

PROGRAM and ABSTRACTS

The
26th Meeting
of the
**Association of
Marine Laboratories
of the Caribbean**



June 11 - 16, 1994
at the
Bahamian Field Station
San Salvador, Bahamas*



**26th MEETING
OF THE
ASSOCIATION OF MARINE LABORATORIES
OF THE CARIBBEAN**

June 11 - 16, 1994

PROGRAM AND ABSTRACTS

**BAHAMIAN FIELD STATION
SAN SALVADOR ISLAND, BAHAMAS
1994**

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26TH MEETING OF THE ASSOCIATION OF MARINE LABORATORIES OF THE CARIBBEAN

PROGRAM

Saturday - June 11

- 7:00 AM Rendezvous at Red Aircraft, Ft. Lauderdale International Airport
- 8:00 AM Depart from Ft. Lauderdale
- 10:30 AM Arrival at San Salvador - Customs & Immigrations - Transport to Riding Rock Inn (RRI) & Bahamian Field Station (BFS)
- 11:45 AM Bus leaves RRI for BFS
- Noon Lunch in BFS Cafeteria
- 1:30 PM Opening Session in Conference Room: Welcome and Opening Remarks by Dr. Donald T. Gerace, Dr. Daniel Suchy, and Dr. Paul Yoskioka. Official Opening by The College of The Bahamas
- 2:00 PM Choice of Field Trips:
1-Snorkeling on Gaulin Reef
2-Boat Tow in Grahams Harbour
3-Snorkeling on Gerace Reef
4-Snorkeling on Grassbeds
- 4:00 PM Bus leaves BFS for RRI
- 5:30 PM Bus leaves RRI for BFS
- 5:30 PM Cocktails in Conference Room
- 6:30 PM Dinner in BFS Cafeteria
- 7:30 PM John Ogden:
Keynote Address: Regional Marine Laboratory Research Networks: The Caribbean Leads the Way
- 8:30 PM Colin Higgs:
Marine Environmental Policies and

Fishing Industry in The Bahamas

- 9:00 PM James Carew:
Carbonate Banks and Islands: Where Biology become Geology
- 9:30 PM Bus leaves BFS for RRI

Sunday - June 12

- 7:30 AM Bus leaves RRI for BFS
- 7:30 AM Breakfast in BFS Cafeteria
- 8:30 AM G.W. Smith, D.T. Gerace, T.B. Smith & B.M. Greenwood:
Seagrass Standing Stock, Biomass and Species Distribution: A Six-Year Study
- 9:00 AM John Mylroie:
Pleistocene Carbonate Deposition/Dissolution Cycles, Carbon Dioxide Flux, and Global Climate in the Quaternary
- 9:30 AM Mary Jane Berman:
Archaeology at the Three Dog Site
- 10:00 AM Coffee Break
- 10:30 AM H. Allen Curran:
Monitoring the Health and Change of Coral Reefs: Two Patch Reef Examples from Fernandez Bay, San Salvador Island, Bahamas
- 11:00 AM James F. Battey, K.A. Brown, & J.A. Richards:
Characterization of an Acyl-Carrier Protein Isolated from the Dinoflagellate Symbiont of Symbiotic

Cnidarians

- 11:30 AM Paul Jeff Godfrey:
Opening a "New World" in a Bahamian Wilderness: Ecological Exploration and its Consequences on San Salvador Island.
- Noon Lunch in the BFS Cafeteria
- 1:00 PM Choice of Field Trips:
1-SCUBA Diving with RRI
2-SCUBA or Snorkeling on Gaulin Reef
3-Inland Ponds
4-Fortune Hill Plantation
5-Fossil Reef & Snorkeling in Fernandez Bay
- 3:00 PM AMLC Executive Board Meeting in Conference Room
- 4:00 PM Bus leaves BFS for RRI
- 5:30 PM Bus leaves RRI for BFS
- 5:30 PM Cocktails in Conference Room
- 6:30 PM Dinner in BFS Cafeteria
- 7:30 PM George Dennis, Robert Wicklund & Judith Lang:
Further Examination of the Relationship between Local Environmental Factors and Coral Bleaching at Lee Stocking Island, Bahamas
- 8:00 PM Julian Granberry & John Winter:
Bahamian Ceramics
- 8:30 PM Thomas A. McGrath:
Monitoring the Coral Patch Reefs of San Salvador Island, Bahamas
- 9:00 PM John Mylroie & James Carew:
Karst Features of The Bahamas
- 9:30 PM Slide Presentation: 27th AMLC Meeting, The William P. MacLean Marine Science Center, University of the Virgin Islands, St. Thomas, USVI
- 10:00 PM Bus leaves BFS for RRI

Monday - June 13

- 7:30 AM Bus leaves RRI for BFS
- 7:30 AM Breakfast in BFS Cafeteria
- 8:30 AM Lourdes Dominguez Glez:
Emplazamientos de Grupos Agroalfareros en Las Costas del Centro Sur de Cuba
- 9:00 AM William D. Head, Wade O. Watanabe, Simon C. Ellis, & Eileen P. Ellis:
Nassau Grouper Aquaculture: Induced Multiple Spawning
- 9:30 AM Maria M. Criales:
Effect of the Tortugas Gyre on the Distribution and Transport of an Oceanic and a Coastal Penaeoid Shrimp Larva
- 10:00 AM Coffee Break
- 10:30 AM Jorge Febles Dueñas:
The Important Role of the Bahamas Archipelago in Peopling Cuba from the North American Continent
- 11:00 AM Edward J. Klekowski:
Using Mangroves to Screen for Mutagens in Tropical Marine Environments
- 11:30 AM Alida Ortiz Sotomayor, Edgardo Ortiz Corps, & Luis Jiménez Robles:
Marine Education at the University of Puerto Rico: A Life Experience
- Noon Lunch in BFS Cafeteria
- 1:00 PM Choice of Field Trips:
1-SCUBA Diving with RRI
2-SCUBA or Snorkeling on Gaulin Reef
3-Snorkeling on Lindsay Reef
4-Geology Field Trip
5-Three Dog Site
- 4:00 PM Bus Leaves BFS for RRI
- 5:30 PM Bus Leaves RRI for BFS
- 5:30 PM Cocktails in Classroom 2

Poster Session:

Ricardo Bitter:
Molluscan Community Associated to
Thalassia in Three Zones at Morrocoy
National Park, Venezuela

Carlos A. Carmona Suarez:
Community Structure of a Guild of
Protunid Crabs in a Coastal Beach in
Venezuela

Jesus E. Conde, H. Díaz & B.
Orihuela:
Local and Geographical Variations in
the Mangrove Crab *Aratus pisonii*

William G. Lindsay, Jr.:
Description of Some Aspects of the
Anatomy of the Helmets *Cassis*
tuberosa and *Cassis madagascarensis*

M. Sánchez, Roselena & Zoraya
Alvarez:
Nutritional Evaluation of *Artemia*
naupliid (Strain Las Cumaraguas,
Venezuela) as Food for *Penaeus*
vannamei Larvae

6:30 PM Dinner in BFS Cafeteria

7:30 PM Gary Ostrander:
Baseline Studies of Coral Reef Fish
Assemblages Around San Salvador
Island, Bahamas: Initial Preparation
for Potential Bleaching Events

8:00 PM Vance P. Vincente:
Caribbean Coral Reefs: Fragile or
Robust?

8:30 PM David Forcucci:
Automated Monitoring Along the
Florida Keys Reef Tract: An Integral
Component of the Seakeys Program

9:00 PM Karl Bloomquist:
Cleaning Symbiosis or Advanced
Commensalism Between Shrimp
(Hippolytidae) and Moray Eels
(Muraenidae)?

9:30 PM Bus leaves BFS for RRI

Tuesday - June 14

7:30 AM Bus leaves RRI for BFS

7:30 AM Breakfast at BFS Cafeteria

8:30 AM Karen M. Burns & Jay M. Sprinkel:
Analysis of Recapture Data from
Selected Reef Fish Species Tagged off
Florida's West Coast

9:00 AM Ronald Shaklee:
Anecdotal Evidence of Early 19th
Century Climate Change in the Cen-
tral Bahamas

9:30 AM Philip Pepe:
A New Visual Censusing Technique
for Enumerating Large Day Active
Reef Fishes

10:00 AM Coffee Break

10:30 AM Kim B. Ritchie, Donald T. Gerace, &
Garriet W. Smith:
Grouping of Bacterial Heterotrophs
from Scleractinian Corals using Meta-
bolic Potentials

11:00 AM William Elliott & Nancy Elliott:
Characteristics of Stromatolites from
Stouts Lake, San Salvador Island,
The Bahamas

11:30 AM Paul M. Yoshioka:
The Bet-hedging Life History Pattern
of Shallow-Water Gorgonians

Noon Lunch in BFS Cafeteria

1:00 PM Choice of Field Trips:
1-SCUBA Diving with RRI
2-SCUBA or Snorkeling on
Ostrander Reef
3-Stromatolites in Stouts Lake
4-Boat Tow in Grahams Harbour
5-Intertidal Walk & Swim

4:00 PM Bus leaves BFS for RRI

5:30 PM Bus leaves RRI for BFS

5:30 PM Cocktails in Conference Room

- 6:30 PM Dinner in BFS Cafeteria
- 7:30 PM William E. Hawkins, William W. Walker, Robin M. Overstreet, & J. MacLaw: Use of Small Indigenous Fish Species as Sentinels of Pollution in Warm Coastal Waters
- 8:00 PM Perry L. Gnivecki: Return to Palmetto Grove (SS2), San Salvador Island, Bahamas: The Implications for Bahamian Archaeology
- 8:30 PM Parrish, James d. & Michael W. Callahan: Predation by Reef Fishes on Large Benthic Crustaceans
- 9:00 PM L. M. Sierra, F. Tabash, & J. Molina: Distribución, Abundancia y Elgunce Aspectos Biológico-Pesqueras de les Camarenes en al Litoral Caribe de Costa Rica
- 9:30 PM Bus leaves BFS for RRI

