APPENDIX C

DISTRICT & BRANCH OFFICES

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

904-488-4805



1 NORTHWEST DIST.
Robert V. Kriegel, Dist. Man.
160 Governmental Center
Pensacola, Fl 32501
904-436-8300
(Suncom [illegible])

2 NORTHWEST DIST. BRANCH OFFICE
217 E. 23rd St.
Suite B
Panama City, Fl 32405
904-785-3576
(Suncom 221-3300)

3 NORTHWEST DIST. BRANCH OFFICE
Twin Towers Office Bldg.
2600 Blair Stone Rd.
Tallahassee, Fl 32301
904-488-3704
(Suncom 278-3704)

4 SUWANNEE RIVER ENVIRONMENTAL DIST. CENTER
Highway 90 E. & County Rd. 49
Rt. 3 Box 64
Live Oak, Fl 32060
904-362-1001
(Suncom [illegible]-1001)

5 NORTHEAST DIST.
G. Doug Dutton, Dist. Man.
3426 Bills Rd.
Jacksonville, Fl 32207
904-396-6959
(Suncom 820-5295)

6 NORTHEAST DIST. BRANCH OFFICE
825 N.W. 23rd Ave., Suite G
Gainesville, Fl 32601
904-377-7520
(Suncom 820-6150)

7 ST. JOHNS RIVER DIST.
Alex Senkevich, Dist. Man.
3319 Maguire Blvd., Suite 232
Orlando, Fl 32803
305-894-7555
(Suncom 353-1011)

8 SOUTHWEST DIST.
William K. Hennessey, Dist. Man.
7601 Highway 301 N.
Tampa, Fl 33610
813-985-7402
(Suncom 582-7270)

9 SOUTH FLORIDA DIST.
Philip R. Edwards, Dist. Man.
2269 Bay St.
Fort Myers, Fl 33901
813-332-2667
(Suncom 552-7900)

10 SOUTH FLORIDA DIST. BRANCH OFFICE
3298 Golf Course Blvd.
Punta Gorda, Fl 33950
813-639-4967
(Suncom 552-7636)

11 SOUTH FLORIDA DIST. BRANCH OFFICE
11400 Overseas Highway
Suites 219-224
Marathon, Fl 33050
305-743-9956/9251
(Suncom 451-6694)

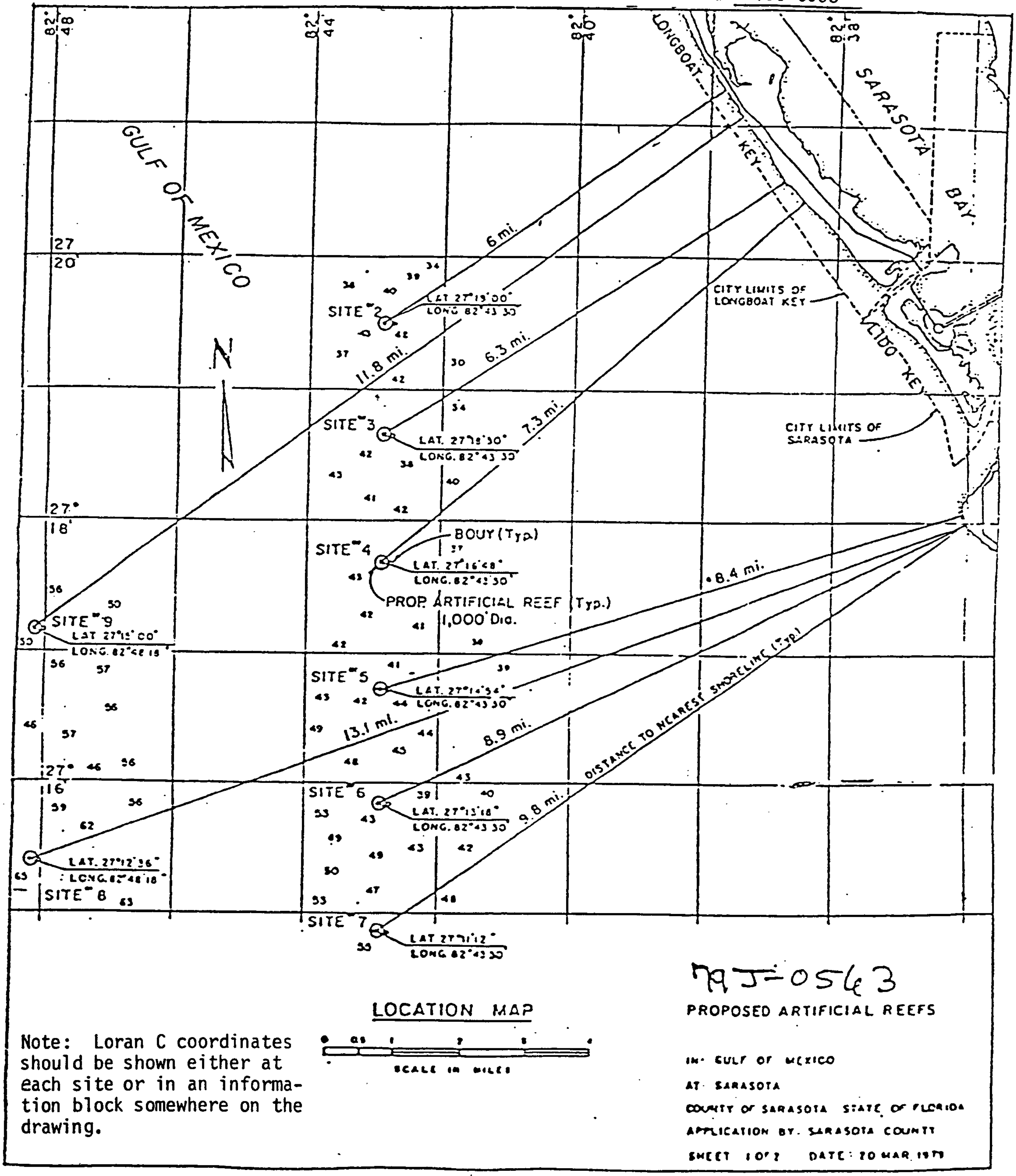
12 SOUTHEAST FLORIDA DIST.
Roy Duke, Dist. Man.
3301 Gun Club Rd.
P.O. Box 3858
W. Palm Beach, Fl 33402
305-689-5800
(Suncom 451-[illegible])

13 SOUTHEAST FLORIDA DIST. BRANCH OFFICE
2745 S.E. Morningside Blvd.
Port St. Lucie, Fl 33452
305-878-3890/335-4330
(Suncom 451-[illegible])

EFFECTIVE JULY 1, 1983

APPENDIX E

DER #
COE # 79J-0563



Note: Loran C coordinates should be shown either at each site or in an information block somewhere on the drawing.

ACKNOWLEDGEMENTS

Project No. IR-82-83
Grant No. NA80AA-D-00038

The Florida Sea Grant College Program wishes to express appreciation to the Florida Department of Environmental Regulation and the United States Army Corps of Engineers for their assistance in reviewing this document.

Dr. Heyward Mathews is a Professor of Oceanography, St. Petersburg Junior College, Clearwater, FL.

Florida Sea Grant College is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number NA80AA-D-00038, under provisions of the National Sea Grant College and Programs Act of 1966. This information is published by the Sea Grant Extension Program which functions as a component of the Florida Cooperative Extension Service, John T. Woeste, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914. The Florida Sea Grant College is an Equal Employment Opportunity-Affirmative Action employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.

Copies available from:

Sea Grant Extension Program
G022 McCarty Hall
University of Florida
Gainesville, FL 32611

This public document was promulgated at a cost of $213.70, or 21.4 cents per copy, to furnish information on artificial reef permitting procedures to interested citizens. Cost does not include handling or postage.

Appendix I

Synopsis of the Phyla

The following description of the major phyla are limited to distinguishing characters. Only existing classes of the larger Phyla that are likely to be encountered are listed. The approximate number of described species is indicated in parentheses.

Phylum Porifera (10,000)
Sponges. Sessile; no anterior end; primitively radial, but most are irregular. Mouth and digestive cavity absent; body organized about a system of water canals and chambers. Marine, a few in fresh water.

Phylum Cnidaria (9000)
Free-swimming or sessile, with tentacles surrounding mouth. Specialized cells bearing stinging organoids called nematocysts. Solitary or colonial. Marine, few in fresh water.
Class Hydrozoa. Hydra, hydroids.
Class Scyphozoa. Jellyfish.
Class Anthozoa. Sea anemones, corals.

Phylum Ctenophora (90)
Comb jellies. Free-swimming; biradiate, with two tentacles and eight longitudinal rows of ciliary combs (membranelles). Marine.

Phylum Platyhelminthes (12,700)
Body dorsoventrally flattened; digestive cavity, when present, with a single opening, the mouth. Free-living and parasitic. Marine, freshwater, a few terrestrial.
Class Turbellaria. Free-living flatworms.
Class Trematoda. Flukes.
Class Cestoda. Tapeworms.

