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PROCEEDINGS OF THE

FLORIDA KEYS CORAL REEF WORKSHOP

OCTOBER 21-22, 1974

sponsored by the

State of Florida
Department of Natural Resources

Coastal
Coordinating
Council

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Florida Coastal Coordinating Council

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FLORIDA KEYS CORAL REEF WORKSHOP

October 21-22, 1974
9:00 A.M.
Main Auditorium
University of Miami
Rosenstiel School of Maine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, Florida 33149

Sponsored by the
Florida Coastal Coordinating Council
State of Florida Department of Natural Resources

COASTAL ZONE
INFORMATION CENTER
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2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

Council Members

Mr. Harmon Shields, (Chairman), Executive Director, Department of Natural Resources
Mr. Jay Landers, Executive Director, Board of Trustees of the Internal Improvement Trust Fund
Mr. Peter J. Baljet, Executive Director, Department of Pollution Control
Mr. L. Kenneth Ireland, Secretary of Administration, Department of Administration

Council Staff Director: W. Bruce Johnson

Council Conference Coordinator: James W. Carr, Research Coordinator

Editor: Mary Lou Stursa, Information Coordinator

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FOREWORD

The Coastal Coordinating Council was established by the Florida Legislature in 1970 to:

1. conduct, direct, encourage, coordinate and organize a continuous program of research into problems relating to the coastal zone;
2. review, upon request, all plans and activities pertinent to the coastal zone and to provide coordination in these activities among the various levels of government and areas of the state;
3. develop a comprehensive state plan for the protection, development and zoning of the coastal zone making maximum use of any federal funding for this purpose;
4. providing a clearing service for coastal zone matters by collecting, processing and disseminating pertinent information relating thereto.

In 1973, Governor Askew designated the Coastal Coordinating Council as the state agency that would develop the coastal zone management plan for Florida under the federal Coastal Zone Management Act of 1972.

In the light of the legislative charges and the Governor's designation, it was felt that the Coastal Coordinating Council was the logical agency to coordinate a workshop designed to acquaint concerned state agencies and researchers in the subject area with current research on corals and coral reef ecosystems

and to define a planning, management and research program for the Florida Keys coral reef tract.

The proceedings of this first workshop are presented here. It was felt by many of those who participated that the work done at these sessions was not complete, and a follow-up workshop was requested. The second workshop, which will further define the research needs and program, is tentatively planned for early 1975 and will include a broader base of participation. The date and further details will be announced in the Coastal Coordinating Council Newsletter.

SYMPOSIUM
October 21, 1974

PROGRAM

9:00 A.M. - 9:15 A.M.	James W. Carr Research Coordinator Coastal Coordinating Council	Opening Remarks. Marine Sanctuary Coral Reef Mapping Program
9:15 A.M. - 9:45 A.M.	David R. Worley Coastal Planner Remote Sensing Specialist Coastal Coordinating Council	Initial project utilizing water penetration film
	William K. Kuyper Remote Sensing Scientist Department of Transportation	Water penetration film. Film characteristics, problems, resolutions, etc.
	John Thompson Harbor Branch Foundation Key Largo, Florida	Validation of water penetration film
9:45 A.M. - 10:45 A.M.	Arnfried Antonius Florida Reef Foundation Homestead, Florida	Determination of the health of Florida reefs
10:45 A.M. - 11:15 A.M.	William S. Alevizon Harbor Branch Foundation Ft. Pierce, Florida	Study of reef fish communities
11:15 A.M. - 11:30 A.M.	Richard N. Mariscal Department of Biological Science Florida State University	Coral nematocysts and sensory receptors as related to feeding behavior and capture
11:30 A.M. - 12 Noon	Phillip Dustan Harbor Branch Foundation Key Largo	Harbor Branch Foundation (proposed research on reefs at John Pennekamp State Park)
12 Noon - 1:30 P.M.	Lunch	
1:30 P.M. - 2:30 P.M.	Edwin A. Joyce Jennifer Smith Walter C. Jaap Florida Department of Natural Resources, Bureau of Marine Science and Technology	(a) In situ experimentation and development of baseline data on lower Florida Keys Reefs. (b) Studies conducted during participation in hydrolab missions at Lacayo, Grand Bahama (c) Project Hourglass (d) Enacted Corals legislation

2:30 P.M. - 3:30 P.M.	Robert N. Ginsburg Rosenstiel School of Marine and Atmospheric Science University of Miami Fisher Island Station Miami	Resume of reef types in Florida
3:30 P.M. - 4:30 P.M.	George M. Griffin Harbor Branch Foundation Key Largo	Effects of dredging on the Natural Turbidity Regime
4:30 P.M. - 5:15 P.M.	W. A. Cockrell Division of Archives, History, and Records Management	The inter-relationships of reefs and archaeological sites

WORKSHOP PROGRAM
October 22, 1974

9:00 A.M. - 11:00 A.M.	Workshop Sessions (Assignment of committee members)	(a) Research group to identify applied coral reef research needs facilities, equipment, priorities, etc. (b) Administrative/ Management group to define program, procedures, etc.
11:00 A.M. - 12 Noon	General Session (Main Auditorium)	Discussion of group sessions
1:30 P.M. - 2:30 P.M.	Conference Coordinator and committee members meet to finalize program and identify grant proposal.	

PARTICIPANTS

Arnfried Antonius
Florida Reef Foundation
P.O. Box 1468
Homestead, Fla.

Vic Anderson
U.S. Army/Corps of Engineers
Jacksonville, Fla.

Randy Armstrong
Dept. of Pollution Control
Tallahassee, Fla.

Douglas Bailey
Fla. Game & Fish Commission
Tallahassee, Fla.

Arnold Banner
Fish & Wildlife Service
Vero Beach, Fla.

Bill Barada
Fla. Skin Daiving Assoc.
Rt. 2, Box 368-A
Kissimmee, Fla.

F. M. Bayls
RSMAS
Miami, Fla.

Frasier Bingham
Dept. of Transportation
Tallahassee, Fla.