Wednesday - June 15

- 7:30 AM Bus leaves RRI for BFS
- 7:30 AM Breakfast at BFS
- 8:30 AM George D. Dennis, Karl W. Mueller, Robert I Wickland: Distribution and Abundance of Snapper and Grouper at Lee Stocking Island, Bahamas
- 9:00 AM John Winter & James Carew: Further Evidence for Sea Level Fluctuations on San Salvador Island, Bahamas
- 9:30 AM Raymond Hayes, Camille King & Kimberly Wallace: Induction of a Heat Shock Stress Response in Scleractinian Coral and Its Relationship to the Phenomenon of Coral Reef Bleaching
- 10:00 AM Coffee Break
- 10:30 AM Christopher C. Kohler:

- Ciguatera Tropical Fish Poisoning: A Review of What's Happening in the Food Chain
- 11:00 AM Nancy B. Elliott & William M Elliott: Pleistocene Biogeography and the Distribution of Aculeate Wasp Populations in The Bahamas
- 11:30 AM David Forcucci: Recruitment of *Diadema antillarum* in the Florida Keys
- Noon Lunch in BFS Cafeteria
- 1:00 PM Choice of Field Trips:
1-SCUBA Diving with RRI
2-Boat Trip Following Columbus
3-Fossil Reef & Snorkeling in Fernandez Bay
4-Lighthouse Cave
5-Fossil Stromatolites & Peat Beds
6-Farquharson Plantation
- 4:00 PM Bus Leaves BFS for RRI
- 5:30 PM Bus Leaves RRI for BFS
- 6:30 PM Last Night Banquet with Annual AMLC Membership Meeting
- 7:30 PM Georgina Bustamante & Rodolfo Claro: Ecofisiología de la Alimentación, El Crecimiento y la Reproducción de Cuatro Especies de Pargos (Pisces: Lutjanidae) de la Plataforma Cubana
- 8:00 PM Ronald Lewis: Attachment Studies on Plastic Panels and Calcium-Carbonate Skeletal Substrata in Fernandez Bay, San Salvador Island, Bahamas
- 8:30 PM Ronald Shaklee: Fluctuations in Hurricane Activity in the Caribbean Basin 1900-1990
- 9:00 PM Maritza Barreto Orta & Jack Morelock: A Coastal Classification System for Tropical Islands
- 9:30 PM Buses leave BFS for RRI for last night partying

Midnight Buses leave RRI for BFS

Thursday - June 16

7:30 AM Bus leaves RRI for BFS

7:30 AM Breakfast

9:00 AM Buses leave BFS for Airport

10:00 AM Depart San Salvador for Ft. Lauderdale

ORAL PRESENTATION ABSTRACTS

KEYNOTE ADDRESS:

REGIONAL MARINE LABORATORY RESEARCH NETWORKS: THE CARIBBEAN LEADS THE WAY

John C. Ogden
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The dynamics of marine biological diversity is driven by ecological processes that operate on large geographic scales and long-time scales. Most marine organisms have a planktonic larval life and very wide distributions with multiple habitat requirements. Others, such as tunas, billfishes, turtles, seabirds, and whales have ocean-wide migrations. Efforts at conservation and management of biological diversity must match these scales.

The marine laboratories of the world have great potential as an infrastructure and focus for programs in research, training, and education, and the conservation of marine biodiversity. Marine laboratories are found in virtually every country, often in undisturbed locations, with ready access to many representative coastal habitats and organisms. The great majority of marine laboratories are tied to academic institutions or museums with long-standing traditions in the study of marine organism, training of scientists and managers, communication and exchange with other laboratories, and environmental impact assessment. Many are government supported with strong mandates for resources management.

While marine laboratories are found within different cultures, they have a common scientific culture and tradition which predispose them to cooperative programs and networking. For example, 80 European marine laboratories have recently joined in the Marine Research

Stations Network (MARS) and the U.S. marine laboratories have formed the National Association of Marine Laboratories (NAML). Regional marine laboratory groups such as the 35 member Southern Association of Marine laboratories (SAML) have been very successful in fostering cooperative projects, notably an initiative in minority opportunities in marine science. However, the Association of Marine Laboratories of the Caribbean (AMLC) is by far the oldest and is the parent organization of the CARICOMP (Caribbean Coastal Marine Productivity) network of marine laboratories, parks, and reserves, which is pioneering regional, cooperative research on marine biodiversity.

The CARICOMP network grew out of discussions of AMLC directors in the early 1980's and was organized in 1985 at a workshop at the Discovery Bay Marine Laboratory in Jamaica sponsored by NSF and the Coastal Marine (COMAR) Program of UNESCO. Subsequently, a standardized methods manual was written with simple protocols for the comparative study of structural and functional characteristics of the 3 principal Caribbean coastal ecosystems, coral reefs, seagrasses, and mangroves. At present 23 marine laboratories, parks, and reserves in 16 countries have signed a memorandum of Understanding with an international Steering Committee, pledging personnel and facilities support for the program, and receiving modest equipment and financial assistance. A key feature of the network is a Data Management Center at the University of the West Indies in Kingston, Jamaica.

The CARICOMP laboratories, parks, and reserves encompass the geographic scale of environmental and ecological gradients underlying regional biodiversity. While the program is still in its infancy, it is expected that the unique regional database will permit tracking of regional phenomena and discrimination of thresholds of ecosystem response to global change in time for effective local and regional management.

A COASTAL CLASSIFICATION SYSTEM FOR TROPICAL ISLANDS

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University of Puerto Rico
Mayaguez, PR 00681

Ramón Vazquez
Electrical Engineering Department
University of Puerto Rico
Mayaguez, PR 00681

Erosion effects many coastal areas of Puerto Rico with major losses of beach sand resulting from the interaction among: 1) physical variables such as waves, winds, tides, currents, storms; 2) geomorphic features such as dunes, eolianities, coral reefs; and 3) the sediment and coastal lithology.

A coastal classification study was carried out to identify and organize the variables affecting the shoreline. This study has resulted in the design of a coastal classification model for tropical coastal areas that can describe and identify the oceanographic and geomorphic condition of a selected area.

Development of the classification model consisted of three phases: 1) the data acquisition process; 2) the classification model development using COSTAS software, and; 3) the field work to verify data obtained by the acquisition process and classification. ERDAS software will be used to analyze the satellite image. The coastal classification program was written in C language. Field observations were added to the data.

The coastal classification identified major categories for coastline types for the southwest and west side of Puerto Rico. Within the categories, detailed subdivision may be described which are related to coastal conditions.

CHARACTERIZATION OF AN ACYL-CARRIER PROTEIN ISOLATED FROM THE DINOFLAGELLATE SYMBIONT OF SYMBIOTIC CNIDARIANS

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and the MacLean Marine Science Center
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St. Thomas, U.S.V.I. 00802

Acyl-carrier protein (ACP) is a small, acidic, highly soluble protein that functions as a co-factor or co-substrate for more than a dozen enzymes in plant lipid metabolism. Levels of ACP have been correlated with rate of fatty acid synthesis and accumulation of lipids in higher plants. We have identified a putative ACP in the dinoflagellate symbiont, *Symbiodinium*, of five species of symbiotic cnidarians. Western blots of dinoflagellate soluble proteins were probed with a polyclonal antibody raised against *Spinacea* ACP. All of the cross reacting dinoflagellate proteins co-migrated with a 9kD *Spinacea* ACP standard. Only one isoform of ACP was found in both freshly isolated and cultured dinoflagellates. The ACP's were quantified by ¹⁴C-palmitoylation using an acyl-ACP-synthetase isolated from *E. coli*. The levels ranged from 6.1 to 21.9 ugACP/gfw, equal to or greater than levels found in oil seeds with very high rates of lipid synthesis. No correlation is found between ACP and total lipid concentration in freshly isolated dinoflagellates. When *Symbiodinium* isolated from Scyphozoan *Cassiopea* is placed in batch culture, ACP and lipid levels fall to one third of those found in freshly isolated dinoflagellates. While ACP plays a central role in lipid metabolism, it does not appear to be the rate limiting factor in lipid accumulation in symbiotic dinoflagellates or their cnidarian hosts.

ARCHAEOLOGY AT THE THREE DOG SITE

Mary Jane Berman
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The excavation of the Three Dog Site, San Salvador, Bahamas has provided new perspectives on a number of questions related to the prehistoric peopling of the Bahamas archipelago. This paper examines what is currently known about Lucayan lifeways and how data from the Three Dog Site and other recently excavated sites have modified or strengthened existing views. The following issues are discussed: migration and colonization, subsistence, settlement structure, ceramic variability, environment, and technology.

CLEANING SYMBIOSIS OR ADVANCED COMMENSALISM BETWEEN SHRIMP (HIPPOLYTIDAE) AND MORAY EELS (MURAENIDAE)?

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College Station, TX 77843

Cleaning symbiosis is a mutually beneficial behavior between marine, freshwater and/or terrestrial organisms. In the marine environment fishes and/or crustaceans remove parasites, necrotic tissue and other undesirable matter from other organisms. Five species (*Lysmata ambionensis*, *L. grabhami*, *L. seticaudata*, *Brachycarpus biunguiculatus*, *Stenopus hispidus*) of tropical shrimp are reported to clean morays (Barbour, 1991; Corredor, 1978; Criales, 1979; Criales & Corredor, 1977; Feder, 1966; Gotto, 1969; Limbaugh, 1961; Randall, 1962; and Roessler & Post, 1972). This study focuses on the "cleaning"/mutualistic behavior of *Lysmata wurdemanni*, a temperate "cleaner" shrimp, in relation to *Gymnothorax* spp. in the laboratory.

This research is different from most of the field work that has been done in the past so a comparison is made with laboratory work on a tropical cleaner, *L. grabhami*, in relation to *Gymnothorax* spp.

L. wurdemanni is known to live in association with moray eels but also lives among rocks and corals away from them. It does not appear to be an obligate cleaner like some of its tropical counterparts. It does not depend on cleaning alone to maintain nourishment. Much of its time is spent picking at the substrate in search of food and cleaning its antennae which pick up chemical cues. It is a nocturnal species and a protandrous hermaphrodite: early in life it is a functional male while later in life it becomes female.