Phylum Rhynchocoela, or Nemertina (650)
Nemerteans. Long dorsoventrally flattened body with complex proboscis apparatus. Marine, few terrestrial and freshwater.

Phylum Nematoda (10,000)
Roundworms. Slender cylindrical worms with tapered anterior and posterior ends. Cuticle often ornamented. Free-living and parasitic. Free-living species usually only a few millimeters or less in length. Marine, freshwater, and soil inhibiting.

Phylum Sipuncula (300)
Cylindrical marine worms. Retractable anterior end, bearing lobes or tentacles around mouth.

Phylum Mollusca (100,000)
Ventral surface modified in the form of a muscular foot, having various shapes; dorsal and lateral surfaces of body modified as a shell-secreting mantle, although shell may be reduced or absent. Marine, freshwater, and terrestrial.
Class Polyplacophora. Chitons.
Class Gastropoda. Snails, welks, conchs, slugs.
Class Bivalvia, or Pelecypoda. Bivalve mollusks.
Class Scaphopoda. Tusk, or tooth, shells.
Class Cephalopoda. Squids, cuttlefish, octopods.

Phylum Annelida (8700)
Segmented worms. Body wormlike and metameric. A large longitudinal ventral nerve cord. Marine, freshwater, and terrestrial.
Class Polychaeta. Marine annelids.
Class Oligochaeta. Freshwater annelids and earthworms.
Class Hirudinea. Leeches.

Phylum Arthropoda (923,000)

Body metameric with jointed appendages and encased within a chitinous exoskeleton. Coelom vestigial. Marine, freshwater, and terrestrial.

Subphylum Trilobitomorpha
Trilobites. One pair of appendages; all other postoral appendages similar.

Subphylum Chelicerata
No antennae; one pair of chelicerae. Body composed of a cephalothorax and abdomen.
Class Merostomata. Horseshoe crabs.
Class Arachnida. Scorpions, spiders, mites.
Class Pycnogonida. Sea spiders.

Subphylum Crustacea
With two pairs of antennae and one pair of mandibles. Trunk variable.
Class Branchiopoda. Fairy shrimps, water fleas.
Class Ostracoda. Ostracods.
Class Copepods. Copepods.
Class Branchiura.
Class Cirripedia. Barnacles.
Class Malacostraca. Amphipods, isopods, shrimps, crabs.

Subphylum Uniramia
With one pair of antennae and one pair of mandibles. None of these are typically marine.
Class Insecta. Insects.
Class Diplopoda. Millipedes.
Class Chilopoda. Centipedes.

Phylum Bryozoa (4000)
Bryozoams. Colonial, sessile; the body housed within a gelatinous or more commonly a chitinous or chitinous and calcareous exoskeleton. Mostly marine, a few freshwater.

Phylum Brachiopoda (280)
Lamp shells. Body attached by a stalk and enclosed within two unequal dorsoventrally oriented calcareous shells.

Phylum Echinodermata (6000)
Secondarily pentamerous radial symmetry. Most existing forms free moving. Body wall containing calcareous ossicles usually bearing projecting spines. A part of the coelom modified into a system of water canals with external projections used in feeding locomotion. All marine.
Class Crinoidea. Sea lilies and feather stars.
Class Stelleroidea.
Subclass Asteroidea. Sea stars.
Subclass Ophiuroidea. Brittle stars and basket stars.
Class Echinoidea. Sea urchins, sand dollars, and heart urchins.
Class Holothuroidea. Sea cucumbers.

Phylum Hemichordata (80)
Acorn worms. Body divided into proboscis, collar, and trunk. Anterior part of trunk perforated with varying number of pairs of pharyngeal clefts. Marine.

Phylum Chordata (39,000)
Pharyngeal clefts, notochord, and dorsal hollow nerve cord present at some time in life history. Marine, freshwater, and terrestrial.

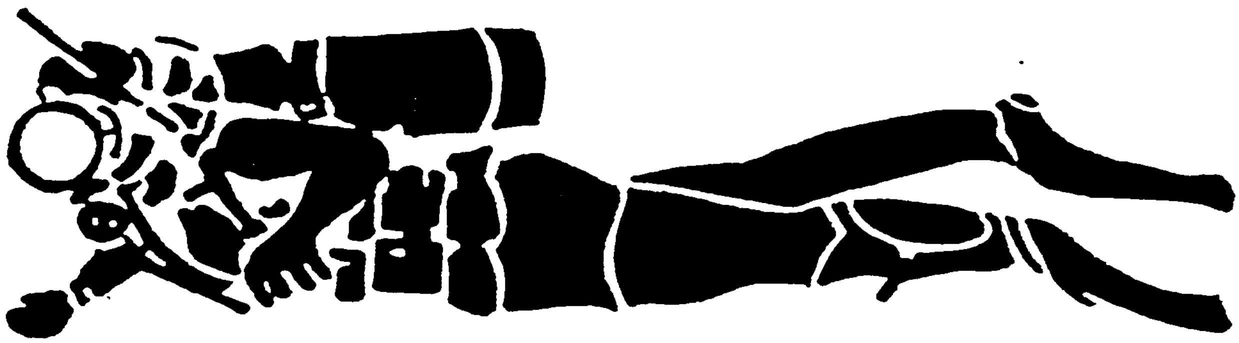
Subphylum Urochordata (1300)
Sea squirts, or tunicates. Sessile, nonmetameric invertebrate chordates enclosed with a cellulose tunic. Notochord and nerve cord present only in larva. Solitary and colonial. Marine.
Class Ascidiacea. Sea squirts, or sessile tunicates.
Class Thaliacea. Free-swimming urochordates.
Class Larvacea. Planktonic urochordates.

Subphylum Cephalochordata (25)
Amphioxus. Metameric fishlike invertebrate chordates.

Subphylum Vertebrata (37,790)

The vertebrates. Metameric. Trunk supported by a series of cartilaginous or bony skeletal pieces (vertebrae) surrounding or replacing notochord in adult.

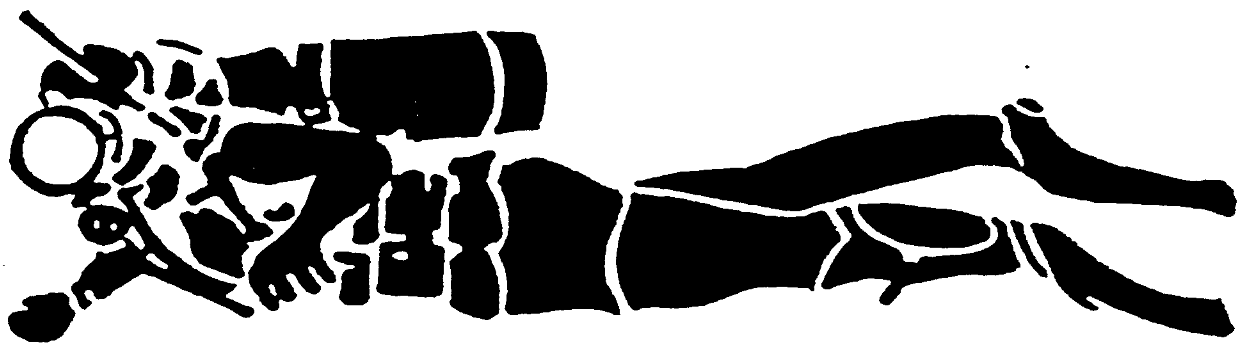
Adapted from Invertebrate Zoology, Robert D. Barnes, 1983.



Appendix J

Suggested Data For Artificial Reef Survey

Name of Reef						
Location						
			Latitude		Longitude	
			Loran		Sightings	
Date when placed						
	Later additions:	A	B	C	D	E
Description of Reef						
	Type of material used:					
	Dimensions					
	Amount of material used:					
Percent with:	Multiple entrances and exist:					
	Only one entrance:					
	Relief and surface area:					
Site description						
	Depth:		Bottom		Top of Wreck	
	Bottom type and description:					
	Nearby bottom features:					
	Current conditions:					
	Average speed				Direction	
	Range of current speed		Low		High	
	Has reef shifted?		Yes	No	When	
	Visibility conditiond:		Average		Range	
	Temperature Conditions:		Bottom		Surface	
Evaluation of reef success						
		Outstanding	Successful	Adequate	No Usefulness	A Disaster
	Use of reef:		High	Medium	Low	
	Who uses the reef?		SCUBA divers	Snorkel divers	Sport fish	Commercial
			High/Med/Low	High/Med/Low	High/Med/Low	High/Med/Low



Appendix K

North American Bottle Distributors

Continental Glass Company
225 Commonwealth Blvd.
Louisville, KY 40202
(502) 583-6866

S. Kiekes and Sons, Inc.
4217 Mint Way
Dallas, TX 75233
(214) 333-3241

Smith Container Corp.
P.O. Box 3844
209-211 Southside Drive
Charlotte, NC 28203
(704) 523-3075