Mary Ann Bogle
RSMAS
Miami, Fla.

Stephen Carins
RSMAS
Miami, Fla.

J. W. Carr
Fla. Coastal Coordinating Council
309 Office Plaza Drive
Tallahassee, Fla.

Nicholas Chitty
RSMAS - Univ. of Miami
Miami, Fla.

W. A. Cockrell
Dept. of State
Tallahassee, Fla.

Tom Coryn
T.I.I.T.F.
P. O. Box 904
Tavernier, Fla.

Dennis Creamer
Fish & Wildlife Service
Vero Beach, Fla.

Gary E. Davis
Everglades National Park
Homestead, Fla.

Terry T. Davis
Dept. of Pollution Control
200 S.E. 65th St.
Ft. Lauderdale, Fla.

Dr. Donald P. de Sylva
RSMAS - Univ. of Miami
Miami, Fla.

S. H. Dickson
Dept. of Pollution Control
Tallahassee,Fla.

Robert Farragut
NMFS/NOAA

Robert Ginsberg
RSMAS - Fisher Island
Miami, Fla.

Walter M. Goldberg
Fla. International University
Miami, Fla.

Ken Gordon
Harbor Branch Foundation
302 N.W. 20th St.
Homestead, Fla.

George M. Griffin
Harbor Branch Foundation and University of Florida
Gainesville, Fla.

John C. Halas
Harbor Branch Foundation
Key Largo, Fla.

Larry Harman
So. Fla. Reg. Plan. Council
1515 N.W. 167th St.
Miami, Fla.

R. J. Helbling
Dept. of Pollution Control
Tallahassee, Fla.

Gary Hendrix
National Park Service
Everglades National Park

Robert B. Holly
USGS
15 Rickenbacker Cswy.
Miami, Fla.

David R. Hopkins
EPA
Atlanta, Ga.

J. Harold Hudson
USGS
15 Rickenbacker Cswy.
Miami, Fla.

W. C. Jaap
FDNR Marine Research Lab.
100 8th Ave., S.E.
St. Petersburg, Fla.

Haynes Johnson
Dept. of Natural Resources
Miami, Fla.

Robert S. Jones
Harbor Branch Foundation
Ft. Pierce, Fla.

Terri Jo Kennedy
Fla. Senate, The Capitol
Tallahassee, Fla.

Bob Kriegel
T.I.I.T.F.
Tallahassee, Fla.

Herb Kumpf
NOAA, NMFS
75 Virginia Beach Dr.
Miami, Fla.

William H. Kuyper
Dept. of Transportation
Tallahassee, Fla.

John Lindell
Fish & Wildlife Service
Vero Beach, Fla.

Karen Lukas
Harbor Branch Foundation
Key Largo, Fla.

William G. Lyons
FDNR Marine Research Lab
100 8th Ave., S.E.
St. Petersburg, Fla.

D.J. Marszalek
RSMAS - Univ. of Miami
Miami, Fla.

Bill Miller
Fla. State University
Tallahassee, Fla.

Richard W. Milter
Dept. of Transportation
District 4
Miami, Fla.

Ralph Montgomery
Fla. State University
Tallahassee, Fla.

Donald R. Moore
RSMAS
Miami, Fla.

Katherine Muzik
RSMAS
4600 Rickenbacker Cswy.
Miami, Fla.

Linda Orr
Palm Beach County Schools
4110 Tanglewood
Palm Beach Gardens

Ronald Riopelle
H. W. Lochner, Inc.
3151 3rd Ave., N. #425
St. Petersburg, Fla.

Chuck Schnepel
T.I.I.T.F.
Miami, Fla.

Don Serbousek
FSDA (Don's Dive Shop)
333 S. Yonge St.
Ormond Beach, Fla.

Gregory Smith
FDNR Marine Research Lab
100 8th Ave.,S. E.
St. Petersburg, Fla.

J.W. Smith
FDNR Marine Research Lab
100 8th Ave. S.E.
St. Petersburg, Fla.

Michael Sosselyn
RSMAS
Miami, Fla.

Jim Stevenson
Dept. of Natural Resources
Tallahassee, Fla.

Micheal B. Stuart
Fla. Audobon Society
2727 Kilgore Place
Sarasota, Fla.

Darrell Tedwell
RSMAS - Univ. of Miami
Miami, Fla.

R. Thomas
P.B.S. & J.
Miami, Fla.

M. John Thompson
Harbor Branch Foundation
Key Largo, Fla.

Anitra Thorhaug
University of miami
Miami, Fla.

Jim Tilmant
National Park Service
Everglades National Park

Morgan Wells
MUST/NOAA
11400 Rockville Pike
Rockville, Md.

Bob Work
RSMAS
Miami, Fla.

David R. Worley
Dept. of Natural Resources
Tallahassee, Fla.

Management Discussion Group

Victor Anderson - Corps of Engineers
Bill Barada - Fla. Skin Divers Association
Frasier Bingham - Fla. Dept. of Transportation
Dennis Creamer - U. S. Fish & Wildlife Service
Arnold Danner - U. S. Fish & Wildlife Service
S. H. Dickson - Fla. Dept. of Pollution Control
R. J. Helbling - Fla. Dept. of Pollution Control
David Hopkins - Environmental Protection Agency (Atlanta)
Robert S. Jones - Harbor Branch Foundation
Terri Jo Kennedy - Fla. Senate (Aide to President of Senate)
Bob Kriegel - Board of Trustees of the I. I. Trust Fund
Herb Kumpf - NOAA-NMFS
John Lindell - U. S. Fish & Wildlife Service
Bill Lyons - Fla. Dept. Natural Resources - Marine Lab
Rich M. Miller - Fla. Dept. of Transportation
Ronald Riopelle - H. W. Lochner, Inc.
Chuck Schnepel - Board of Trustees of the I. I. Trust Fund
Jim Stevenson - Fla. Dept. Natural Resources - Div. Recreation & Parks
M. John Thompson - Harbor Branch Foundation
Jim Tilman - National Park Service (Biscayne Natl. Monument)