ANALYSIS OF RECAPTURE DATA FROM SELECTED REEF FISH SPECIES TAGGED OFF FLORIDA'S WEST COAST

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To date, 4,334 reef fish have been tagged in Mote Marine Laboratory's (MML) Reef Fish Tagging Program. Reef fish are tagged using a plastic tipped Hallprint® dart tag inserted adjacent to the dorsal fin. Twelve species have been tagged by MML personnel, commercial and recreational fisherman and charter boat captains. These species include red grouper (*Epinephelus morio*), gag (*Mycteroperca microlepis*), scamp (*Mycteroperca caphenax*), black grouper (*Mycteroperca bonaci*), Nassau grouper (*Epinephelus striatus*), red hind (*Epinephelus guttatus*), speckled hind (*Epinephelus drummondhayi*), red snapper (*Lutjanus campechanus*), lane snapper (*Lutjanus synagris*), grey snapper (*Lutjanus griseus*), bar jack (*Caranx ruber*) and greater amberjack (*Seriola dumerili*). A total of 560 tags have been returned for an overall tag return rate of 12.9%. The majority of the fish tagged were red grouper (2,780), gag (862), greater amberjack (339),

scamp (184) and red snapper (139). Tag return rates were 14.5%, 9.3%, 18.7% 12.0% and 18.7%, respectively. More than 12% of the recaptures were of fish previously recaptured; one red grouper was recaptured six times. The tag and recapture data include information on water depths, fish growth, movement and days-of-freedom. Approximately 25% of the red grouper and gag, compared to more than 55% of the scamp, moved more than 9 km from the release site. Scamp also showed greater survivability from tagging at greater depths. None of the red grouper or gag tagged at greater than 63 m was recovered while more than 25% of the scamp from those depths were recaptured.

**ECOFISIOLOGIA DE LA
ALIMENTACION, EL
CRECIMIENTO Y LA
REPRODUCCION DE CUATRO
ESPECIES DE PARGOS
(Pisces: Lutjanidae)
DE LA PLATAFORMA CUBANA**

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La Habana, Cuba

Las investigaciones realizadas sobre la dinámica de algunos indicadores morfofisiológicos y bioquímicos (factor de condición, e índices gonadosomático, hepatosomático y de adiposidad mesenterial) y bioquímicos (contenido de proteínas, lípidos y agua en órganos y tejidos) en *Litjanus synagris*, *L. griseus*, *L. analis* y *Ocyurus chrysurus* (cuatro de las especies de mayor valor pesquero en Cuba) mostraron la existencia de una estrecha relación entre el metabolismo de los peces y la reproducción, la alimentación, el crecimiento, y las condiciones ambientales.

A nivel individual los peces transitan por diferentes fases de su ritmo fisiológico dadas por los cambios en los hábitos alimentarios y las

fluctuaciones de la temperatura. El alcance de la madurez sexual y el desove va acompañado de alteraciones notables de los valores de los indicadores que reflejan su estado fisiológico. Sin embargo, como las cuatro especies poseen una prologada temporada de reproducción, se señalan también variaciones en las condiciones de los individuos que desovan en diferentes momentos de la misma. De tal modo, los resultados obtenidos demuestran que a pesar de la pequeña variación anual de la temperatura del agua (5-6°C, como promedio) y discretos cambios en la cantidad y calidad del alimento, ocurren, a nivel poblacional, una marcada fluctuación del estado fisiológico que tiene, entre sus expresiones más importantes, variaciones en la magnitud del metabolismo generativo (cantidad y calidad de los huevos producidos) y somático (crecimiento). Además, la transformación de la alimentación da lugar a un marcado ritmo ontogénico de las condiciones fisiológicas de los peces.

**CARBONATE BANKS AND
ISLANDS: WHERE
BIOLOGY BECOMES GEOLOGY**

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John E. Mylroie
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Shallow-water carbonate depositional environments such as that of the Bahamas, particularly those associated with coral reefs, are the product of both active and passive precipitation of calcium carbonate minerals by a diverse suite of organisms. Tropical and subtropical marine surface waters are saturated or supersaturated with respect to calcium carbonate, and carbonate mineral precipitation can be easily triggered. Some organisms (e.g. corals, mollusca, echinodermata) actively secrete either calcite or aragonite in a controlled process via special-

ized tissue or organs. Other organisms appear to passively cause the precipitation as a result of metabolic activities that shift the microchemical environment in their vicinity or in their cells (e.g. photosynthetic utilization of CO_2) in favor of calcium carbonate precipitation. Recently it has become evident that bacteria with a variety of metabolic pathways, both autotrophic and heterotrophic, are significant producers of microcrystalline carbonate (micrite). Even ooids, which have generally been considered to originate by inorganic precipitation, may also owe their origin, at least in part, to bacterially mediated precipitation. Other sources of micrite include the shedding and breakdown of calcareous algae (e.g. *Halimeda*, *Penicillus*), passive precipitation and epibionts on plants (e.g. *Thalassia*), and the pulverizing effects of a variety of consumers of endolithic algae in the upper few millimeters of subtidal and intertidal rock surfaces and dead coralline skeletons (e.g. parrot fish, *Diadema* and other urchins, chitons). The accumulation of ooids, microorganism test (e.g. foraminifera), and other breakdown of larger skeletal elements, either physically or biologically, also produces sand size and larger particles that accumulate into subtidal sands and gravels. Wave and tidal activity move portions of that subtidal sediment into shoals and onto beaches and tidal mud flats. The beaches and mud flats are generally developed on preexisting subaerial outcrops. The action of wind then winnows sand largely from the beach sources and piles it into eolian dunes.

Quaternary fluctuations of sea level in response to continental glaciation and deglaciation (glacio-eustasy) have controlled the Quaternary evolution of the banks and islands of the Bahamas. During low stands of sea level (> 10 meters below present sea level) the quasi-flat tops of the Bahama banks are completely exposed, and little or no sediment production occurs because the bank margins are so steep and there is little shallow water area. When sea level rises onto the bank tops and they begin to flood, the shallow carbonate "factory" literally comes alive, and sediment accumulation commences. During this transgressive phase of the sea level oscillation the continual reworking of coastal sediments by the ever-encroaching surf

zone effectively "bulldozes" sand that wind redistributes into large dune ridges. As sea-level rise slows down as it approaches the acme of that cycle, reef growth catches up and the wave energy that reaches the shorelines and lagoons is reduced as the biological barriers more effectively dissipate wave energy. During this still-stand phase lagoons fill and coastal dunes develop and are stabilized by vegetation. When sea level falls as global climate slips into the next glacial epoch, some of the accumulated subtidal sediments are reworked into regressive-phase dunes. Island development essentially ceases when sea level again falls below -10 meters.

Because the Bahamas are a tectonically stable area that is undergoing slow isostatic subsidence of 1 to 2 meters per hundred thousand years, only during times when sea level was above present sea level could subtidal deposits that are exposed on the islands today have formed. According to the generally accepted Quaternary sea level curves generated from oxygen isotope data recovered from deep sea cores, only the high stand of sea level that occurred about 125,000 years ago was both high enough and recent enough to have left subtidal deposits that are exposed above sea level today. Geochronological data from the Bahamas supports that conclusion. The surficial geological record of Bahamian islands reveals that they are composed of eolian sediments deposited during one or more high stands that preceded the last interglacial (circa 125,000 years ago); subtidal, shoreface, and eolian deposits laid down during the last interglacial; and transgressive and still-stand phase deposits of the present (Holocene) high stand. Between the packages of sediment accumulated during the high stands are paleosols (fossil soils) that represent the record of the erosional and pedogenic processes that dominate island development during the low stands.

EFFECT OF THE TORTUGAS GYRE ON THE DISTRIBUTION AND TRANSPORT OF AN OCEANIC AND A COASTAL PENAEOID SHRIMP LARVAE

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Penaeoid shrimp larvae were analyzed at 56 stations from the cruise LH3 of the R/V Longhorn in the Florida Keys and Dry Tortugas from May 29-June 30, 1991, as part of the Southeast Florida and Caribbean Recruitment Project (SEFCAR). Six genera of the superfamily penaeoidea were identified and larval stages differentiated among zoeae, mysids and postlarvae. The three most abundant genera were the oceanic shrimp *Solenocera* sp., with 17.4%; and the pink shrimp *Penaeus duorarum*, with 8%. The oceanic *Solenocera* sp. larvae and the coastal species *P. duorarum* were further analyzed with the oceanographic conditions of the region. The formation and evolution of the cold cyclonic Tortugas Gyre off Dry Tortugas was documented by Lee et al. (in press). Evidence of the gyre in this research was supported by the narrow ridge of isotherms off the Tortugas transect and by the cyclonic trajectory of the drifter Halley. The gyre was intensively developed at the Tortugas transect during leg 2 and 3 of the cruise. Abundances of these two genera were significantly higher at the Tortugas transect during these legs. The effect of the gyre was different on the coastal species *P. duorarum* than on the oceanic *Solenocera* sp. For the coastal species (*P. duorarum*) which spawn in the Tortugas grounds, retention of larvae by the internal circulation of gyre at the Tortugas spawning grounds was shown to be a possible mechanism of local recruitment. For the oceanic *Solenocera* sp. which spawn on the outer edge of the gyre, high concentrations of larvae were found at the onshore stations of the Tortugas transect during leg 2 as result of the cyclonic circulation of the gyre and the onshore Ekman transport. Vertical distribution of these species

was restricted to the mixed layer when the strong thermocline was present.

MONITORING HEALTH AND CHANGE OF CORAL REEFS: TWO PATCH REEF EXAMPLES FROM FERNANDEZ BAY, SAN SALVADOR ISLAND, BAHAMAS

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Health and change of living coral reefs are today topics of major concern and investigation for marine scientists and policy makers around the world because many reef areas are thought to be in decline. Given their close proximity to the large North American scientific community, the reefs that typically rim the islands of the Bahamas Archipelago are surprisingly poorly known. On San Salvador Island, a program of reef monitoring is in its initial stages of development. This report describes the ecologic health and short-term change of two coral patch reefs located on the leeward shelf of San Salvador Island that were studied with surveys in 1983-84 and 1992-93.