Smith Container Corp.
P.O. Box 387
Maple Ave.
Colonial Heights, VA
(804) 526-6265

Texberry Container Corp.
4729 Greatland
San Antonio, TX 78218
(512) 661-6731

Texberry Container Corp.
P.O. Box 2944
New Orleans, LA 70189
(504) 254-1947

Northwestern Bottle Co.
611 Merrit Street
Nashville, TN 37203
(615) 255-9292

W. R. Hill and Co., Inc.
114 Virginia St.
P.O. Box 646
Richmond, VA 23205
(804) 643 2645

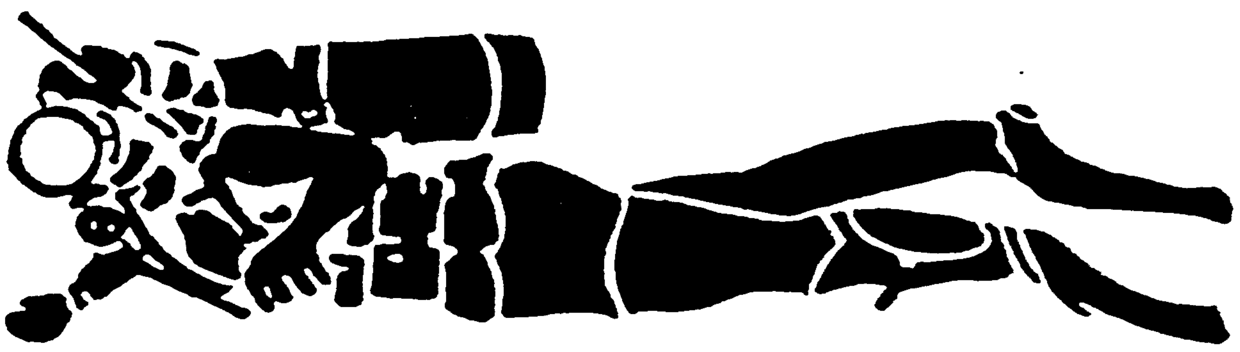
Smith Container Co. (Main)
3500 Browns Mill Rd., S.E.
P.O. Box 6716
Atlanta, GA 30315

Smith Container Corp.
8022 Office Ct.
Suite 107
Orlando, FL 32809
(305) 851-8310

Texberry Container Corp. (Main)
P.O. Box 33367
6040 Donoho
Houston, TX 77033
(713) 644-5201

Texberry Container Corp.
1102 Inwood Drive
Dallas, TX 75247
(214) 638-4260

Northwestern Bottle Co.
849 Roland Street
Memphis, TN 38114
(901) 274-9211



Appendix L

Sample Questionnaire For Travel Cost Method Interview

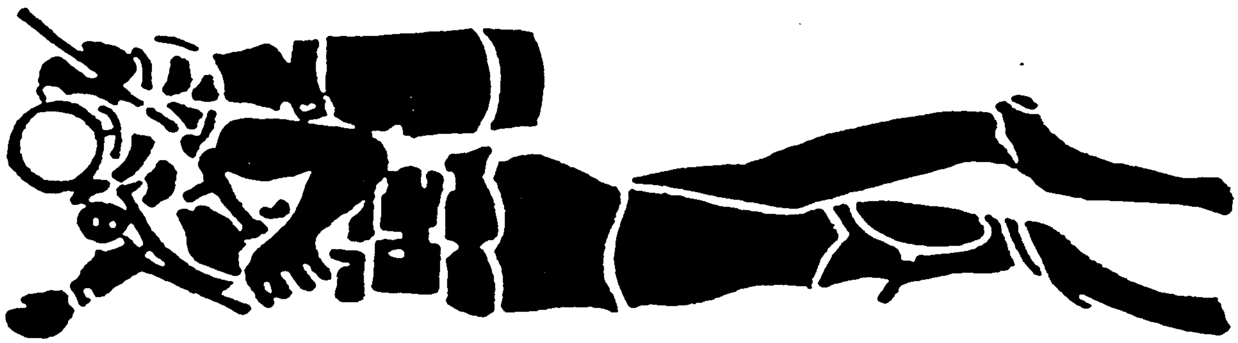
Date ______________

Time ______________

Interviewer ____________________________

1) What is your hometown?
2) How many miles (one-way) from your home to the dive/fishing site? ____________
3) What is the approximate amount you spent to arrive at this site? $______
   (This should include fuel for boat and car (if applicable), meals, tolls, or other expenses incurred enroute.)
4) How many divers/fishermen are in your party? ____________
5) How many trips did you and your party make to this site in the past year?
   ____
6) What is the purpose of your trip?
   __________ photography
   __________ spearfishing
   __________ general exploring
   __________ fishing

Note: Additional questions can be added about the purpose of the activity to provide more information about users from different travel zones. Also, if the party does not usually travel together as a group or if each has a different hometown, it is advisable to record a separate questionnaire for each number.



Appendix M

Sample Questionnaire For Iterative Bidding Method Interview

Date ____________________

Time ____________________

Interviewer ____________________________

1) How many divers/fishermen are in your party? ____________
2) How many trips did you and your party make to this site in the past year?

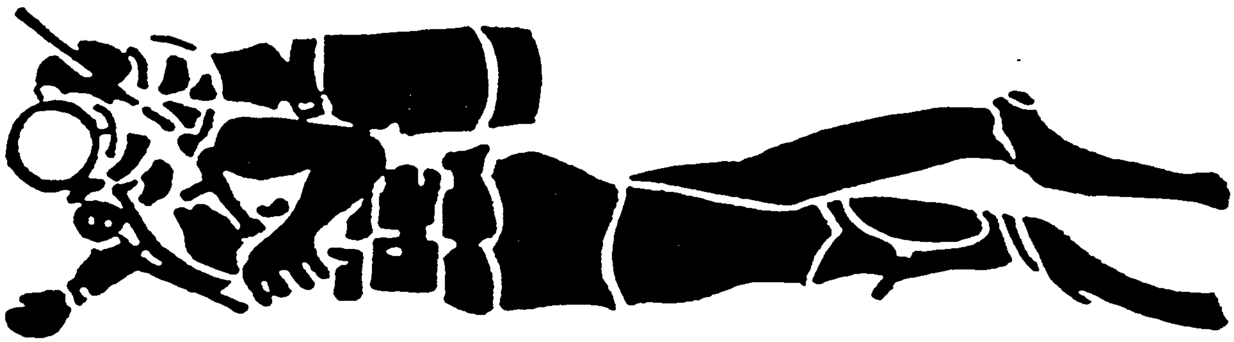
____

3) What is the purpose of your trip?
   _________ photography
   _________ spearfishing
   _________ general exploring
   _________ fishing

We are trying to determine the economic value of sport diving on artificial reefs in Florida. Let's pretend that I'm selling an annual pass to use this particular artificial reef. If you didn't have a pass, you couldn't use the reef. Please realize that this is only hypothetical and neither the city nor the state is planning to actually require such a permit. Now, if you were planning to make the same number of trips to this site in the coming year, would you be willing to pay $_______ for this permit?

Initial starting value $_________

Maximum willingness to pay:$__________



Appendix N

Guidelines for Working with Slides

<u>Slides are useful because they:</u>

-Hold attention,

-Get the message across quickly,

-Build interest,

-Clarify points -- show exactly what is being discussed,

-Can share experiences otherwise impossible or impractical to convey,

-Focus attention on a large screen image,

-Are flexible -- you can add to, remove, and rearrange them for different presentations.

1. When preparing a slide presentation, you can write the audio portion first and then match up the visual portion after. <u>BUT, remember that the VISUALS will carry the burden of the message</u>. Any narration or sound effects will be secondary, and will support or enhance the visual message.
2. You could take an existing article and use it as the basis for a slide script, but probably the easiest way to avoid using more words than you need, is to start by outlining your material. Once you have listed the points you wish to make in the proper order, it will be easy to expand those points into sentences, and in turn use those sentences to develop narration.
3. Because viewers will not be able to grasp many details from a single viewing, don't try to present more than 2 or 3 main concepts or points in any presentation. If you do want your audience to retain portions of the information, you may need to supplement the slide program with hand-outs summarizing various points, or discussions.
4. When writing your slide script:

   -limit each slide to one main idea;

   -limit each slide to 15-20 words;