Research Discussion Group

Arnfried Antonious - Fla. Reef Foundation
Randall L. Armstrong - Fla. Dept. Pollution Control
Douglas Bailey - Fla. Game & Fresh Water Fish Commission
Nicholas Chitty - RSMAS
Gary E. Davis - Everglades Natl. Park - U. S. Park Service
Terry L. Davis - Fla. Dept. Pollution Control
Donald P. DeSylva - RSMAS
Phillip Dustan - Harbor Branch Foundation
Robert Farragut - NOAA-NMFS
Robert N. Ginsburg - RSMAS
Ken Gordon - Fla. Dept. Natural Resources - Marine Lab
George M. Griffin - Univ. of Florida
John C. Halas - Harbor Branch Foundation
Roger Hanlon - RSMAS
Ray Hixon - RSMAS
Robert B. Holly - USGS (Miami)
Harold Hudson - USGS (Miami)
Walter C. Jaap - Fla. Dept. Natural Resources - Marine Lab
Haynes Johnson - Fla. Dept. Natural Resources - Survey & Mngmnt.
William H. Kuyper - Fla. Dept. Transportation
Karen Lukas - Harbor Branch Foundation
Donald R. Moore - RSMAS
Raoul G. Rehrer - RSMAS
Gregory B. Smith - Fla. Dept. Natural Resources - Marine Lab
Jennie Smith - Fla. Dept. Natural Resources - Marine Lab
Michael E. Stuart - Fla. Audubon Society
Morgan Wells - NOAA-MUST (Rockville, Md.)

Abstract

Water Penetration Film: Characteristics, Problems, Resolutions, Etc.

William K. Kuyper

Types of photographic films used by the Remote Sensing Section by the State Topographic Office, Department of Transportation, were presented and demonstrated.

The presentation referred to the various uses of these films in collecting data in the various parts of the electromagnetic spectrum, primarily in the 390-920 namometer range. Types of films presented and demonstrated were the Eastman Kodak Aerial Color film, Type 2445; Color Aerial Infrared Type 2443 and the EKCo Experimental Water Penetration Film (SO224).

Advantages and limitations of the various films were demonstrated. The keynote was the ability of the new water penetration film's capability to record bottom information to some degree up to depths of approximately 120 feet at the edge of the reef at Molasses Key (near Tavernier, Florida). Other observations of bottom phenomena, ranging from shoreline and up to depths of 60 feet were easily identified. This particular film, Water Penetration Film, SO224, shows its superiority over regular color and color infrared film for delineating bottom data in a semitropical and tropical environment.

Validation of Water Penetration Film

M. John Thompson

One February 23, 1974, the Department of Transportation, in conjunction with the Coastal Coordinating Council, flew a compass course transect from Tavernier Creek to Molasses Reef Light, off Key Largo, Florida. Bottom features were photographed with an experimental water penetrating film developed by Kodak. Altitude was 12,000 feet, yielding a flight corridor 3/4 mile wide and a photographic scale of one inch equals 2000 feet.

Two major habitats are recorded in these photographs: (1) the lagoon, or backreef community, composed mainly of grassbeds and patch reefs. In the Florida Keys this habitat stretches from the outer reef line to shore, an average distance of about six nautical miles; (2) the outer reef itself. Molasses Reef is the only outer or fringing reef shown in these sample photographs and it appears in prints numbers 140 and 141.

Visualization of all bottom features in the lagoon area from Tavernier Creek to the inside of Molasses Reef (Photo numbers 136-140) is excellent. There are several patch reefs in both Molasses Reef Channel and the White Banks areas which are extremely well delineated. Halo effects around those patch reefs which lie in *Thalassia* beds are quite prominent. Depths along this entire portion of the transect do not exceed 33 feet.

Nearshore, in Hawk Channel and around Tavernier Key, resolution of bottom features deteriorates slightly (Photos 136 and 137). This

is attributed to increased ambient turbidity which is characteristic of Hawk Channel. Two artifacts, apparently produced by locally heavy concentrations of suspended material, are seen in photograph number 136. Both these areas are adjacent to the tidal flats surrounding Tavernier Key.

Morphologically, Molasses Reef is composed of a series of levels or steps at gradually increasing depths (Photos 140 and 141). Thalassia from the lagoon community gradually thins out into a barren rubble zone with a depth of between three and six feet. This zone extends oceanward for approximately 600 feet and is an area of high wave energy with very little coral or algal growth. Photographically, it is well visualized. Between this zone and the reef crest is a sheltered rubble zone 300 to 400 feet wide and at a depth of 6 to 12 feet. There is considerable more coral, gorgonid, and algal growth here and this can be detected from the photographs. Molasses Reef's spur and groove system has a total width of approximately 500 feet, but it can be subdivided into the reef crest and the shallow fore reef slope. The reef crest, with an average depth of 15 feet, is well visualized. Resolution remains good down to the base of the shallow fore reef slope, or to a depth of 35 or 40 feet. The deep fore reef slope gradually drops from 40 to 55 feet over a linear distance of 450 feet. Although this slope can be made out from the photographs, all detail is lost. Molasses Reef's outer reef face is a steep drop from 55 to 90 feet deep in approximately 15 feet of linear distance. This drop is extremely difficult to detect in the photographs.

Although photographic detection of bottom features indicates that the new Kodak film will penetrate water to a depth of 90 feet and beyond, workable resolution on photographs produced by the February 23, 1974, over flight was lost after a depth of 40 to 45 feet. Visualization down to this depth, however, did allow detailed differentiation of the major zones comprising Molasses Reef. Resolving power of the new film in lagoon and back reef habitats is excellent, and it allows differentiation of relatively minor changes in density of bottom cover. This film will be an excellent tool for the ecological inventory of Florida's coral reef and lagoon area resources along Florida's Keys.