Snapshot Reef covers an area of 50 x 50 m and is dominated by heads or knobs of *Montastrea annularis*. This reef was mapped to show the position and size of its coral heads, and 64 of these heads were studied in detail. In order to characterize the reef, measurements were made of the height of each head, percent live coral coverage, dominant coral species, total number of coral species present, and the relative occurrence of algae, sponges, octocorals, and dead coral surface. Several types of statistical analyses were performed, indicating a direct relationship between coral head height and number of coral species and also between relative abundance of octocorals and number of coral species. An inverse relationship was observed between relative abundance of algae and amount of bare coral surface. there was a strong

correlation between height in 1992 and a combination of percent living coral and number of coral species. An average increase in size of the coral heads of 13 cm from 1984 to 1992 was determined, and there were more coral species, less algae, and less sponge on each head in 1992 than 1984. However, there was not a significant change in the percentage of live coral on the heads. the overall picture is one of a reef in at least a steady state condition.

The nearby Telephone Pole Reef has been studied by comparisons of transects and photographs made in 1983 and 1992, and they reveal that significant recent change has occurred. In 1983, this reef consisted largely of *Montastrea annularis* heads with dense thickets of *Acropora cervicornis* in its outer parts. today the *M. annularis* heads remain seemingly unchanged, but virtually all of the *A. cervicornis* has died and collapsed to form layers that now are being covered by rapidly growing heads of *Porites*.

With the recent opening of a large Club Med on San Salvador, possibly the biggest news on the island since its "discovery" by columbus, the Fernandez Bay reefs likely will be more heavily used for recreation by sport scuba divers. These surveys have established a baseline for monitoring ecologic health and change on these reefs in the future.

DISTRIBUTION AND ABUNDANCE OF SNAPPER AND GROUPER AT LEE STOCKING ISLAND, BAHAMAS

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Snapper and grouper are major predators on coral reefs throughout the tropics, but also a primary target of man's predation. At many locations natural populations of snapper and grouper are depleted due to fishing, though some areas are still relatively undisturbed due to low human populations levels and protection through government regulation. One such site is Lee Stocking Island, Exuma Cays, Bahamas, where large populations of esteemed food fish such as Nassau grouper (*Epinephelus striatus*) and mutton snapper (*Lutjanus analis*) still occur and their distributions may represent relatively undisturbed conditions. Diver visual census was used to determine the distribution, abundance, and size structure of snapper and grouper. In both groups juvenile fish tend to be found in shallow water and body size increased with depth. Snapper differed from grouper in forming diurnal aggregations and being more active at night. Grouper were more solitary and active around the crepuscular period. Mutton snapper differed from other snapper in that a principal portion of the adult population inhabits shallow waters on the bank. In addition mutton snapper are more diurnally activity and do not form large diurnal aggregations as are common in other snapper. Behavior and activity patterns of shallow-water groups of mutton snapper suggest

that these differences may be due to increased risk of predation in shallow-water habitats that may be shelter limited.

**FURTHER EXAMINATION OF
THE RELATIONSHIP BETWEEN
LOCAL ENVIRONMENTAL
FACTORS AND CORAL
BLEACHING AT
LEE STOCKING ISLAND,
BAHAMAS**

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Once again in 1993 the reefs around Lee Stocking Island, Bahamas experienced a moderate bleaching event. We now have adequate information to make interannual comparisons of hydrographic and meteorological events for two bleaching and four non-bleaching years. Previous analysis indicated that the main characteristics of bleaching years are elevated water temperatures in late summer (July-August) that are closely associated with low wind conditions and little rain. The primary difference between the two bleaching years (1990 vs 1993) was a secondary warming trend in September 1990. Its absence in fall 1993 may have reduced the severity of bleaching, which peaked in early October.

In 1993 a reef monitoring program was in place allowing us to closely follow the progress of the bleaching event. Minor bleaching was first observed in early August following the late July warming. A sample of "affected" and

"unaffected" coral colonies was selected shortly after the start of bleaching and was videographed weekly between late August and mid November to follow the progression of the event. Initially unaffected corals were less likely to bleach and most did not bleach as severely as the initially affected corals.

**PLEISTOCENE BIOGEOGRAPHY
AND THE DISTRIBUTION
OF ACULEATE WASP
POPULATIONS IN
THE BAHAMAS**

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During the Wisconsin Glaciation, several extensive banks were exposed in what is now the Bahama archipelago. The northernmost of these, the Little Bahama Bank united the Abacos and Grand Bahama. The most extensive land mass, called Paleoprovidence, united the islands on the Great Bahama Bank in the central Bahamas (Andros, New Providence, the Biminis, Cat Island, Long Island, the Exumas and Eleuthera). To the south larger independent banks were exposed underlying the islands of San Salvador, Mayaguana, Inagua, the Crooked-Acklins bank, and the Turks and Caicos. We are currently comparing aculeate wasp populations in the Bahamas, predicting more similarities among islands that were united during the Pleistocene, with the greatest differences on the islands that have remained isolated. These predictions have generally been supported. Comparisons between islands on the Great and Little Bahama Banks showed that the proportion of shared species among islands on the same bank was 0.51 ± 0.03 , and among islands on different banks, 0.40 ± 0.02 . San Salvador shows many affini-

ties with the wasp fauna of the Great Bahama Bank Islands. This is not true for other of the southern islands we have studied so far. collections on Great Inagua reveal a diverse but different wasp community devoid of social wasps but with a number of Sphecidae not found in the Northern or Central Bahamas. Mayaguana has a depauperate wasp fauna also without social wasps, and it has an endemic species in the genus *Pachodynerus*.

CHARACTERISTICS OF STROMATOLITES FROM STOUTS LAKE, SAN SALVADOR ISLAND, THE BAHAMAS

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Large, columnar, living stromatolites are found in Stouts Lake, a hypersaline inland lake on San Salvador Island. There are about 750 stromatolites found in two parallel rows along the eastern shore of this lake. Typically the stromatolites are about 30 cm in diameter and stand about 50 cm tall. The living component of the stromatolites is about 5 mm in thickness and contain four very distinct layers: the top dark green layer contains the cyanobacterium *Lyngbia*, the next bright green layer contains the cyanobacterium *Microcoleus*, then a salmon pink layer of photosynthetic bacteria and finally a black-brown layer of bacteria involved in decomposition. For the past three years we have measured the growth rate of these stromatolites. For the first two years the stromatolites grew at about 1 mm/yr then a lowering of the lake level caused a shrinking of about 4 mm. For the past year stromatolites have continued to grow at their original rate. Growth of these stromatolites is therefore episodic. New stromatolites are now forming on the western shore of the lake and we

are in the process of measuring their growth rate.

THE IMPORTANT ROLE OF THE BAHAMAS IN PEOPLING CUBA FROM THE NORTH AMERICAN CONTINENT

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This paper concerns: a) the climatic and landscape conditions in the caribbean during 16,000-3,000 years B.C., that favored the peopling of Cuba circa 8,000-6,000 years B.C., from the North American Continent through the Bahamas archipelago; b) the existence of trade between the bahamas and Cuba in later times; c) characteristic lithic artifacts, faunal remains, and settlement location (coastal and interior).

AUTOMATED MONITORING ALONG THE FLORIDA KEYS REEF TRACT: AN INTEGRAL COMPONENT OF THE SEAKEYS PROGRAM

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The SEAKEYS (Sustained ecological Research Related to Management of the Florida Keys Seascape) program has established a research framework which encompasses the large geographic scale and long time scale of natural marine processes and ecosystem variation upon which human impact is superimposed. the core of the program is a series of instrumented,

satellite-linked monitoring stations which span the 220 mile-long coral reef tract. Hourly monitoring since 1991 of oceanographic and meteorological conditions has documented the potential impact of periodic phenomena such as Hurricane Andrew, "The storm of the Century", and reduced salinities caused by Mississippi flooding. The influence and associated anomalies of these and other more predictable events, such as winter cold fronts and summer doldrums, vary along the reef tract emphasizing the importance of geographic scale.

RECRUITMENT OF *Diadema antillarum* IN THE FLORIDA KEYS

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Population density and size structure of *D. antillarum* in the Florida Keys have been monitored since 1990/91. A mortality event occurred in 1991, and densities on off-shore coral reefs along the Keys have remained very low ($< 0.1 \text{ m}^{-2}$). To understand at what stage populations are limited, larval influx, settlement and recruitment of *D. antillarum* individuals were used to estimate the timing and abundance of larvae entering the Keys. limited larval influx is occurring in the Florida Keys, however recruitment patterns differ between reefs and between habitats within reefs.

RETURN TO PALMETTO GROVE (SS2), SAN SALVADOR ISLAND, BAHAMAS: THE IMPLICATIONS FOR BAHAMIAN ARCHAEOLOGY

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In their overview of the Caribbean in *Chronologies in New World Archaeology*, Irving Rouse and Louis Allaire (1978:465) were able to omit the Bahamas from consideration due to the paucity of chronological data. This is all the more shocking given the fact that nearly 100 years of archaeological research had been conducted in the Bahamas archipelago at the time of their overview. Over the last 16 years, the work of a number of researchers in the region (e.g., Berman and Gnivecki, Hoffman, Keegan, Rose, and Winter) have attempted to correct this chronological lacunae. This paper is another corrective in that independent, but collective, effort.

The site of Palmetto Grove (SS2), San Salvador Island, Bahamas, was originally tested in 1960 by John M. Goggin, and in 1965 by Charles A. Hoffman. Because this site, the type site of Palmettan ware, was not chronometrically dated by either Goggin or Hoffman (1965, 1970), dates have been primarily derived from comparative stratigraphy (e.g., stratigraphy, typology, stylistic, and technological studies).

In 1993, the Lucayan Ecological Archaeology Project was granted permission to conduct a series of test excavations specifically directed at the extraction of wood charcoal for the chronometric dating of the Palmetto Grove site. Two dates, so far, have been obtained: cal A.D. 1280 (1410) 1460 (Beta-67064), and cal A.D. 1430 1483) 1654 (Beta-66089), both with a 2 sigma, 95% probability. This paper will explore the implications of these two dates for the dating of the type site of Palmettan ware for Bahamian archaeology.