   -include titles to supplement, not duplicate visual material

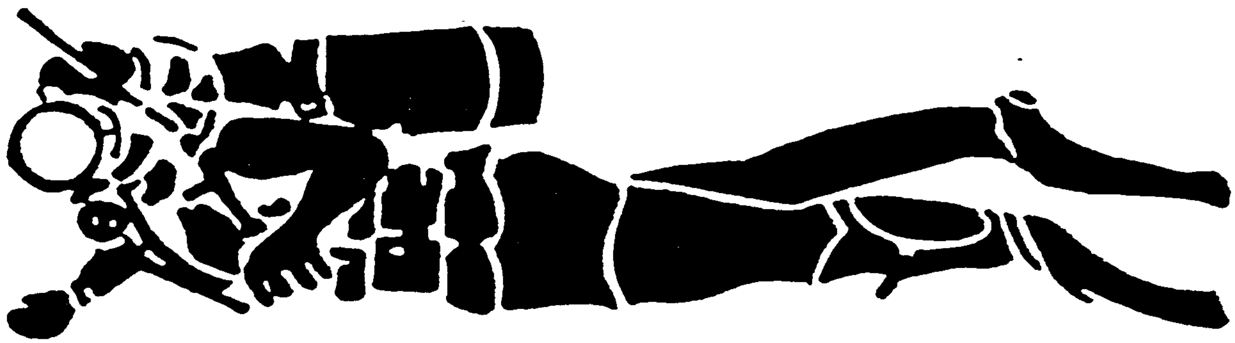
   -use several simple slides rather than one complicated one, especially if you must discuss a subject at length;

   -make duplicates if you need to repeat a slide in several different places;

   -plan a good pace, don't leave a slide on the screen after discussing its subject;

   -never say "in this slide we see"

APPENDIX _____



Appendix 0

Guidelines for Preparation of Information for the News Media

The Press Release

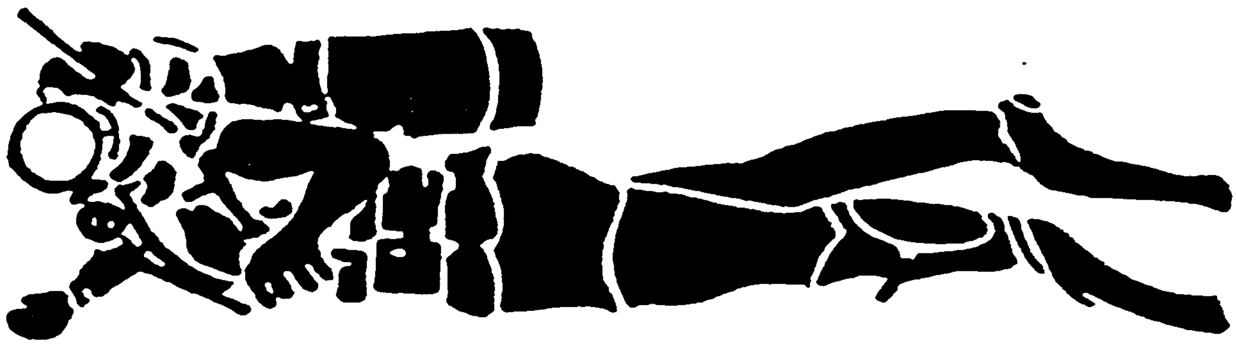
Writing the Release

1. Mentally or physically arrange the information in order of importance. Determine what deserves the most emphasis.
2. Write the story beginning (the lead) emphasizing the most important point or points of the story. Make sure it is interesting, accurate and that you have enough information to back up the lead.
3. The lead should establish the angle of the story and the story should stick to that angle. If your lead is the right lead, the rest of the story should come easier.
4. Write the rest of the story. Include all information that is pertinent and necessary and leave out all unnecessary or irrelevant material. Make sure all ideas are presented simply and clearly.
5. Use words which generally will be understood by the majority of readers. Avoid highly technical or jargonistic language, unless you define it.
6. Check lengths of sentences and of paragraphs. Sentences that are short, to the point and lacking in complexity stand the best chance of communicating effectively, but they should vary somewhat in lengtand structure. Variety helps avoid monotony.
7. Rewrite your story if necessary. If a sentence is too long, perhaps you can make two or more sentences out of it. If sentences or paragraphs do not seem to be in the right order, you should rearrange them.
8. Ask yourself if other words would be better than ones you used. Be specific. Use the right word.
9. Make sure grammar and spelling and punctuation are correct, and check your style sheet to make sure your story conforms to it.
10. Check facts again. Are they correct. <u>Accuracy</u>!

APPENDIX _____

<u>**Format for Press Release**</u> Following is a guide for releases to print media:

1. Paper--8 1/2" by 11" white paper is preferred, although legal-size paper is acceptable.
2. Typewrite, mimeograph, or offset. <u>Do not send carbons to media</u>.
3. Double-space all copy. Use wide margins. Do not hyphenate words at end of lines. Do not carry a paragraph over from one page to another.
4. Use one side of the paper only.
5. Identify the sender (organization and/or individual) at the top of the page. Provide name, address, and telephone number of the person who can be reached for further information, both during and after office hours.
6. A headline is usually written as shown in the sample news release (Appendix D) to give the editor an idea as to the content of the release. If the story is used in the paper, however, the headline will most likely be written.
7. If the story is for use on receipt of the release, mark it for IMMEDIATE RELEASE. If there is a chance that the release may reach the newspaper before the date intended for the release the release date should also be included.
8. Unless it is for local news media only, a dateline is usually included at the beginning of the first paragraph (e.g., Gainesville, FL, May 3, 1982). The date should be the time the news takes place, not the date you put out the release or the date you expect the papers to use it. In many cases the date will not be used because it is not relevant to the information in the release.
9. If your release requires more than one page, type "more" at the bottom of each page except the last. In the upper lefthand corner of the second and succeeding pages type the subject of the story and the page number In some cases the succeeding pages are marked in the upper lefthand corner as follows: Add 1 (for the second page) and then the subject of the story; Add 2 (for the third page), etc. The end of story is marked in some way usually with the numeral "30" or by the use of "# # #".



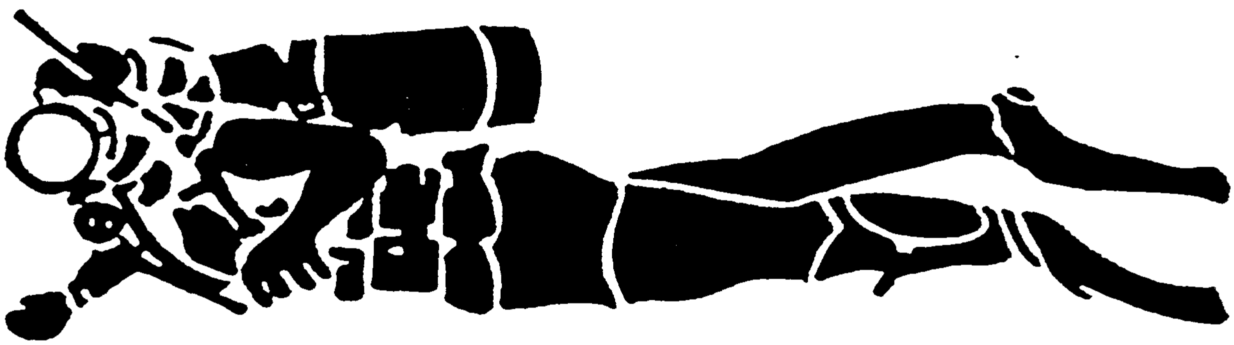
Appendix P

Guidelines for Preparation of Magazine Articles

Writing the Article

1. The first step, even before beginning to write the article, should probably be to prepare a query letter to an editor. This will help locate an editor who may be interested in the subject and thus save time in writing because the editor may have certain requirements such as a specific word length, the way in which the subject should be treated in the magazine, etc. If the first editor turns the story down, try another editor, and another. Many editors are willing to look at a completed manuscript but even if interested may request it be rewritten to their specifications.
2. Before starting to put the words on paper assemble all the information and organize it in a logical way. The story may be told chronologically or may simply be a discussion of the material in a logical way.
3. As with a newspaper story, the lead of a magazine article is important. The job of the lead is to "hook" the reader, to create enough interest in the story that the reader will want to continue reading. Indicate what the article is about and what the reader may expect.
4. In the body of the article present the information which you have--the "meat" of the article. If possible, intersperse presentation of facts with anecdotes which are interesting and relevant to the subject as this makes for more interesting reading.
5. The end of the article should satisfactorily sum up the material for the reader. Depending upon the subject, a summary of the facts presented in the body of the article may be appropriate. If the ending can in some way refer back to the lead it creates the feeling of a neat, coherent package.
6. In writing the article be specific. If there are facts and figures that need to be in the article don't leave them out. This will give an air of authenticity to the article and create a feeling of credibility for the author. enhance your credibility as the author. Use concrete words rather than abstract words. These words will help to make your article more specific.
7. The actual mechanics of writing vary greatly from person to person. But whether you write rapidly throughout the first draft and then revise and revise again, or whether you write very slowly getting every sentence right before going on to the next one, chances are that you are going to have to do some revision before arriving at the final manuscript if only to fill in a few black spaces in the information which were not evident when you started writing.
8. When the article is ready for final typing it should be prepared as shown .