Abstract

Determination of the Health of Florida Reefs

Arnfried Antonius

A study, aimed at determination of the health of Florida Reefs was initiated in late 1972. The first part of the survey, including the major reefs of the John Pennekamp Coral Reef State Park and the Hen and Chickens Reef has been completed in 1973. To validate results, comparative data from the Barrier Reef in British Honduras at a location near Stann Crek were gathered in 1974.

A method has been developed which uses the percentages of live versus dead coral surface area to quantitatively describe the health condition of reefs.

The main State Park Reefs turned out to be only insignificantly inferior in health condition to the Barrier Reef, with dead coral surface area in both cases remaining below 10%. The Hen and Chickens Reef was found to be devastated to over 80%. Other reefs outside of the State Park, which have not yet been surveyed quantitatively, are believed to show signs of deterioration and will be studied in detail in the near future.

Abstract

The Comparative Structure of Two Western Atlantic Reef Fish Communities

William S. Alevizon

The fish faunas associated with shallow coral reef areas off Key Largo, Florida, and the Aves Island group off Venezuela were censused between February and May of 1974. Sixty 2 3/4 minute super-8 mm underwater movie films or "cinetransects" taken by a SCUBA diver swimming about the reefs provided repetitive counts of resident fish species. The structure of each community was analyzed graphically by plotting the log abundance against the frequency of occurrence for each species and subdividing the resulting graph into units based on both variables.

The Key Largo community contained a greater number of species, and had a greater species diversity and equitability than did that of the Venezuelan reefs. This may reflect the greater structural complexity of the Key Largo reef habitat.

Abstract

Proposed Research on Reefs at John Pennekamp State Park

Phillip Dustan

The reefs of the Florida Keys are the most northern reefs in the Western Hemisphere situated along a mainland coast. By definition they are fringe populations as they live at the limits of prolific coral growth. This means that the reefs are under great natural stresses aside from any that may be imposed by man and his devices. Should there be added stresses resulting from man's occupation of the Florida Keys and adjacent areas the reef populations may not remain as splendid as they are today or have been in the past.

There is a tremendous amount of variation in reef corals, not only between species but within as well. A coral colony is the result of a complex symbiotic relationship between a coelenterate animal and a dinoflagellate alga. Each is capable of variation, both physiologic and genetic. Recent work on *Montastrea annularis* has shown that within a species there seem to be subpopulations, or ecotypes, that occupy and select different habitats. The population genetics and dynamics of fringe populations are not well understood, so on theoretical grounds we do not have a clear idea of what the structure of the Keys reef coral populations should be. We do know, however, that all are subject to the sieve of natural selection and must assume, until otherwise proven, that they are adapted to their

respective habitats. The limits of their responses are the variables that need quantification, for this will give insight into how much stress these complex ecosystems can withstand.

The Harbor Branch Foundation maintains a field station at John Pennekamp State Park. Future plans for research center around the structure of the coral reef at Carysfort Light. We plan to establish permanent areas in which to study the dynamics of reef coral populations, mainly the parameters of mortality, recruitment, distribution, and growth. Other research interests lie in the area of endolithic algae, the photophysiology of zooxanthellae, and the role of sediment in coral mortality.

The Harbor Branch Foundation is a non-profit organization devoted to further understanding the sea and its inhabitants. Visiting scientists are welcome at Pennekamp as they all are involved in this same venture. The lab at Pennekamp may be regarded as a resource open to those who can benefit by its use.

Abstract

Observations on Florida Reef Corals
Treated with Fish Collecting Chemicals

Walter C. Jaap and Jennifer Wheaton Smith*

Studies to determine possible deleterious effects of fish collecting chemicals on reef corals were initiated. Chemical study sites were established at Eastern Sambo Reef (ca. 5 nmi ESE of Key West, Florida) and monitored for one year. Specimens of both scleractinia and octocorallia, representing eight and seven genera respectively, were treated.

A quinaldine (2 methyl-quinoline)/acetone/seawater solution and Chem Fish Collector (a commercial rotenone preparation) were dispensed over individual colonies. Immediate and long term visible effects were noted.

Post-treatment observations revealed no damage to octocorals due to either type of chemical. Scleractinia suffered little or no damage from quinaldine treatment. Five scleractinian specimens (*Acropora cervicornis*, *Acropora palmata*, *Siderastrea siderea*, *Diploria strigosa*, and *Dichocoenia stokesi*) were severely damaged by Chem Fish Collector treatment. In general, scleractinia were most susceptible to chemical treatment than were octocorals.

Abstract

Growth Studies on Gorgonian Octocorals

Jennifer Wheaton Smith

Results of growth studies conducted at Eastern Sambo Reef (ca. 5 nmi ESE of Key West, Florida) on seven gorgonian octocorals (*Plexaura homomalla*, *Plexaurella dichotoma*, *Eunicea tourneforti*, *Muricea atlantica*, *Pseudoplexaura porosa*, *Gorgonia ventalina*, and *Pseudopterogorgia americana*) are reported. Specimens were measured *in situ* with a meter stick about every three months for thirteen months.

One year's average growth was 4.1 cm. The range of growth between individuals was 2.4 to 5.5 cm. Results of this study are not significantly different from those of Cary (1914) at Dry Tortugas, and Kinzie (1970) at Discovery Bay, Jamaica.

Abstract

Scleractinian Growth Rate Studies

Walter C. Jaap

Results of growth studies conducted at Eastern Sambo Reef (ca. 5 nmi ESE of Key West, Florida) on five species of scleractinia are reported. Specimens were measured *in situ* about every three months for thirteen months.

Most rapid growth was noted for *Acropora cervicornis* (11.5 cm/yr) and *Acropora palmata* (10.5 cm/yr). Slower growth was observed for *Montastrea annularis*, *Meandrina meandrites*, and *Diploria clivosa* (all averaged less than 1 cm/yr). Rates compare favorably with those from previous Florida investigations, but are retarded when compared to those of some other Caribbean studies.