**OPENING A "NEW WORLD"
IN A BAHAMIAN WILDERNESS:
ECOLOGICAL EXPLORATION
AND ITS CONSEQUENCES
ON SAN SALVADOR ISLAND**

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Over the past six year, scientists and students working at the Bahamian Field Station have created new trails into the interior of the island to conduct research and field trips within walking distance of the station. The newly completed trail system takes people into examples of nearly all the major habitats on this complex island (see the Bahamian Field Station Trail Guide). researchers and students, as well as all visitors to the BFS, now have easy access to a previously closed region because trails were cut through otherwise impenetrable vegetation. A de facto wilderness was opened for exploration, and many new discoveries have been made. Some habitats are small and easily damaged. we have seen the negative impact of people on intertidal plant communities, and have had to reroute trails onto rock.

The BFS has long had a policy of strict control of research and education projects and promotes a **No Collection** policy in sensitive areas, unless necessary for research. Some blue hole pond species are quite rare and overcollection could quickly wipe out unique populations. At present the BFS depends on voluntary compliance with the **No Collection** policy, since it is impossible to police such rules when hundreds of people can get into these once

isolated environments. even the mere presence of people in the area can facilitate migration of exotic plants into the interior, or micro-organisms from one pond to another. there is also potential disturbance of wildlife in areas where people were once rare. this new access has raised many questions for the staff and researchers of the BFS. However, if the trails are not maintained, they will disappear in a few years, and these questions will be moot. Is access to such an outstanding ecological area worth the very real impacts of periodic human presence in a wilderness?

BAHAMIAN CERAMICS

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The nature of aboriginal Lucayan ceramic wares suggests the hypothesis that they constitute a Palmettan Ostionoid subseries representing a calcareous environment adaptation of Greater Antillean traits evidenced in three ceramic styles - Abaco Redware, Crooked Island Ware, and Palmetto Ware - whose stylistic origins stem from eastern Cuban Ostionan and Hispaniolan Meillacan and Chican sources 600-1200 A.D.

**USE OF SMALL INDIGENOUS
FISH SPECIES AS SENTINELS
OF POLLUTION IN WARM
COASTAL WATERS**

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Fishes are often used as sentinels to

monitor pollution effects. typically, large fish specimens are captured by trawl or by hook and line and tissues and organs are analyzed for biochemical, physiological, or pathological biomarkers that might reflect the exposure history of the organism. Studies at our institution have been directed toward utilizing small fish species that are indigenous to various locations in the subtropical and tropical western hemisphere as sentinels of environmental aquatic pollution. studies have been conducted on the guppy (*Poecilia reticulata*), sheepshead minnow (*Cyprinodon variegatus*), Gulf killifish (*Fundulus grandis*), and mosquitofish (*Gambusia affinis*) in both field and laboratory situations. These species usually can be easily captured with nets or traps close to the shore. Each is readily adaptable to the laboratory and can be easily bred and maintained. They are especially useful in pathology studies because histologic sections of whole specimens can be mounted and examined on a single glass slide. We have exposed specimens of each species to various carcinogenic compounds and confirmed the development of neoplastic lesions suggesting that the fishes should be sensitive to environmental carcinogens as well. Recent field studies comparing specimens from non-contaminated and contaminated sites showed site specific pathologic changes that appear to reflect responses to contaminant exposures.

INDUCTION OF A HEAT SHOCK STRESS RESPONSE IN SCLERACTINIAN CORALS AND ITS RELATIONSHIP TO THE PHENOMENON OF CORAL REEF BLEACHING

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The 70 kiloDalton heat shock protein family (hsp70) is induced in scleractinian corals following experimental exposure to unseasonably warm sea water temperatures in aquaria. After natural field bleaching, the expression of hsp70 is no longer detectable in the Caribbean coral, *Montastrea annularis*. Previous reports have indicated that, in the bleached condition, the coral colony has lost its capacity to secrete a skeleton, to reproduce, to obtain sufficient nutrition and to defend itself effectively against predators. Our studies indicate that the bleached coral colonies of *Montastrea annularis* (zooxanthellate) and *Tubastrea coccinea* (azooxanthellate) were exposed to sea water temperature approximating the range in which field bleaching in the Caribbean is known to occur, i.e., 29-30°C. This temperature was less than three degrees above normal sea temperature. Following known intervals, colonies were harvested and rapidly frozen for further analysis. Homogenized tissue scrapings were separated by SDS-polyacrylamide gel electrophoresis and the proteins were transferred onto nitrocellulose paper. Western blots were prepared by reaction with anti-hsp70 complexed to alkaline phosphatase to yield a visible product at sites of the heat shock protein antigen. Our results indicate that initial induction of hsp70 above constitutive levels occurs rapidly, within one hour of immersion into warmer sea water. Thereafter, the level of hsp70 decreases over 12-24 hours to pre-exposure background values. Field bleached tissues of *M. annularis* do not reveal any constitutive hsp70, nor do they respond to temperature elevation by induction of hsp70. We conclude that the metabolic stress response of the coral tissues to a sudden elevation in temperature is a rapidly appearing, slowly equilibrating, and ultimately reversible reaction which occurs before any visible indication of bleaching. The field bleached coral colony may represent a metabolically compromised organism which has lost the capacity to react to thermal stress by induction of heat shock protein as part of the normal stress response.

NASSAU GROUPE AQUACULTURE: INDUCED MULTIPLE SPAWNING

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The Nassau group (*Epinephelus striatus*) is an important fishery in the Bahamas and Caribbean but overfishing is quickly depleting wild stocks. Despite this rapid decline very little work has been done to assess the aquaculture potential of Nassau grouper. The purpose of this paper is to report the results of experiments on hormone-induced spawning of captive Nassau grouper broodstock. Five males (2.9-9.1 kg) and three females (3.5-6.8 kg) were trapped off Lee Stocking Island, Bahamas, and maintained in a 20 m³ circular fiberglass tank supplied with flow-through seawater (36 ppt) and constant aeration. Gonadal maturity of each individual was monitored at approximately monthly intervals. In males, presence of milt was determined by applying pressure to the abdomen and in females, oocytes were sampled by biopsy using a polyethylene cannula. Spawning was attempted when a female was found with oocytes at the tertiary yolk globule stage of development. To induce final maturation, females were injected intramuscularly with human chorionic gonadotropin (HCG) at a dose of 1,000 IU/kg body weight. In some females, a second injection of 500 IU/kg body weight was administered after 24 hours. Males were not injected with hormone. Proper time of strip-spawning was based on morphological criteria including the fullness of the abdomen in females and a change from a normal color pattern to a distinct "bicolor" phase in both sexes. During the period from December 3, 1991 to April 28, 1992 a total of eight spawnings were obtained from three females: two females spawned three times and one female spawned two times, with the interval between spawnings for an individual female ranging from 28-75 days. Mean daily water temperature during the spawning period was 24.5°C (range=22.4-26.4°C). Mean oocyte diameter at

first injection was 534 µm (range=517-546 µm) and time to spawning ranged from 37-48 h after the first injection. Mean spawned egg diameter was 924 µm (range=871-959 µm) and the number of eggs spawned per female ranged from 200,000 to 2,000,000 (54,045-340,000 eggs/kg body weight). Fertilization rates ranged from 18-80% and hatching rates ranged from 68-90%. The results demonstrate that wild-caught Nassau grouper broodstock can be maintained in captivity for extended durations and that females can be induced to spawn from two to three times over a five month reproductive season with no adverse effects on fish health. These findings reveal a reproductive competency that minimizes broodstock requirements and enhances suitability for commercial aquaculture.

USING MANGROVES TO SCREEN FOR MUTAGENS IN TROPICAL MARINE ENVIRONMENTS

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Mangrove-fringed coasts are a common sight along many tropical shores. In the Caribbean and the Gulf of Mexico the red mangrove, *Rhizophora mangle*, often forms large forests between the land and the sea. These arborescent flowering plants are one of the few tree species that has the necessary adaptations to grow in sea water. In addition, red mangroves possess reproductive traits that permit the easy detection of nuclear and cytoplasmic mutations in the field. Because of these reproductive characteristics, coastal mangrove forests may be assayed for genetic damage in the same way as colonies of bacteria or yeasts are screened for mutation. The difference between mangroves and microbes is one of scale; mangroves are larger, have longer life cycles, and are exposed to environmental mutagens for greater periods of time (i.e. years rather than hours).

For a full discussion see:
Edward J. Klekowski, Jr., Jorge E. Corredor,

Robin Lowenfeld, Elizabeth H. Klekowski and Julio M. Morell. 1994. *Using Mangroves to Screen for Mutagens in Tropical Marine Environments*. Marine Pollution Bulletin. In Press.

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CIGUATERA TROPICAL FISH POISONING: A REVIEW OF WHAT'S HAPPENING IN THE FOOD CHAIN

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Ciguatera is a serious human intoxication potentially resulting from ingestion of any of over 400 species of marine fishes found within the tropics. The association of toxin-producing dinoflagellates with macroalgae commonly consumed by herbivorous fishes appears to be one of the first links in the transmission of ciguatera toxins up the fish food chain. Numerous dinoflagellate species may contribute to the ciguatera syndrome (e.g., *Gambierdiscus toxicus*, *Ostreopsis* spp. and *Prorocentrum* spp.). Until recently it was believed that ciguatera toxins could be consumed by fish with no detrimental effects. Laboratory studies demonstrated that herbivorous and piscivorous fishes, as well as adult brine shrimp (*Artemia* spp.), are adversely affected by *G. toxicus* toxins. Intoxication signs among fishes include color changes, inactivity, loss of equilibrium, erratic swimming, loss of orientation, inability to feed, and in some cases, death. *G. toxicus* cells were lethal to brine shrimp. In a ciguatera-prone region of the Caribbean, a significant negative correlation was found between the percentage of fish feeding on macroalgae and epiphytic dinoflagellate density, suggesting that herbivorous fishes might avoid consumption of large quantities of dinoflagellates

during individual feeding forays. Laboratory studies failed to demonstrate that herbivorous fishes avoid cultured *G. toxicus* cells. Attempts to directly relate laboratory studies to nature should be made cautiously because wild dinoflagellates are generally more toxic than those raised in culture.