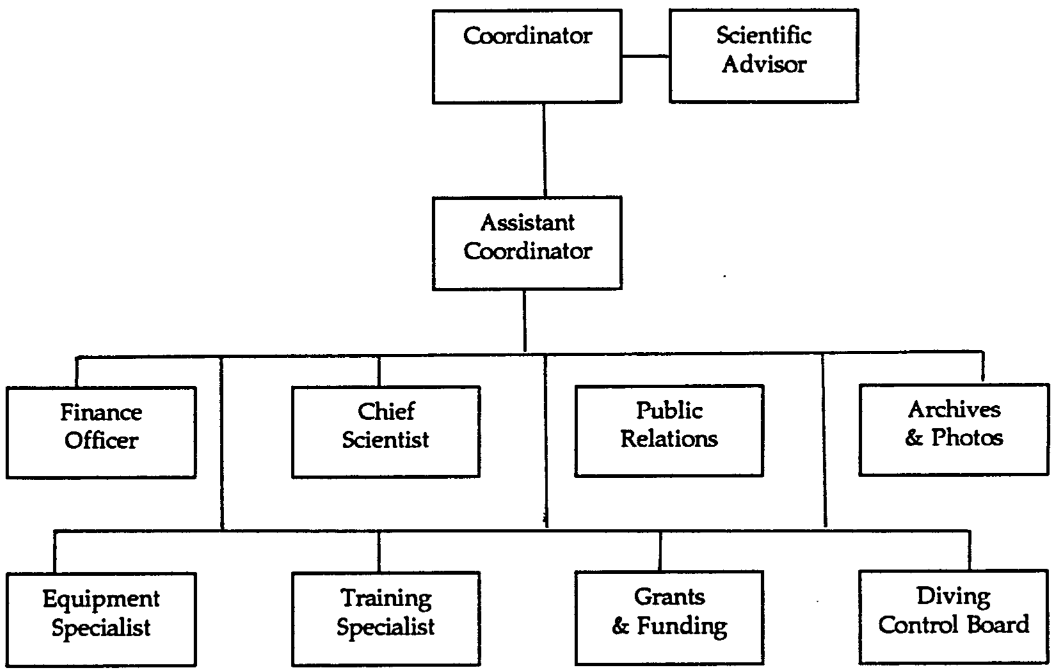
APPENDIX ____

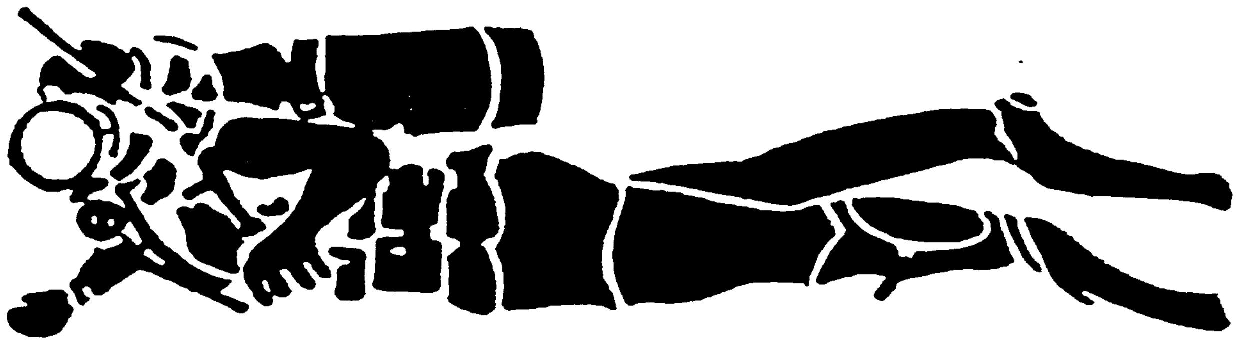


Appendix Q

Jacksonville Scubanauts Reef Research Team

Proposed Organizational Chart





BOAT CAPTAIN

This position works under the general direction of the Dive Master. Responsible for total control and safety of crew and passengers at all times. Responsible for ensuring boats used for reef research activities meet Coast Guard requirements and are seaworthy for desired projects. Organizes radio contact between other project vessels. Responsible for organizing equipment and gear storage on boat while in transit. Must be capable of compass navigation and adept in using all associated electronics, including VHF radio, loran C, depth recorder, etc. Instructs all passengers in the location of safety gear, use of facilities and proper technique for entering and exiting water. Performs related duties as required.

CHIEF PHOTOGRAPHER

This position reports directly to the Reef Research Coordinator and is responsible for recording all Reef Research activities using video equipment and/or still photography. Edits raw video footage and develops and reproduces slides and prints as necessary. Responsible for producing all training videos and other promotional videos and/or slide presentations as needed. Works closely with and provides photographic support to all divisional activities of Reef Research Team coordinating all phases of photography. Develops and maintains photography cataloging system, coordinating subject efforts with archivist. Performs related duties as required.

CHIEF SCIENTIST

This position is responsible for supervising and directing all scientific activities of the Reef Research Team. Develops and implements systems for underwater data collection and management. Supervises and directs permitting activities, archivial systems, data collection, mapping, and scientific diver training. Delegates project leaders and assists in organizing assignments. Compiles data and prepares detailed written reports regarding project activities. Works closely with Professional/Academic Advisors to insure acceptable scientific methods are being applied consistently. Supervises the development and preservation of physical reference collection. Assists Archivist in developing cataloging system. Assists Scientific Dive Instructor in methods and procedures. Performs related duties as required.

COLLECTION/MAPPING & SURVEY SPECIALIST

This position works under the general direction of the Chief Scientist. Responsible for supervising and assisting in the collection of biological samples, map preparation, and related marine surveys. Establishes and implements consistent sampling techniques to insure creditable data. Responsible for the proper care and handling of subject specimens including preservation and transportation to specimen library. Performs probe test, obtains bottom samples and takes physical measurements of structures as needed. Prepares site maps including precise location (loran C), water depth, water temperature, visibility checks, etc. Works closely with archivist to insure data is recorded promptly and precisely. Performs related duties as required.

DIVE MASTER

This position is responsible for organizing, coordinating, and supervising all diving activities involving Reef Research Team. Responsible for overall enforcement of safety standards and practices. Assist Scientific Dive Instructor and Technical Dive Instructor in planning and directing training dives for new Team members. Provides technical support and expertise regarding diving conditions. Responsible for terminating a project if weather and/or sea conditions dictate. Performs related duties as required.

EQUIPMENT SPECIALIST

This position works under the general direction of the Dive Master. Serves as custodian of all Reef Research Team equipment. Provides central storage area for Team equipment and develops and administers method of accounting for subject equipment. Responsible for routine maintenance of same. Procures additional equipment as needed. Performs related duties as required.

FINANCIAL OFFICER

This position is responsible for developing and administering the financial program for the Reef Research Team. Supervises and assists staff personnel engaged in acquiring funds for Reef Research. Performs public speaking engagements and slide presentations before private industries and government agencies. Supervises and assists in writing grants to obtain additional funding. Researches and investigates new funding sources both public and private. Drafts correspondence and submitted letters of inquiry to various interest groups. Responsible for coordinating and receiving all donations, cash or otherwise, within Reef Research Team. Will be required to maintain necessary records and prepare and submit financial reports as needed. Performs related duties as required.

GOVERNMENT/ACADEMIC/SPORT COMMUNITY LIAISON

This position works under the general direction of the Public Relations Officer. Responsible for representing the Reef Research Team with a variety of community and special interest groups. Attends community functions, academic and sporting events relating to reef research and reports observations regarding same. Recommends and assists in implementing suggestions to promote positive public image with community at large. Performs related duties as required.

GOVERNMENT GRANT SPECIALIST

This position works under the general direction of the Financial Officer. Responsible for researching, writing and submitting an assortment of grant applications to various governmental agencies for the express purpose of obtaining funds. Makes public presentations before governmental groups, establishes contacts and works within established framework to process grant applications. Responsible for enforcing all grant requirements. Submits written reports and records as needed. Performs related duties as required.

LOGISTICS COORDINATOR

This position works under the general direction of the Dive Master. Responsible for coordinating vehicle and vessel transportation to and from Reef Research Team project sites. Provides appropriate maps and time schedules for subject activities. Prepares and distributes itineraries for same. Works closely with Chief Scientist, Dive Master and Boat Captain assigning personnel as needed. Performs related duties as required.

MEDIA & PRODUCTIONS

This position will work under the general direction of the Public Relations Officer, providing technical support in areas of recruiting, photography, finance and science, as needed. Duties include creating and staging a variety of visual displays, organizing slide presentations and video programs. Assists the Public Relations Officer in drafting and editing narratives to accompany same. Provide technical support and expertise regarding radio and television productions. Assists Public Relations Officer in generating publicity for Reef Research Team through a variety of mediums. Performs related duties as required.

PERMITTING SPECIALIST

This position works under the general direction of the Chief Scientist. Responsible for initiating, implementing and monitoring the complete permitting process for artificial reef construction. Establishes and complies with standard operating procedure of various governmental agencies. Establishes and publishes a current list of permitted sites for use by Reef Research Team. Files new applications and requests permit extensions as needed. Prepares correspondence and submits reports as required. Remains abreast of changing legislation which may effect artificial reef construction and reports same to Reef Research Team. Performs related duties as required.