Abstract

Observations on Expulsion of Zooxanthellae at Middle Sambo Reef

Walter C. Jaap

Large scale "bleaching" of Middle Sambo Reef (10.4 km ESE of Stock Island Bridge, Key West, Florida) was investigated on September 26, 1973. Discoloration of organisms was generally confined to the reef flat. The hydrozoan coral *Millepora complanata* and a zoanthidian *Palythoa* sp. displayed greatest pigment loss. Some *Acropora palmata* and *Montastrea annularis* colonies were mildly discolored. All corals were still viable when observed.

Several days of calm weather, high ambient temperatures and low tides at midday are believed to have contributed to water temperature elevation sufficient for thermal stress of the organisms, thereby triggering expulsion of algal symbionts and resulting in the "bleached" appearance. Studies by Yonge and Nichols (1931) and Goreau (1964) reported similar discoloration of reef organisms which they attirubted to expulsion of zooxanthellae (*Gymnodinium microadriaticum*). Re-examination of the area on November 6, 1973, revealed that most of the affected organisms had regained their normal coloration.

Abstract

Coral Studies Conducted at Hydro-Lab
Lucaya, Grand Bahama

Walter C. Jaap

Hydro-Lab missions in April and July, 1974, have produced much information on scleractinia species composition in the northern Bahamas. Sampling was accomplished along 10 m traverses of a transect from shore to the escarpment (1-70 m) in conjunction with a scleractinia-milleporina diversity study.

In contrast to the Florida fringing bank reefs, typical western Atlantic zonational patterns (i.e., back reef, reef flat, reef crest, fore reef slope) are absent at the Hydro-Lab location. The first constructional feature is a shallow fringing reef one to three meters deep, ca. one km from shore. *Acropora palmata*, *Acropora cervicornis*, *Diploria strigosa* and *Millepora* spp. are the dominant reef corals. Colony counts ranged from 20 to 37, with 4 to 8 species on an individual transect; highest colony density for a single meter was 7, five being anastomosing branches of *Acropora cervicornis*. A depauperate sand plain 400-500 m in width separates the fringing from the deeper zone of scleractinian development. In deeper regions (12-27 m) 11 to 35 colonies representing 8 to 12 taxa of stony corals were encountered on typical 10 m transects. Two species recently described from Jamaica were encountered: *Madracis formosa* Wells and *Mycetophyllia aliciae* Wells. A new, unusual species, *Goreaugyra memoralis* Wells, 1973, first reported off Andros, Bahamas and a possible new taxa of encrusting *Porites* were also collected. Excursions on the escarpment face showed hermatypic corals growing at the greatest depths sampled (70m).

Abstract

Studies on Eastern Gulf of Mexico Corals

Jennifer Wheaton Smith

Studies based largely on material collected furing Project Hourglass, supplemented by SCUBA observations and collections, are providing information on species dominance, diversity, distribution (both bathymetric and geographical) and community associations of Eastern Gulf of Mexico coral faunas.

Suitable substrate for sessile benthic organisms along the West Florida Shelf is discontinuous. When present, rocky substrate is generally in the form of low undercut limestone ledges covered with extensive invertebrate and vegetative growth; these constitute the "patch reefs" of the inner West Florida Shelf. Within this region, octocorals are known to be represented by 39 species (including 9 new distributional records). Of the total, 33 are gorgonaceans with 13 and 12 species within the families Plexauridae and Gorgoniidae, respectively. Scleractinia are represented by at least 15 species included in 7 families.

Factors other than substrate interact in determining distribution and abundance of corals in the Eastern Gulf. Temperature is suggested as being less of a determining factor than previously suspected. Turbidity is quite likely limiting. The irregular occurrence of complete reef kills associated with phytoplankton blooms on the inner West Florida Shelf is definitely a previously underestimated limiting factor.

SCUBA observations and collections at the Florida Middle Ground (ca. 100 nmi NW of Tampa Bay) reveal that this area supports the most prolific and diverse coral community along the West Florida Shelf. Octocorals, including *Muricea elongata*, *Muricea laxa*, *Plexaura flexuosa*, *Plexaurella fusifera*, *Eunicea calyculata*, *Pseudopterogorgia acerosa* and *Diodogorgia nodulifera*, represent a fauna similar to that of the inner shelf. The scleractinian fauna demonstrates a more pronounced tropical affinity at the Florida Middle Ground than at other west coast sites. Collections include *Dichocoenia stellaris*, *Porites divaricata*, *Madracis decactis*, *Scolymia lacera*, *Scolymia cubensis*, *Agaricia agaricites* and *Helioseris cucullata*. Representatives of the genera *Manicina*, *Stephanocoenia*, *Solenastrea* and *Oculina* have also been noted.

Abstract

Florida Reef Types

Robert N. Ginsburg

The only living coral reefs in the United States occur off the Florida Keys. In this curving reef tract, extending some 180 miles off Key Biscayne to the Dry Tortugas, there are representatives of all but one of the major reef types in the Western Atlantic.

Along the seaward edge of the shallow-water platform facing the Straits of Florida there are numerous examples of zoned marginal or barrier reefs in which the moose-horn and elk-horn corals, *Acropora palmata* and *Acropora cervicornis*, are major contributors. In the lagoon-like area, some 3-7 miles wide, there are numerous lagoon or patch reefs, irregular, unzoned clusters of massive brain and star corals, *Diploria* sp., and *Montastrea* sp., together with lush growths of sea fans and sea pens, alcyonarians and gorgonarians, and associated smaller corals and calcareous algae. At several localities along the Florida Keys there are reef-like buildups of branched corals, *Porites divaricata*, branched coralline algae, *Goniolithon strictum*, and segmented green algae, *Halimeda* sp.

Superimposed on this three-fold subdivision of reef types across the Reef Tract there are variations along it as well: reefs are most numerous and most luxuriant seaward of islands that are long enough to shelter them from the effluent of shallow Florida Bay. Where the islands are small and the passes between them large, as between Lower

Matecumbe Key and Big Pine Key, water from Florida Bay, at times either supersaline or brackish or with elevated temperatures and high turbidity, flows out across the reef tract and prevents the growth of the reef-building community.