ATTACHMENT STUDIES ON PLASTIC PANELS AND CALCIUM-CARBONATE SKELETAL SUBSTRATA IN FERNANDEZ BAY, SAN SALVADOR ISLAND, BAHAMAS

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The comatulid crinoid *Davidastor rubiginosa*, found in shallow-water patch reefs in Fernandez Bay at San Salvador, was the subject of a study designed to document the effects of encrusting and boring organisms on its calcium-carbonate skeletal remains. The insight provided could then be applied to fossil crinoids to determine the circumstances surrounding their fossilization. An important step in this investigation was an examination of the succession of attached organisms in a variety of microenvironments.

Whole crinoids were collected and ossicles were recovered using a chlorox (sodium hypochlorate) solution. Ossicles and some arm segments with soft tissue attached were then glued to plexiglass and plastic plates fastened to PVC stubs, which were then attached to concrete hemispheres, with the whole "implant" covered with a plastic basket to keep out large scavengers. The implants were engineered in such a way as to control sun versus shade, and top side versus underside surfaces. In addition, 3 different sites at Snapshot Reef were used in this

study; two on hardground surfaces, and one in the loose sand adjacent to the reef. The implants were recovered at intervals ranging from 5 days to nearly 2 years, and were examined using binocular and scanning electron microscopes.

Over 30 different types of attached organisms were found and described as distinct morphotypes representing a wide variety of green and red algae, sponges, hydrozoa, bryozoa, foraminifera, serpulid worms, and ascidians (?). The extent of coverage, the diversity of the assemblage, and the species involved all determined, in part, by the environmental variables studied, but do not seem to be controlled by the nature of the substrate.

MONITORING THE CORAL PATCH REEFS OF SAN SALVADOR ISLAND, BAHAMAS

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World-wide coral bleaching in 1987 and 1988 was followed by significant declines in the health of the world's reefs. Western Atlantic reefs were particularly hard hit. The reefs around San Salvador Island, Bahamas seemed to show dramatic declines in hard coral cover and species diversity, but quantifying the decline was not possible because there was no ongoing monitoring of these reefs. A long-term monitoring study on patch reefs around the Island was begun in 1992. Ten-meter transects were established on two patch reefs. Mapping showed that they represented the substrate cover and coral species diversity of the reef overall. These sites have been monitored three times a year with the aid of Earthwatch volunteers for water temperature, water clarity (visibility), Ph, salinity and dissolved oxygen. Quadrat maps and phototransects have been made yearly on these transects. Haphazard linear point intercept analysis and quadrat mapping of the reefs have shown that the transects continue to represent the general reef environment. Transects on a third patch reef were established in 1993 in an area of

significant decline as a way of comparing trends seen in healthier reef systems to a dying reef. While coral cover and diversity have remained relatively constant over the period on all the reefs, an increase in algae cover has been seen. Water temperatures were particularly high in February, 1994, perhaps signalling the onset of higher than usual sea temperatures for the year, a major suspected cause of the 1987/88 event. With monitoring sites in place, impacts on the reefs by such conditions will be noted and tracked, perhaps shedding light on the causes and the course of bleaching and related problems.

KARST FEATURE OF THE BAHAMAS

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The Bahama Islands have landscapes that are dominated by original depositional features, and are only slightly modified by subsequent dissolutional (karst) processes. The high porosity of the limestones that form the islands results in rapid infiltration of meteoric water and the absence of surface streams and related erosional features such as valleys and channels.

The karst features of the Bahamas fall into four main categories: karren, depressions, caves, and blue holes. Karren are dissolutional sculpturing at the centimeter to meter scale found on exposed and soil-covered limestones. A variety of etched and fretted surfaces develop. Coastal karren, improperly called phytokarst, is a particularly common example in coastal areas wetted by sea spray. Karren are part of the epikarst, the weathered zone on the limestone surface.

Depressions are large basins completely enclosed by surrounding topography. In the

Bahamas, these large depressions are usually constructional in origin; that is, swales between eolianite ridges or other deposits. Depressions that extend below sea level contain lakes with salinities ranging from fresh to hypersaline, depending on the water budget of a given island, lake surface area, and subsurface hydrology. These constructional depressions can be linked to caves that connect to the sea; tidal pumping causes exchange of waters that keeps these lakes at marine salinity. Lake margins are little modified by dissolutional processes when salinities are marine or higher.

There are four main types of caves in the Bahamas: pit caves, flank margin caves, banana holes, and lake drains. 1) Pit caves are formed from dissolution by descending meteoric water collected in the epikarst. These caves are vertical shafts that often descend in a stair-step fashion, with occasional small chambers, and are rarely open all the way to the fresh-water lens. 2) Flank margin caves are formed in the distal margin of the fresh-water lens, under the flank of an eolianite ridge, where fresh water and sea water mix and produce dissolutionally aggressive water. These caves consist of chambers with limited vertical extent but broad horizontal dimensions. They usually have a series of passages that trend into the enclosing ridge, but which end abruptly. 3) Banana holes are isolated chambers dissolved at the top of a past fresh-water lens. Those with thin roofs often collapse to produce small depressions that collect soil and provide excellent conditions for growing specialty crops such as bananas, hence their name. 4) Lake drains are conduits that carry water into and out of lakes in a pattern related to tides. Their presence results in lakes that maintain marine salinity despite climatic conditions.

Blue holes are pits with a depth to width ratio greater than one that extend below sea level for a majority of their depth. The name is derived from the dark blue color that makes these water-filled features distinctive. Blue holes are divided into two types: 1) ocean holes, which open directly into a lagoon or the ocean, are tidally influenced, and contain only marine water; and 2) inland blue holes, which open onto the land surface or isolated pond or lake, may be tidally influenced, and exhibit surface water

chemistries from fresh to marine. Blue holes are flooded karst features of polygenetic origin. They may develop as pit caves formed during sea level lowstands, as gaps in fractures formed from bank-margin failure, and from collapse of large dissolutional voids at depth. Blue holes may open laterally into horizontal cave systems at a variety of depths.

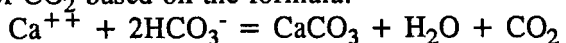
The landforms of the islands of the Bahamas have origins that are dependent on the position of sea level. During sea-level highstands, abundant carbonate sediments are formed. Some of those sediments are deposited as eolian dunes and the intervening swales form the constructional depressions. Banana holes, flank margin caves, and lake drains develop in the freshwater lens, which follows sea level. When sea level falls carbonate deposition stops and phreatic caves are drained. Banana holes and flank margin caves that are dry today formed during the last interglacial, circa 125,000 years ago when sea level, and the freshwater lens, were about 6 m higher. Far below modern sea level, blue holes often connect to banana holes and flank margin caves that formed when sea level was much lower than today. Pit caves, karren, and epikarst form on the subaerially exposed portion of the platforms during sea-level highstands, and on the entire platform surface when sea level is low.

PLEISTOCENE CARBONATE DEPOSITION/DISSOLUTION CYCLES, CARBON DIOXIDE FLUX, AND GLOBAL CLIMATE IN THE QUATERNARY

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The ice core record from Greenland and Antarctica indicates that Late Quaternary atmospheric CO₂ levels were elevated during glacio-eustatic sea-level highstands, and were at a minimum during sea-level lowstands. It has been hypothesized that this CO₂ flux was driven by

carbonate platform submergence cycles, which leads to the deposition of CaCO_3 and the release of CO_2 based on the formula:



It was further hypothesized that the CO_2 thus released would help drive global warming and terminate glaciations. This argument is patently false, as global warming and glacial melting are a prerequisite for carbonate platform flooding.

The global area of carbonate platforms subject to glacio-eustatic submergence/emergence cycles is estimated to be $6 \times 10^5 \text{ km}^2$. During submergence, these banks deposit CaCO_3 at the rate of 1 to $2 \times 10^3 \text{ g/m}^2/\text{yr}$, equivalent to the release of bicarbonate CO_2 at the rate of about $200 \text{ g/m}^2/\text{yr}$ of carbon. Average Quaternary submergence cycles last 10^4 years over the platform area of $6 \times 10^5 \text{ km}^2$, releasing 1.2×10^{18} grams of carbon as CO_2 as a result of CaCO_3 deposition. During emergence, CO_2 is sequestered as bicarbonate by dissolution of CaCO_3 , driving the equation above to the left. Studies of carbonate dissolution rates of rock volumes indicate that $75 \text{ m}^3/\text{m}^2/\text{yr}$ of CaCO_3 is dissolved. Given Quaternary limestone densities of 2.0 g/cm^3 , this is equivalent to $18 \text{ g/m}^2/\text{yr}$ of carbon sequestered. Average Quaternary carbonate platform emergent cycles last 10^5 years, exposing $6 \times 10^5 \text{ km}^2$ of platform. Karst processes during these emergent cycles sequestered $1.1 \times 10^{18} \text{ g}$ of carbon by dissolution of CaCO_3 . These values exceed the flux of $1.69 \times 10^{17} \text{ g}$ of carbon observed in the ice core record.

The amount of carbon as CO_2 released during submergent cycles approximately equals that sequestered during emergent cycles, indicating no net loss or gain of CO_2 as regards carbonate platforms during the Quaternary. During submergence, deposition is mostly as a layer on the bank surface, whereas during emergence, dissolution takes place both on the surface and throughout the volume of the exposed platforms. This difference in the location of carbon flux allows carbonate platform tops to keep up with subsidence.

If CO_2 levels are a factor in global climatic change, then karst processes can have a major impact on climate by removing CO_2 from the atmosphere when carbonate platforms are

exposed. Such sequestering of CO_2 may prolong global cooling and accentuate the amount of ice produced, increasing the duration and magnitude of sea level fall. Carbonate deposition and release of CO_2 must await platform submergence caused by other factors, and so cannot by itself produce global warming. However, such CO_2 production may help extend an interglacial.