PRIVATE INDUSTRY FOUNDATIONS SPECIALIST

This position works under the general direction of the Financial Officer. Responsible for researching, writing and submitting an assortment of grant applications to various private industry foundations for the express purpose of obtaining funds. Makes public presentations before subject groups. Establishes contacts and works within established framework to process grant applications. Responsible for enforcing all grant requirements. Submits written reports and records as needed. Performs related duties as required.

PROFESSIONAL/ACADEMIC ADVISOR

The function of this position is to provide the means for building credibility and legitimizing various research methodology used by the Reef Research Team and linking the teams efforts to the scientific community. One, primary advisor, having credentials (preferably a PHd. in marine science, with field research experience) recognized by the academic community, should be appointed to oversee all research methodology before a project begins. Secondary advisor(s) should be considered since reef research covers more disciplines than most individual researchers have expertise in. Thus, advisors should be solicited based on the research teams needs and project priorities. Temporary appointments should be considered for special needs such as: mapping, benthic and fish surveys, experimental design and engineering. When unusual phenomena are observed, specialists should be brought in to verify the observations. The advisor(s) should also be asked to review any materials before they are published to insure its technical accuracy. Where available , the Sea Grant Extension Agent should be included as an advisor, since they have access to a wide variety of marine specialists.

PUBLIC RELATIONS OFFICER

This position is responsible for all phases of public relation activities involving Reef Research Team. Supervises and directs all promotional aspects both visual and written including radio, television, newspaper, magazines, public speaking engagements, etc. Works closely with all divisional activities of Reef Research Team to insure proper exposure with media and special interest groups. Arranges and schedules speakers for common interest groups. Writes and edits articles of interest involving Reef Research for publication in newspapers, magazines and associated periodicals. Coordinates public relations effort with Photo Specialist to insure activities are properly recorded. Supervises and directs the recruiting of new candidates for Reef Research Team. Performs related duties as required.

RECRUITMENT SPECIALIST

This position works under the general direction of the Public Relations Officer. Responsible for soliciting and enrolling new volunteers into Reef Research Program. Plans and coordinates activities within diving community generating a continuing interest among potential candidates. Develops and maintains standard criteria for accepting new candidates. Assists in training and certifying new Reef Research Team members. Performs related duties as required.

REEF RESEARCH COORDINATOR

Serves as Chief Administrative Officer of the Reef Research Team directing all phases of program activities. Responsible for administering established policies and procedures in accordance with project objectives. This position will be elected by general membership of the Reef Research Team and will report to the President of the Jacksonville Scubanauts.

Duties include organizing project activities to insure coordination with academic and sport community involved in reef enhancement. Serves as chief spokesman for Reef Research Team with news media and other community related groups. Provides group leadership to foster growth, generate revenue, and promote positive public image. Works closely with other organizations involved in reef enhancement to develop and maintain communications network. Provides logistical support to various team functions as needed. Performs related duties as required.

SCIENTIFIC DIVE INSTRUCTOR

This position works under the general direction of the Chief Scientist. Responsible for training and supervising the diving activities relative to the collection of scientific data. Responsible for directing and enforcing appropriate safety rules and regulations. Serves as chief time keeper for diving activities. Assists divers in and out of water with equipment and specimens. Performs related duties as required.

SECRETARY

Performs all secretarial duties for Reef Research Team including recording and transcribing minutes of all meetings and maintaining record of all associated events. Responsible for collecting, sorting and routing all correspondence. Works closely with Archivist to insure records and correspondence are properly preserved. Maintains current mailing list, including addresses and phone numbers of all Reef Research Team members. Performs related duties as required.

STANDARDS & SAFETY SPECIALIST

This position works under the general direction of the Dive Master. Responsible for insuring all Reef Research Team dives comply with industry safety standards. Performs routine visual inspections to insure proper equipment is being used. Responsible for insuring first aid supplies and medical oxygen are on hand during all Team dives. Maintains list of emergency medical personnel including telephone numbers and addresses. Develops and routinely updates plans to handle medical emergencies as needed. Performs related duties as required.

TECHNICAL DIVE INSTRUCTOR

This position works under the general direction of the Dive Master. Responsible for assisting the Dive Master with all Reef Research diving activities. Responsible for training and certifying new members relative to underwater safety, data collection techniques and overall skills assessment. Works closely with new members during related diving activities. May assist as time keeper or boat assistant as needed. Visually inspects equipment to insure overall safety of Reef Research Team. Performs related duties as required.

TREASURER

This position reports to the President of the Jacksonville Scubanauts Inc. and is elected by general membership of subject organization. Duties include handling and processing all accounts receivable and accounts payable for Reef Research activities. Maintains monthly balance on Reef Research Account and submits financial reports as needed. Performs related duties as required.

ARCHIVIST

This position works under the general direction of the Chief Scientist. Responsible for designing and implementing a computerized archivial system for recording and preserving scientific, historical and organizational Reef Research related data. Develops cataloging system and reference index for retrieval of subject information including video tapes, photographs, slides, books, periodicals, newspaper clippings, business activities of Reef Research Team, physical reference collection, etc. Coordinate with various members of Reef Research Team the receiving, entering and extraction of data from archive, as necessary. Serves as custodian of specimen and reference library. Provides information necessary for the preparation of written reports and data required for statistical analysis as required. Performs related duties as required.

ASSISTANT REEF RESEARCH COORDINATOR

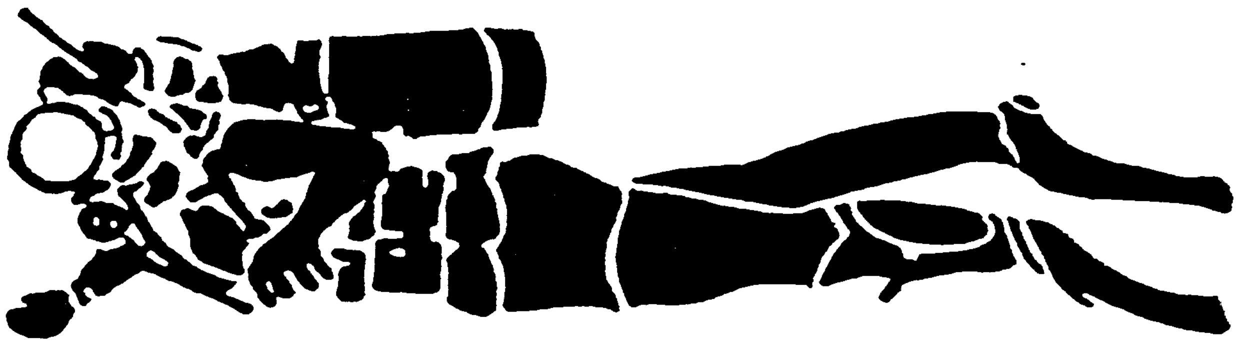
Serves as Assistant to Reef Research Coordinator supervising all phases of program activities. This position will be appointed by the Reef Research Coordinator and will serve a term concurrent with other officers of the Jacksonville Scubanauts. Reports directly to the Reef Research Coordinator and acts on behalf of same, in his absence.

Duties include assisting the Reef Research Coordinator in organizing all project activities. Serves as liaison between various divisions of Reef Research Team to insure proper coordination with each. Responsible for identification and storage of laboratory specimens, training videos and other related material. May be required to chair special committees as directed. Performs related duties as required.

Appendix R

Project Management Form

Name	Project Prep	Boat	Dive Operator (1)		Dive operator (2)	
			Dive 1	Dive 2	Dive 1	Dive 2
	Food					
	Lodging					
	Transportation					
	Boats					
	Equipment & Air					
	Safey Officer					
	Chief scientist					
	Dive master					
	Admin Assist					



Appendix S

Jacksonville Scubanauts, Inc. Reef Research Team

Archivist

May 27, 1987

Overview

There are three tasks that must be performed before a successful archive can exist. First, if the information/data is not written down, it never happened. Secondly, if the supervisors of the various areas delineated by the organizational chart are not aware of the information/data which is available in the archive, it may as well not exist. And last but not least, if the various supervisors do not deliver the information/data to the Archivist, it does not exist.