A first step in planning the management of this unique reef area is an assessment of the distribution of the various reef types. This inventory of reefs is best accomplished through a cooperative mapping program using high-quality color aerial photography, coupled with observation and classification of the reefs by teams of diving scientists. From this inventory of reefs and their distribution it will be possible to select representative examples in different areas for long-term monitoring of natural and man-induced changes.

Effects of Dredging on the Natural Turbidity Regime of the Northern Florida Keys

George M. Griffin

A typical "hard-rock" dredge-fill project on the Atlantic side of Key Largo was monitored for 390 days in order to document the amount of suspended sediment produced, its distribution, and the effects on water clarity and biota near the dredge. The total project involved excavation of a 2000 x 50 x 10 foot entrance canal into Hawk Channel, plus 15,500 feet of perimeter and other interior canals; only the entrance canal was monitored in this study, as it had the greatest potential for detrimental effects on water clarity and biota. To insure the unbiased nature of the study, there was no cooperation or contact of any kind between the research team and the developers.

Effects of dredging on water clarity, and on the potential sedimentation rate, were determined by three independent methods:

1. The instantaneous distribution of the dredge plume was measured 15 times by towing an optical transmissometer along a traverse grid surrounding the dredge site; results were converted to optical equivalent suspended matter concentrations in mg/l and presented as concentration contour maps and cross sections.

2. The longer term potential sedimentation rate was monitored by an array of 18 sediment trap stations, each of which contained a pair of collectors. The traps were serviced at average 3-week intervals. Natural variations in concentration, mostly related to varying wind

stress, were subtracted from total accumulations by a controlled contour method. Resultant excess accumulations, due to the dredge, were calculated in terms of $mg/cm^2/day$; values were contoured and presented as maps of effluent distribution.

3. The $CaCO_3$ mineralogy of the dredge effluent differed significantly from that of the natural Hawk Channel environment. A quantitative method, based on X-ray diffraction analysis, was developed to distinguish the percentage of dredge-generaged sediment in each sediment trap collection. Results, in terms of % dredge material, are presented on maps for 15 periods of dredge operation.

Data from the above three methods re-enforced one another and allowed the extent and amount of excess dredge effluent to be clearly defined, both on an instantaneous and longer term basis.

Due to the proximity (0.48 n. mile) of a small patch reef, it was possible to use the health of the reef as a biologic indicator of dredge effects. This reef was observed and measured by a coral specialist during dredging and following its completion. The health of seagrasses and associated benthic organisms was observed in a reconnaissance manner.

From these measurements and observations, the following were concluded:

(1) The dredge generated turbid plumes that varied in concentration near the source from approximately 37 to 212 mg/l at the water surface. Background turbidity at the same time varied from 2 to 3 mg/l.

(2) The maximum distance to which the plume could be detected with a 1-m transmissometer, sensitive to variations of approximately 1 mg/l (1 ppm), varied at different stages of the project. During active the extension stage without a diaper, it extended from 1968 to 3120 feet; with a diaper from 1770 to 4038 feet.

During active spoil removal with a diaper, the plume extended from 950 to 3180 feet. A dormant period of approximately 4 1/2 months was interspersed, during which the spoil was eroded, causing a low intensity plume detected for 900-1100 feet. After completion of dredging, an area of mildly turbid water remained and this was detectable for a radius of 600-1400 feet.

However, the area of relatively intense plume, greater than 40 mg/l, rarely extended more than 300-600 feet from the dredge during any of the stages.

Concentration vs. distance plots show that the plume suspensate settles normally, with surface concentration declining in a logarithmic manner and gradually fading into the background turbidity. In general, the area of plume influence rarely exceeds the limits of an area extending 0.3 n. mile alongshore and 0.33 n. mile offshore, or o.1 square n. mile.

(3) The turbidity diaper was capable of significantly reducing the fugitive concentration in the plume. For example, 2 feet inside the diaper, concentration was 66 mg/l, whereas, 2 feet outside it was only 18 mg/l. However, gross leaks in the diaper were noticed frequently, especially at the points to which anchors were attached. At these leaks, concentrations as high as 120 mg/l were measured in

the fugitive plume. Other gross leaks were noted when the diaper was not properly repositioned to follow the dredge. Therefore, it is concluded that turbidity diapers need to be redesigned to eliminate leaks, and that operators need to exercise more attention to their proper positioning.

Also, the diaper is of little value unless the canal is dredged below wave and current base, so that it can act as a permanent trap for the effluent. Otherwise, the fine debris that settles behind the diaper will be re-suspended and cloud the water following completion of the project.

(4) Very little dredge effluent actually reached the coral patch reef 0.48 n. mile NNE of the canal; this was shown by all three independent types of measurement. On only one occasion was surface turbidity at the patch reef actually increased by the dredge--a 1.1 mg/l increase over a background level of 2.6 mg/l. At that time the turbidity diaper was in use but leaking badly. The biological team could detect no abnormal changes in the reef during the project year. Likewise, there was no detectable influence of the dredge on the sea grasses or other inshore biota near the canal, except denudation of the parallel strips used for the spoil fingers. Otherwise, the sea grasses and scattered inshore corals tolerated the increased turbidity without apparent change.

(5) Natural turbidity varied moderately in the dredge area, from 0.5 to 4.9 mg/l at the control patch reef 0.48 n. miles to the NNE, and up to approximately 7.5 mg/l near the eventual end of the canal. These natural variations are related to wind stress, resulting in higher turbidity during the winter.

(6) Sediment trap studies indicated that the corals at the patch reef, which are almost entirely Siderastrea siderea, must have cleared at least 125 $mg/cm^2/day$ of fine sediment from their surfaces during March and April 1973: the dredge was inactive during this period and the sediment at the reef was almost entirely of natural origin. This value can be compared to the artificial excess fallout rates attributed to the dredge and effecting the bottom close to the spoil fingers: During six test periods of several weeks each, the excess fallout near the spoil fingers exceeded 100 mg; for three periods it exceeded 200 mg; and for one period it exceeded 300 $mg/cm^2/day$. The effect these higher rates would have on the corals is not known. Surprisingly, four of these "high periods" occurred when the dredge had been inactive for months, and were produced by waves eroding spoil during the windy winter and spring.