MARINE EDUCATION AT THE UNIVERSITY OF PUERTO RICO: A LIFE EXPERIENCE

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The Sea as a Source of Knowledge is the major conceptual and philosophical framework developed and implemented by the Marine Education Program, University of Puerto Rico Sea Grant, at the Humacao University College. This appropriate, but long subestimated, approach has proven to be pertinent to students, teachers and the public-at-large that live within a marine context. The interdisciplinary study of the marine environment, with truly multidimensional analytic principles and displaying a varied diversity of pedagogical strategies (lectures, demonstrations, guided fieldtrips, workshops, open discussions, etc.), is an effective motivator for students (i.e., to follow careers in science, mathematics and engineering) and teachers. Here we will emphasize our experiences with students and teachers in the
Science and Mathematics domain.

Research results have demonstrated that lack of motivation in students foster their withdrawal from science and mathematics courses. One way to bring them back and spark their interest is to present the basic concepts in science and math using examples and situations from the marine environment, specially the tropical island characteristics of Puerto Rico.

The U.P.R. Marine Education Center has developed in-service training workshops on marine sciences concepts which may be applied by teachers in their different science and mathematics courses. With this enhancement and training activity teachers improve their own science course content, their pedagogical strategies and lure their students to science, mathematics, and engineering careers. The impact of this program on education is to make science and mathematics attractive, relevant and meaningful even if they do not study oceanography or marine sciences.

Ten public and private schools in Puerto Rico, have been carrying out this alternative/complementary educational approach since 1985. At Berwind High School approximately 240 students have participated up to 1992, 100% graduated from high school, including one group of high-risk students. Fifty five percent have continued college education in science, engineering and mathematics. Ten percent have gone to graduate school in mathematics, biochemistry, and environmental sciences.

Marine laboratories or field stations throughout the Caribbean should explore the possibility of developing areas for in-service teacher training programs and initiatives directed to educationally charm students. Teaching strategies used in this program make it applicable to students of different ethnic or racial backgrounds. Teachers and students from the Caribbean are invited to consider exchange programs at University and pre-college level through the UPR Sea Grant Program.

BASELINE STUDIES OF CORAL REEF FISH ASSEMBLAGES AROUND SAN SALVADOR ISLAND, BAHAMAS: INITIAL PREPARATION FOR POTENTIAL BLEACHING EVENTS

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Anthropogenic impacts on aquatic ecosystems continue to increase world-wide at an alarming rate. Perhaps the most insidious influence is that of non-point source pollution which has been linked to such "global changes" as depletion of the ozone layer, acid rain, and coral reef bleaching. Bleaching events have lead to coral reef mortality rates of 50% (Costa Rica) to nearly 100% (Galàpagos Islands). To date, however, most of the attention has been focused on the corals themselves and studies of potential changes in the resident fish communities have not been reported. Coral reef fishes not only depend on the coral structure for shelter, but the coral is both a direct source of food (coral polyps) and residence for invertebrate food items. The objectives of these studies were to design, develop, test, and implement techniques for sampling resident fish populations on an annual basis at the various reefs around San Salvador. Discussion will focus baseline data collected from four reefs representing four distinctly different reef ecosystems around San Salvador Island.

PREDATION BY REEF FISHES ON LARGE BENTHIC CRUSTACEANS

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Large crustaceans occur widely in hard substrates in shallow tropical waters and have been reported in the diets of many demersal fishes. In pristine habitats of the Northwestern Hawaiian Islands, we made a quantitative study of the trophic relationships between these benthic-demersal groups by collecting and quantifying the large crustaceans in samples of hard substrate and determining quantitatively the composition of gut contents of most of their fish predators. More than half of the shallow-water, carnivorous, demersal fish species with recognizable gut contents ate crabs, about half ate shrimps, and about a quarter ate stomatopods. Of the many predator species examined, the dominant consumers were from 11 families, especially Holocentridae, Labridae, Mullidae and Apogonidae. Large crustaceans accounted for over a third of all food taken by the fish community sampled. They also made up several percent by weight of all benthos in collections from the hard substrate. Brachyurans were the dominant crabs eaten, especially Xanthidae, followed by Portunidae, Majidae, and 6 less abundant families. The importance of these groups was generally similar in benthic collections. Anomurans, especially hermit crabs, were conspicuous in the diets and in the benthos. Shrimp (several families) were second only to crabs in importance in the diet of the fish community and were more numerous than crabs in the benthos, but lower in biomass. Stomatopods were widely consumed by the fishes, accounting for several percent of all large crustaceans eaten, although uncommon in benthic collections. Our results demonstrate that the trophic linkage between large benthic crustaceans and demersal fishes in these tropical habitats is of great quantitative importance to both groups.

A NEW VISUAL CENSUSING TECHNIQUE FOR ENUMERATING LARGE DAY ACTIVE REEF FISHES

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A modification of the Strip Transect, Visual Technique (STVT) for censusing fishes was developed and tested. The new method, called the Kick Cycling, Visual Technique (KCVT), does not require the advance deployment of markers of any sort (as does STVT). Divers need only a compass and a slate to carry out a census and use a standard kick cycle method for estimating the distance covered while swimming along a compass heading. This is of great advantage when time is limited and the goal of a census is to visit multiple sites over large reef areas.

The KCVT was tested against the STVT at two different locations in the Western Caribbean. Parrotfish and surgeonfish were chosen for censusing because they are abundant, large, day active fish that move about slowly; an ideal choice for visual censusing. All censusing was done in mixed zone environments on the seaward side of the reef crest at depths of 30 to 40 feet. STVT censuses were preceded 4 to 24 hours in advance by the deployment of buoys to mark distances on the bottom. Each fish count covered a horizontal distance of 20 meters and all parrotfish and surgeonfish that were within 2.5 meters to either side of the dive team were counted. Paired censuses were performed in the early afternoon at the same marked locations; by the same dive teams within 24 hours of one another but no less than one hour apart. Pairings included strip transects versus kick cycling censuses and upcurrent versus downcurrent censuses.

Parrotfish and surgeonfish counts were analyzed separately. The data from each census was analyzed for its precision ($p = \text{[standard deviation}/\sqrt{n}]/\text{mean}$). In all cases the precision value was less than 0.2 and thus within acceptable parameters. Paired censuses were

compared using ANOVA. No significant differences were found between strip transects and kick cycling censuses nor between upcurrent versus downcurrent censuses ($p=.05$). These results indicate that KCVT can replace STVT for censusing certain fishes.

GROUPING OF BACTERIAL HETEROTROPHS FROM SCLERACTINIAN CORALS USING METABOLIC POTENTIALS

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Bacterial heterotrophic communities associated with *Monastrea annularis* changed during bleaching events (Ritchie et al., 1994). These changes were detected using metabolic potential measurements as determined by carbon source utilization patterns (CSUPs). Other than this study, very little is known about the structure of the microbial communities associated with healthy or bleached corals. It is important to understand these communities because certain types of bleaching appear to be caused by infectious agents. The acroporid corals appear to be particularly susceptible to white band disease (WBD) and there is evidence that WBD is caused by a bacterial pathogen (Phillips, 1983). We collected samples from healthy and bleached white band diseased *Acropora cervicornis* growing off the coast of San Salvador Island at two sites during 1993. Surface samples from both healthy and bleached areas were plated on an appropriate medium and pure bacterial cultures were exposed to 95 different carbon sources from which CSUPs were obtained. Water samples were used as controls. The CSUPs were compared from each source and with those previously obtained from *M. annularis*. Community shifts previously observed with *M. annularis* were also demonstrated with *A. cervicornis*. In

addition, certain bacterial groups were only found with WBD samples. These isolates are being evaluated for their potential for causing white band disease.

ANECDOTAL EVIDENCE OF EARLY 19TH CENTURY CLIMATE CHANGE IN THE CENTRAL BAHAMAS

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Anecdotal records (diaries, autobiographies, news account, etc.) provide valuable regional weather data for historic eras. Charles Farquharson, a 19th Century plantation owner on San Salvador Island, maintained a diary for 1831 and 1832 which includes descriptions of the daily weather conditions. Climate conditions can be derived from the narrative by comparing observed weather events of 1831 and 1832 with Farquharson's observations on how these conditions varied from expected norms. Farquharson's descriptive accounts of temperature, wind and rainfall were evaluated against contemporary weather norms. In lieu of actual rainfall amounts, "days with rain" was used as a comparative measure. Wind direction was routinely cited by Farquharson and could be compared directly to contemporary weather data. Temperature variations had to be inferred from descriptive phraseology as was the case for wind speed. The primary focus of this research lay with the comparison of rainfall patterns during 1831 and 1832 with contemporary rainfall amounts. The weather conditions in 1831 produced a prolonged drought with precipitation that was barely half the annual rainfall recorded during contemporary times. Conditions improved in 1832 with rainfall more closely approximating contemporary standards. The inference of a climate change in the region is drawn from Charles Farquharson's commentary on how conditions in 1831 and 1832 were a departure from expected weather norms. His expectations for precipitation exceed contemporary rainfall

amounts. Consequently it is inferred that moisture conditions during the era of plantation development on San Salvador exceeded rainfall amounts recorded on the island today.

FLUCTUATIONS IN HURRICANE ACTIVITY IN THE CARIBBEAN BASIN 1900-1990

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Hurricane records from the United States National Weather Service were examined to determine if there has been any significant change in the tracking characteristics, frequency, intensity or points of origin for hurricanes tracking through the Caribbean Basin during the Twentieth Century. Hurricane tracks were categorized according to their points of origin, general tracking characteristics, intensity and frequency to analyze any changes that have occurred and to determine if these changes might be attributed to the general pattern of atmospheric warming that has transpired during this time span.

DISTRIBUCIÓN, ABUNDANCIA Y ELGUNCO ASPECTOS BIOLÓGICO-PESQUEROS DE LOS CAMARENES EN EL LITORAL CARIBE DE COSTA RICA

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Note: This paper was transcribed from a nearly illegible facsimile, so errors will most likely be found)

La explotación del recurso camarón en el litoral caribe de Costa Rica no es una pesquería tradicional sino

ocasional y su pesca va dirigida hacia el consumo local. El análisis de las estadísticas de pesca arrojó que los volúmenes de captura nunca han sobrepasado las 700 toneladas y que estos valores se alcanzaron en 1974 y 1975. Cuando operaron en la zona dos osmareneros procedentes de la flota del pacífico. No se observó una regularidad mensual en la pesca de este recurso y ocasionalmente se pesca durante todo el año. Pero se observó que la mayor actividad pesquera se realiza durante la temporada baja de la pesca de la langosta. Los resultados obtenidos por posotros muestran que las especies más abundantes son *Xyphopenasus kroyeri*, *Ponaeus aztecus* y *P. brasiliensis* y que su mayor abundancia se localiza el norte de la ciudad de Limón. Las hembras de las tres especies alcanzan mayor tamaño que los machos y predominaron las hembras sobre los machos. Por lo general, durante todos los meses, se capturaron hembras que sus gonadas desarrolladas y machos con sus ampullas llenas.