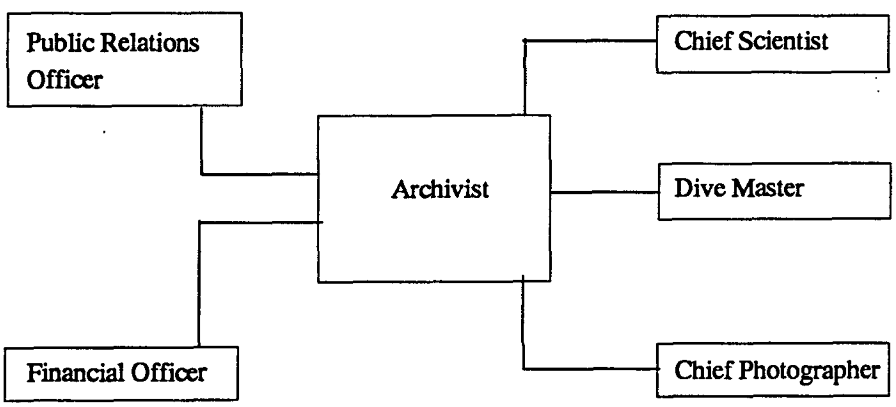
Standard Operating Procedures

1. All information which pertains to an area which is supervised by the Public Relations Officer shall be delivered to the Archivist via the Public Relations Officer.
2. All information which pertains to an area which is supervised by the Chief Scientist shall be delivered to the Archivist via the Chief Scientist.
3. All information which pertains to an area which is supervised by the Dive Master shall be delivered to the Archivist via the Dive Master.
4. All information which pertains to an area which is supervised by the Financial Officer shall be delivered to the Archi ist via the Financial Officer.
5. All information which pertains to an area which is supervised by the Chief Photographer shall be delivered to the Archivist via the Chief Photographer.
6. All information provided by the advisors should be delivered to the Coordinator or Assistant Coordinator. The Coordinator or the Assistant should then forward the information to the appropriate supervisor.
7. Each area should establish uniform data sheets to ensure consistent data collection as well as consistent computer input. For example:

   Chief Scientist: dive logs, boat logs

   Chief Photographer: video/photo index log

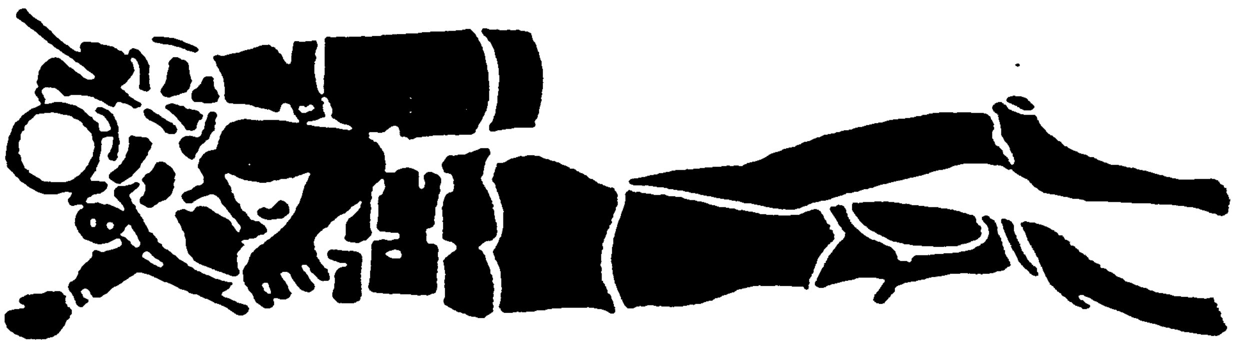
   Dive Master: equipment inventory log



Archivist's

<u>Shawn Brayton</u>
Public Relations Officer
Chief Scientist
(excluding preserved samples)
Chief Photographer, Dive Master

<u>Wendy Short</u>
Financial Officer
Collection Specialist
(preserved Specimen and soil smaple)



Appendix T

Jacksonville Scubanauts, Inc.

Reef Research Team
P.O. Box 43370
Jacksonville, FL 32203-2270

Position Statement

The Reef Research Team is a group of volunteer sport divers operating as a committee of the Jacksonville Scubanauts, a non-profit diving organization. The primary objective of the Reef Research Team is to observe, collect, document and record scientific data for use in further enhancing our marine habitats. We envision this effort as a long range community project spanning many years and involving hundreds of volunteers.

Using the tools of research, education and diving, we are committed to assisting the sea in building reefs around suitable man-made objects, in an effort to increase marine life in areas now barren and unproductive. We will study the presence of these inhabitants and report our findings. Appropriate agencies will interpret the value and impact these structures have in relation to our economic, environmental and recreational activities.

Through education we intend to inform the public of the need for protecting all reefs, both natural and man-made. By example, we will demonstrate good conservation practices on the reefs.

We aim to create a better understanding among all water sportsmen, particularly those who fish or hunt the reefs, by being more understanding and considerate of each others' needs and viewpoints.

May 18, 1987

By - Laws of

Jacksonville Scubanauts, Inc.

(Florida Not For Profit Corporation)

Article I.

This corporation shall be known as Jacksonville Scubanauts, Inc. (A Florida Not For Profit Corporation).

Article II.

Active Members shall be eighteen (18) years of age or older and be nationally certified scuba divers. All other members shall be designated "Other Members" and shall not be entitled to own stock or to vote.

Only Active members, in good standing, shall be entitled to a vote in corporate affairs.

Only Active Members shall be eligible to hold office in the

Corporation. Candidates for office must be active and in good standing for ninety (90) days prior to nominations. Nominations must be held thirty (30) days prior to elections.

In the event that a presiding officer relinquishes his post or is found to be unfit for office, nominations shall be held at the next regular meeting with election and installation at the following meeting. (Nominations from the floor will still be taken on the third meeting.)

Article III.

Purpose and Objectives:

For the preservation, support and promotion of the sport of skin and scuba diving and its various forms of allied activities.

To dedicate ourselves to the furtherance of the sport together with sound conservation, good sportsmanship and cooperation with and for federal, state and local agencies as well as other worthwhile groups and projects.

To promote fellowship among underwater sportsmen by sponsoring contests, outings and other educational, social and recreational programs.

- Provide assistance to the public and scientific community of Florida by providing scientific data concerning reef enhancement productivity and to locate and evaluate sites for future Fish Enhancement placement locations.

- Create an opportunity for divers to utilize their skills and experience for the benefit of public interest.

- Educate the public of the utilization of fish enhancement devices offshore and develop a workable relationship with the scientific community in obtaining information concerning the Fish Enhancement Program.

This organization shall be incorporated so that it can contract in its own name, to protect its members, officers and directors from personal liability and to provide an organizational format which will allow us to pursue our Purposes and Objectives as set forth here in.

Article IV.

The officers of the corporation shall be a President, Vice-President, Secretary and Treasurer. All elective officers shall be elected on the first meeting night in May of each year. Officers shall be installed in June, of the same year, and shall hold this office for one year, or until their successors are elected and qualified. Officers shall serve without pay.

The outgoing or past President shall be appointed as a member of the Board of Directors for a term of one year after his departure from office.

The Stockholders shall elect officers and approve the selection of Reef Coordinator who, with the inclusion of the immediate past president shall constitute the Board of Directors.

Duties of the President:

The duties of the President shall be:

- To preside at all meetings of the corporation.

- To appoint any persons or committees not otherwise ordered by the corporation.

- To personally represent the corporation on proper occasions and business contracts.

- To assist all other officers of the corporation in the performance of their duties.

- To promote interest on the part of each corporate member on corporate life and activities.

- To vote only when one vote is necessary to break a tie.

- The President shall be the Chief Executive Officer of the corporation, shall have general and active management of the business and affairs of the corporation subject to the directions of the Board of Directors, yet shall be excluded from holding thee office of the Reef Research Coordinator.

Duties of the Vice-President:

The duties of the Vice-President shall be:

- To be the Membership Chairman.

- To perform the duties of the President in his absence.

- To assist in any other manner which the President deems necessary.

- To act as Program Chairman whose duties shall be as the President directs.

Duties of the Secretary:

The duties of the Secretary shall be:

- To have custody of and maintain all of the corporate records except the financial records.

- To record all the minutes of all meetings of the Stockholders and Board of Directors.

- To perform such other duties as may be prescribed by the Board of Directors or President.

- To send out notices of all regular and special meetings.

- To handle all corporate correspondence.

- To perform such other duties as generally fall to that office.

- To retain copies of all corporate correspondence by any other member.

The Duties of the Treasurer:

The duties of the Treasurer shall be:

- To collect dues from all members.

- To collect all other money due the corporation.

- To make all payments from corporate funds when so ordered by the corporation.

- To be responsible for filing all required IRS returns for the corporation at the end of the fiscal year, which shall be May 31.

- The Treasurer shall have custody of all corporate funds and financial records, shall keep full and accurate reports of disbursements and render account thereof at each meeting of stockholders and whenever else required by the Board of Directors or President, and shall perform such other duties as may be prescribed by the Board of Directors or President.

- All money matters over $50.00, including the Reef Research Account, must be approved by the Board of Directors.

All checks are to be signed by the corporation's Treasurer or by the President. The Board of Directors is encouraged to submit expenditures over $100.00 for the approval of the Stockholders present at any given meeting including the Reef Research Team Account.

- Expenditures associated with reef research must first meet the approval of the Reef Research Team Committee. The Reef Coordinator will submit the expenditure to the Board of Directors for review. The Reef Research Team Committee must respond to prudent suggestions by the Board of Directors.