(7) Zones of excess accumulation migrated as the spoil fingers were extended and then cut-back. Thus, the zone of potential impact shifted, and only the trap within 100 feet of the inner end of the canal was affected through the whole project. The shifting of zones probably reduced the potential impact on the biota at any one place.

(8) The fact that the project extended over a long time period, with an intervening inactive period of approximately 5 months was a favorable biologic factor. Thus, the debris sedimented in the first phase had time to disperse before the second phase material arrived, lessening the period of continual potential impact.

(9) Waves and currents caused nearly all of the dredge effluent to be carried out of the dredge area. The ultimate fate of this material is not known with any certainty. It is presumed to have been trapped in part by the seagrasses, in part trapped by the fringing red mangrove swamp, and in part merged into the relatively high turbidity of the Hawk Channel.

(10) Compared to hydraulic dredging, "hard-rock" dredging as practiced at Key Largo has less impact on water clarity, sedimentation rates, and biota. This is largely because the concentration in the plume is much less (a few hundreds of mg/l maximum vs. several thousand in hydraulic dredging). Also, the material being dredged is the rather inert Key Largo Limestone, which is less apt to contain pesticides, toxic metals, or oxygen-demanding organic debris than is the natural suspended sediment of Hawk Channel. The particles in the plume are greater than 95 percent $CaCO_3$ in the form of stable calcite and aragonite. The dredge material settles at a rate that does not differ significantly from the natural suspended material of the area.

Recommendations Concerning Future Dredge Projects in the Keys

Because dredging of the entrance canal at Basin Hills appears to have had no detectable impact on the coral patch reef 0.48 n. miles to the NNE or on the remaining grass flat areas, it seems reasonable that future dredging regulations in the Keys could use this project as a minimum model, at least until it is proved that the system can tolerate greater stresses. Based on this general philosophy, it is suggested that future regulations include consideration of these criteria prior to approval:

(1) Significant reefs composed of hermatypic corals, and more than 20 percent alive, within one n. mile of the proposed canal must be located and mapped. Canals and related temporary or permanent spoil areas should be positioned so as to approach no closer than 0.5 n. mile to such reefs in order that they be protected from excess sedimentation. The more or less continuous linear zones of low (less than 1 foot high) non-reef forming Porites divaricata and other similar corals that occur within several hundred yards of shore should not be included in this restriction.

(2) Locations where the surface of the nearshore bottom is composed predominantly of bare limestone bedrock should be favored for entrance canals, and areas of significant Thalassia beds should be avoided. In this way, the sediment trapping ability of the Thalassia will continue to aid in water clarification.

(3) Also to aid in sediment trapping and water clarification, a fringe of red mangrove should be preserved along the shoreline and care must be taken to preserve its vitality during and after dredging. The width of this zone should be determined by future research; for the present it is suggested that it be at least 100 feet, or no less than the pre-existing width if that should be less than 100 feet. (The natural width of the mangrove fringes along Key Largo varies from approximately 60 feet to several hundred yards, and is easily discerned on color aerial photos.)

All spoil shall be deposited no closer to the coastline than the width of this fringe. There should probably be no objection to stilt or catwalk structures, or piers over parts of this fringe zone, so long as they do not involve clearing of vegetation or otherwise interfere with healthy growth of the mangrove.

(4) The number of dredged entrance canals should be limited so as to avoid excessive turbidity during dredging, and also to avoid the low level turbidity that persists after dredging. A periodicity averaging one entrance canal per linear mile of coast seems reasonable, with the actual canal site being selected so as to avoid live coral reefs and grass flats, as described above.

(5) Between entrance canals, perimeter canals, separated from the coast by the mangrove fringe described above, seem on the whole to be a desirable alternative to an excessive number of entrance canals. However, legislation seems necessary to force property owners to connect into them. Perhaps entrance and perimeter canals should be dedicated for public use in the same way as streets in inland subdivisions.

The maximum depth of perimeter canals should be limited to whatever depth will allow for adequate water exchange with adjacent natural open water bodies. Otherwise the perimeter canals quickly become oxygen depleted, with resulting fish mortality and diminished recreational usage. Also, adequate vents to open water must be provided for oxygen ventilation. It is suggested, in lieu of further research, that vents be provided every 200 linear feet of perimeter canal, and that these be open channels 3 feet deep and 10 feet wide to allow limited passage of small boats. These vents should not extend more than approximately 50 feet seaward of the mangrove fringe.

(6) No additional artifical "cross-key" waterways should be allowed between the Atlantic side of the Keys and the Florida Bay, Barnes Sound, Card Sound, side. This restriction would prevent greater influx of the more turbid bay waters into the reef tract area.

In addition to higher turbidity, the bay waters also undergo much greater seasonal temperature and salinity fluctuations than the Hawk Channel waters, and all of these factors are detrimental or even lethal to growth of coral and other sensitive organisms of the reefs tract area.

(7) The hard-rock dredge techniques described earlier, as employed at Basin Hills, a produce much less turbid than hydraulic dredging. Therefore, it is recommended that no other type of dredging be permitted in the Keys.

Also, because the rate of effluent generation and dispersal is important in assessing its effect on water clarity and possible biologic damage, it is recommended that, in lieu of further research, the rate of dredging in the Keys be restricted to that at Basin Hills, i.e. approximately 570 cubic yards per 8-hour working day. In addition, the total rate of fallout should be monitored by sediment traps 100 feet away on both sides of the canal extension, and limited to a maximum 200 $mg/cm^2/day$, averaged over a one-week period. If the total fallout exceeds this amount, dredging should pause for one week, to allow the natural forces to clear the organisms of sediment.

(8) Turbidity diapers seem beneficial only if the dredge operator repositions them frequently, so as to close gaps. Attention to this seems especially necessary, in the final phase, when one of the parallel spoil fingers has been completely removed, leaving a large potential opening. Also, gross leaks were frequently observed at anchor points on the corners of the diaper. This suggests that a redesign of diapers is needed to eliminate the depression of the corners.

The diaper allows suspended matter to settle to the bottom instead of being dispersed immediately as a turbid plume. However, no permanent benefit is obtained from this unless the canal is dredged deeply enough to form an effective sediment trap; otherwise, natural waves and currents and boat wakes will re-suspend the fines whenever the diaper is removed. Therefore, it is suggested that regulations requiring a diaper, to be effective in reducing turbidity permanently, must be coupled with a requirement that the canal be dredged to several feet below the effective base of the expected disturbances. The minimum required depth would have to be determined by further research, but is probably on the order of 8 to 10 feet. This depth would exceed the maximum of 6 feet previously recommended by the Department of Pollution Control (1973) for all canals. Perhaps the DPC recommendation should be re-examined and possibly applied only to perimeter and other interior canals.

(9) Lastly it is recommended that research into the technology of dredging and its potential effects continue. At present there is insufficient quantitative knowledge of at least five points: (a) the tolerance limits of organisms to increased sedimentation and turbidity; (b) the width of mangrove fringe and/or Thalassia beds necessary to provide adequate natural suspended sediment traps (i.e. natural water clarification); (c) the ultimate depositional site of the excess particles generated by the dredge; (d) the optimum methods of providing oxygen bearing water to the perimeter and other interior canal systems; and (e) the size-distribution of the dredge effluent and the effects of abnormalities in size distribution on the respiration of some of the imporant organisms of the inshore area.

WORKSHOP SESSIONS

Management Session

Discussion Topics

1. Values
2. Problems
3. Management Research Needs

Values

1. Commercial/sport fishing
2. Preservation of environment
3. Recreational value (aesthetic, commercial)
4. Aesthetic value
5. Resource value ($ value, fisheries, landings, etc.)
6. Importance of scientific research
7. Nursery value
8. Storm protection
9. Uniqueness of bio-habitat
10. Protection of water quality (protection from sediments in Florida Bay)
11. Consideration of expanding reef tract area
12. Corals greatest source of reef sand
13. Great educational value (uniqueness)

Problems

1. Dredging
2. Turbidity by large craft
3. Anchoring on reefs (removal of traps) - Commercial

4. Harvesting for corals

5. Ocean outfalls

6. Pollutants - upland and ships - ship channels - agricultural industrial

7. Extent - composition - dynamics - natural and unnatural effects

8. Physical - biological dynamics

9. Fisheries exploitation

10. Visitor use - what level or method of use

11. On-shore - offshore development

12. Beach nourishment effects

13. Effects of mosquito control

14. Problem of nutrients

15. Reef damage causes

16. Protection problems - equipment, manpower

17. Canals and channels - water movement, temperature change, pollutants

18. Lack of defined forms and coordinated enforcement and implementation

19. Exposure

20. Leachates

21. Has damage occurred?

22. Distribution of pollutants

23. Sources of funding

Management Research Needs

1. Mapping needs

2. Monitoring program

3. Goals and guidelines

4. Dissemination of information (format and means)

5. New legislation

6. Hydrology studies

Research Session

Topic of Discussion

Research Needs and Objectives

Research Needs and Objectives

1. Reef Inventory (Mapping)

   a. Reef Types - Palm Beach to Tortugas

   *USGS, *CCC, Fla. Reef Foundation (ground truth), National Park Service, Rosenstiel School, NOAA (MUST), Harbor Branch Foundation, State University System, Ocean Research

2. Man's Activities (Diving, sports, commercial fisheries, coastal development, *CCC, SUS, Regional Planning Councils, Other univeristy groups

3. Water Quality

   a. Baseline Parameters

   b. Continuous Monitoring

   Identification of problems (pesticides, turbidity, etc.) SUS, NOAA (MUST), (NMFS), (RSMAS), NPA, DPC

4. Education

   Films, brochures, naturalist, teacher training (legislative, public - show films from FRF to inform)

   Fla. Reef Foundation, DNR, NPS, USGS, SUS, Univ. of Miami Sea Grant (RSMAS), NOAA (MUST)

PROPOSED RESOLUTION

WHEREAS, the State of Florida is faced with the unique situation of having the only coral reefs located in the continental United States, and

WHEREAS, these coral reefs are of economic, social and aesthetic value to the citizens of the State of Florida and the United States, and

WHEREAS, the coral reefs provide recreational pleasures, sport and commercial fisheries activities and hurricane protection for the Florida Keys, and

WHEREAS, the coral reefs are under stressed conditions due to the corals growing at the northernmost limit of their tolerance and to man's associative activities, and

WHEREAS, the State of Florida is faced with the problem of providing protection, planning, research and management for the coral reef tract, and

WHEREAS, the effect of the coral reefs on the economy of South Florida is of significant value, and

WHEREAS, a continuous research monitoring program is necessary to determine the health of the corals and assess future stresses on the coral reef tract.

NOW, THEREFORE, BE IT RESOLVED, that the Florida Coastal Coordinating Council be designated as the state coordinating agency for a Florida Coral Reef Management/Research Program.

BE IT FURTHER RESOLVED that the Department of Natural Resources, Marine Research Laboratory be responsible for and properly funded and staffed to implement a major research program on the coral reef tract in order to protect the benefits of the reefs to the citizens of the State of Florida.

BE IT FURTHER RESOLVED that all agencies reporting to the Governor and Cabinet are directed to assist the Florida Coastal Coordinating Council and the Marine Research Laboratory in accomplishment of a coordinated coral reef management/research program and that agencies and independent institution not reporting directly to the Governor and Cabinet are respectfully requested to provide such assistance as is necessary to insure the successful completion of this charge.

IN TESTIMONY WHEREOF, the Governor and Cabinet of the State of Florida have hereunto subscribed their names and have caused the official seal of the said State of Florida to be hereunto affixed, in the City of Tallahassee, Florida, on this _____ day of _____ A.D., 1974.