Article V.

Board of Directors:

- Function: The business of this corporation shall be managed and its corporate powers exercised by the Board of Directors. To make recommendations upon Stockholder expulsions. To properly investigate and present to the corporation all business or important activity situations.

- Number: This corporation shall have no more than six (6) but no less than four (4) directors.

- Qualifications: All of the members of the Board of Directors shall be of full age, and at least one shall be a citizen of the United States. It shall be necessary for the Directors to be Stockholders

- Vacancies: Vacancies in the Board of Directors shall be filled by appointment by a majority of the remaining members of the Board of Directors. That the appointee shall fulfill the appointed office until such time as a new officer can be elected in accordance with the various Articles of this, the By-laws, at which time the appointee, if different from the new officer elected, shall step down and the new elected officer shall be installed as a member of the Board of Directors.

- Quorum: The presence of a majority of all of the Directors shall be necessary at any meeting to constitute a quorum to transact business. The act of a majority of Directors present at a meeting where a quorum is present shall be the act of the Board of Directors.

- Place of Meeting: Director's meetings may be held within or without the State of Florida.

- Time of Meeting: Meetings of the Board of Directors shall be held immediately following the annual meeting of Stockholders each year, at such times, thereafter as the Board of Directors may deem necessary, and at other times upon the call of the President or by a majority of the Directors. Notice of each special meeting shall be given by the Secretary to each Director not less than five (5) days before that meeting unless each Director shall waive notice thereof before, at or after the meeting.

- Executive Committee: The Board of Directors may by resolution, designate two (2) or more of their number to constitute an Executive Committee, who, to the extent provided in such resolution, shall have and may exercise the powers of the Board of Directors

Article VI.

All elective officers shall be nominated at the meeting to be held on the meeting night in April of each year. The nominees shall be voted upon and elected at the annual election to be held on the meeting night in May of each year. Officers shall be installed in June of the same year and shall hold this office for one year, or until their successors are elected and qualified. Voting shall be by secret ballot.

Article VII.

- The regular meetings of the corporation shall be held by the second Wednesday of each month at 7:30 P. M. The President or Board of Directors may call a special meeting at any time by mailing a notice to all Stockholders at least five (5) days in advance.

- The annual meeting of the Stockholders of this corporation shall be held on the second Wednesday of May, 1985, and each year thereafter, unless and until these By-Laws be amended as provided for herein.

- The annual meeting shall include the election of officers.

- At least ten (10) Active Members, in good standing shall constitute a quorum for the transaction of corporate business.

- Every Stockholder having the right and entitled to vote at any meeting of the Stockholders shall be entitled, upon each proposal presented at the meeting, to one vote.

Article VIII.

These By-Laws may be amended by the Board of Directors, subject to approval by a majority of the Stockholders present, so long as they constitute a quorum, at the next monthly meeting.

Article IX.

Roberts Rules of Order shall govern the parliamentary proceedings of this corporation, unless otherwise provided in the By-Laws. The order of business shall be:

- Speaker (optional).

- Reading and approval or revisions of the Minutes of the previous meeting.

- Treasury report.

- Executive Board Members and committee reports.

- Old business

- New business

-Dive Reports (optional).

Article X.

- Active Membership is open to any person, subject to provisions set forth in the By-Laws, male or female, over the age of eighteen (18) years who will abide by the laws of the organization and who expresses a desire and willingness to be dedicated to the purpose herein stated.

- Active Members will be entitled to one vote each and one share of stock each and to any and all other rights and privileges according to the By-Laws provided they are not more than two (2) months in arrears in their dues.

- The applicant shall be provided with a copy and will have read and agreed to the By-Laws of this corporation. The applicant shall execute a statement that he/she has read and agreed to the By-Laws and will be bound by them and will provide an original and one copy (front and back) of their nationally recognized certification card and shall sign such other and further document as the corporation deems necessary or useful to accomplish its corporate purposes.

- Applications for membership must be recommended by an Active Member, in good standing. At the expiration of one month, his conduct being satisfactory and being voted in by a quorum, he/she becomes a member (Active or Other) and will be entitled to all the privileges of their membership. Prospective Members shall complete an application for membership chairperson.

- Active Members shall have the right to bring a non-member quest on two club dives. Any Active Member bringing a quest to a club dive shall be responsible for the conduct and behavior of their guest. In the event that there are limited resources (for example, spaces on a dive boat) for which both members and guests are competing, the active member shall be entitled to take priority and precedence over the other member and non-member guest and shall be entitled to all available resources before any non-member guest will be entitled to same.

Article XI.

- Active Membership dues shall be $16.00 per 6 months or $30.00 per year per person. All other Membership dues shall be $12.00 per year to be paid annually.

- Membership dues are not refundable or transferable.

- That all Active and Other Members belonging to a single family, not withstanding the other provisions of these By-Laws, shall pay no more, for all members of the family, than $32.00 per 6 months or $60.00 per year for the entire family. These may be no more than two (2) Active Members per family.

Article XII.

- Upon a complaint of conduct on the part of any member which might reflect unfavorable on the organization as a whole, said member may be expelled by a quorum present at any meeting. Any member so expelled shall immediately surrender their stock in this corporation to a corporate officer.

- Changes must be submitted in writing and the member given a hearing before the Board of Directors, which in turn will report its findings to the corporation with its recommendation that the charges be considered as proven and the member expelled, or the charges be considered not proven and the accused remain a member of the corporation.

- Upon demand of a quorum of Active Membership or upon recommendation of the Board of Directors as ratified by a quorum of the Active Members present at any meeting an officer may be removed from office. Said officer must have the right to speak in his own behalf.

- Any officer missing three (3) consecutive meetings will be notified that unless he/she attends the next meeting, his/her office will be considered vacant.

- That two-thirds of the Stockholders present at any meeting, so long as a quorum is present, can override the officers and Board of Directors upon motion duly made and seconded by such Stockholders.

- Upon the infraction of any diving rule as set forth by the Dive Committee (said committee to be organized and controlled by one of the Officers of the corporation as designated by the President of the corporation) or willfully acting dangerously or causing harm to another person, or themselves while diving, that member shall be subject to immediate dismissal from the corporation. Said member must have the right to be heard in their own behalf. Any officer or their designee should have the right to dismiss a member for any such infraction or unsafe practice, said dismissal being effective immediately upon notification to the offending member. The offending member, on the instant of notification, shall no longer be a member of Jacksonville Scubanauts, Inc. (A Florida not for profit corporation) or any subsidiary thereof for any reason or purpose whatsoever until the monthly meeting following such dismissal at which time the offending member shall have the right to be heard in their own behalf.

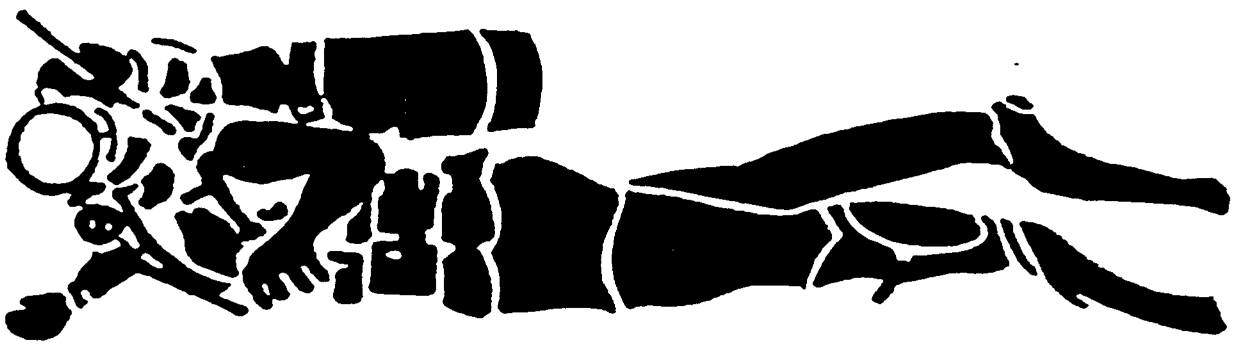
Article XIII.

- Should any Active Member leave the corporation for any and all reasons whatsoever, that Active Member shall immediately return any and all corporate property. The member shall also return any stock in which that member own an interest.

- Any member shall return their share of stock upon demand of the corporation, for any reason.

- The corporation shall keep in its records all issued shares of stock. The actual "shares" shall not be distributed to the member per agreement of the member and the corporation.

Appendix U



JULIAN DATE CALENDAR

FOR LEAP YEARS ONLY

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244	.	305		366	31

(USE IN 1964, 1968, 1972, etc.)

GPO: 1964 O—722-665

1776, 1780, 1784, 1788
1792, 1796, 2000, 2004,
2008, 2012, 2016, 2020

JULIAN DATE CALENDAR

(PERPETUAL)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

7510-226-5401

FOR LEAP YEAR USE REVERSE SIDE