SEAGRASS STANDING STOCK, BIOMASS AND SPECIES DISTRIBUTION: A SIX YEAR STUDY

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Seagrass meadows occur off the north, south, and east coast of San Salvador Island, Bahamas. Meadows are particularly extensive in Grahams Harbor to the north and in somewhat protected areas in the south. The occurrence and extent of these meadows were calculated from thermal satellite images. In addition, sites were established from which cores were taken along transects twice a year (summer and winter) for the past six years. Contents of these cores were analyzed for seagrass species, above and below sediment biomass, and leaf count. French Bay showed the highest levels of biomass for *Thalassia* but was highly variable compared to Grahams Harbor. The Grahams Harbor site was found to be the most stable from year to year with respect to species distribution and biomass. This site also exhibited consistent seasonal fluctuations in *Thalassia* biomass, increasing

during the winter months. An East Beach site showed a typical successional pattern progressing from *Syringodium* dominance to *Thalassia* dominance over a three year period. Seagrass meadow stability was dependent on susceptibility to tidal currents and storm surges. The climax community in San Salvador consists of a mixture of *Halodule*, *Syringodium* and *Thalassia* (the dominant species). This distribution is common in the Caribbean. We suggest that similar seasonality may also be common in carbonate sediments.

CARIBBEAN CORAL REEFS: FRAGILE OR ROBUST?

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Underwater photographs and in situ notes were taken within a 160m² grid at Cayo Enrique Reef during 1984, 1986, 1988, and 1993 to determine changes in coral populations. Of the 293 coral colonies found within the reef front grid, 50% (n=146) died during the nine year interval while only 21% (n=61) survived. Only a few colonies (5) increased in cover. Life coral surface decreased in 69 colonies while only 5 colonies showed significant growth. More than 50% mortality was found in 9 of the 14 species found. Mortality was highest in *Acropora palmata*, *Agaricia agaricites* and in *Eusmilia fastigiata* where all monitored colonies died (100% mortality). As expected, lower (but significant) mortality rates were found in *Montastrea annularis* and in *Siderastrea siderea*. Mortality was attributed to: damselfish (*Stegastes planifrons*) behavior (42%); filamentous algal overgrowth (34%); overgrowth of corals by green (*Hallimeda opuntia*) calcareous algal mat development (16%); and, to overgrowth by sponges (7%). Cayo Enrique Reef, like many other Caribbean reefs, is more vulnerable now to any additional external sources of stress, whether natural or anthropogenic in origin. The implications of other reef monitoring

studies are discussed.

FURTHER EVIDENCE FOR SEA-LEVEL FLUCTUATIONS ON SAN SALVADOR ISLAND, BAHAMAS

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Coastal peat bogs and fossil cyanobacteria are additional forms of evidence which can be examined for sea level fluctuations on San Salvador Island, Bahamas. Mangrove peat bogs found on the southeast and western shores of the island reveal a high stand of the sea around 950 ± 70 B.P. to 1525 ± 60 B.P. A high stand of the sea is evidenced along the shoreline of inland lake system where one can find fossil cyanobacteria. These fossils are approximately six feet above the current lake level, possibly remnants of the Sangamon interglacial.

THE BET-HEDGING LIFE HISTORY PATTERN OF SHALLOW-WATER GORGONIANS

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Shallow-water gorgonians of the Caribbean have relatively long lifespans (decades), high fecundities (1000s of planulae), and probably a late age (or minimum size) of first reproduction. According to the bet-hedging interpretation of life history pattern, these demographic features are associated with high and constant

survival of large (adult) colonies coupled with low and variable juvenile survival (or recruitment). Results of a 9 year (1983-1992) monitoring study of gorgonian populations near La Parguera, Puerto Rico are consistent with these predicted patterns. For instance, the average survivorship of large colonies (> 10 cm tall) of *Pseudopterogorgia* spp. was high ($94\% \text{ y}^{-1}$) and constant (range: $92\text{-}100\% \text{ y}^{-1}$) while the average survivorship of small colonies (≤ 5 cm) was relatively low ($77\% \text{ y}^{-1}$) and variable (range: $53\text{-}83\% \text{ y}^{-1}$). In addition, recruitment was highly variable ranging from 0.4 colonies per m^2 in 1983 and 1992 up to 35 colonies per m^2 in 1985. This life history pattern has resulted in episodic variations in the population structure of gorgonians. For instance, colony densities has increased from less than 10 to over 62 colonies per m^2 during the study period at one of the field sites.

POSTER ABSTRACTS

MOLLUSCAN COMMUNITY ASSOCIATED TO THALASSIA IN THREE ZONES AT MORROCOY NATIONAL PARK, VENEZUELA

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Worldwide, seagrass beds constitute one of the most conspicuous and coastal habitat types. Spatial distribution of species associated to *Thalassia* is determined by the sensibility of mesofauna to biotic and abiotic factors. Marine invertebrate communities associated to *Thalassia* from very close zones suffer dramatic composition and density oscillations. Molluscan species constitute one of the components of this community. The objective of this study is to analyze the molluscan community associated to *Thalassia* beds, and to know as well, which is its relationships with environmental and biological parameters. The benthos was studied, specifically the molluscs associated to *Thalassia* beds, and to know as well, which is its relationships with environmental and biological parameters. The benthos was studied, specifically the molluscs associated to *Thalassia testudinum*, and also the physical and biological parameters at different localities in the Morrocoy National Park, Venezuela. In each locality an area of 20 x 20 m was selected, in which 130 random selected 1 x 1 m quadrates were sampled, during 13 months. In each site, dissolved oxygen, salinity, temperature, organic matter, carbon, nitrogen, texture of sediments, *Thalassia* leaves and rhizomes biomass were determined.

Fifteen species of molluscs were reported (gastropods and bivalves), being the 3% of total number of reported invertebrates. Their relative abundance and dominance increased

when *Thalassia* rhizomes biomass did. In fact, it is reported a gradient on the percentage of molluscs dominance in sampled localities as follows: $A < B < C$, being at locality C the highest value. High rhizomes biomass seem to reduce the efficiency of molluscan predators. The presence of reported species would be related with the very stable seagrass bottom. Environmental stress would be also related with the distribution of some molluscs species. Structure of benthonic community associated to *T. testudinum* shows the organisms response to local variation in both interacting, biotic and abiotic characteristics.

COMMUNITY STRUCTURE OF A GUILD OF PORTUNID CRABS IN A COASTAL BEACH IN VENEZUELA

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An immense amount of literature exists upon a wide variety of aspects concerning portunid crabs. Few works, however, deal with the community structure of this family, and the Caribbean populations of these species, in spite of the potential importance from the commercial point of view. In Venezuela, a wide spectrum of portunids have been reported and some of them are of commercial importance (*Callinectes bocourti* and *C. sapidus*). Falcón State, situated on the western part of Venezuela, is distinguished by a considerable extension of marine coasts with predominance of sandy and sandy-muddy littorals, holding a high variety of portunid crabs, specially from the genus *Callinectes* and *Arenaeus*. This work shows the community structure and some ecological aspects

of portunid crabs in a sandy beach bay, situated in La Vela de Coro, Falcón State - Venezuela. Monthly samplings were carried out with a manual net 6 meters long, between January 1993 and January 1994 in 3 different marine stations (1, 2 and 4) along a sandy beach with a relative low profile. A fourth station (3) was located in a brackish lagoon. Surface water temperature and salinity were measured. The depth varied between 0.5 and 1.5 meters. Captured animals were identified in situ. Sex was determined and carapace length was measured. Number of captured crabs of each species in each station were added up for the 13 months sampled.

Station 1 presented 70% *Arenaeus cribarius*, 20% *Callinectes danae*, and 10% *C. sapidus*. Station 2 presented 80% *Arenaeus cribarius* and 20% *Callinectes danae*. Station 4 presented 94% *A. cribarius*, 3% *C. bocourti* and 3% *C. sapidus*. Station 3 (estuarine) presented the highest variety with 65% *C. danae*, 13% *C. bocourti*, 10% *C. exasperatus*, 5% *C. maracaiboensis*, 3% *C. marginatus*, and 2% *C. sapidus*. In all the 3 marine stations salinity varied very little, showing a mean of 37 ppt for stations 1 and 2, and 36 ppt for station 4. The estuarine station (3) showed highest salinity in the months of February 93 (27 ppt) and January 94 (39 ppt), and lowest between July and October (4 to 6 ppt). Temperature varied very little in all four stations, oscillating between a maximum of 29 and a minimum of 25°C (in January). Male:female relationship from *Arenaeus cribarius* was 1.95:1, presenting a mean size of 20.6 (n=109). Male:female relationship from *Callinectes danae* was 1.35:1, presenting a mean size of 22.3 (n=87). No berried females of any kind of the species were found. Increment of salinity in the estuarine station is caused by the entrance of sea water during peak high tides between the months of November and December. Species found in the brackish lagoon are proper of this kind of habitat, hence having the highest diversity of all stations. The most abundant species were *A. cribarius* in the marine environment, and *C. danae* in the brackish area. *A. cribarius* is typical marine species. *C. danae* was found in both marine and estuarine habitats, being most frequent in the latter and in the most protected area.

LOCAL AND GEOGRAPHICAL VARIATIONS IN THE MANGROVE CRAB *Aratus pisonii*

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Latitudinal clines have been used extensively to explain intra-specific variations in life history and population features, up to the point where they have become paradigms of classic biogeography and evolutionary biology. Their importance, though might be overstated, although latitudinal clines can help to disclose the selective forces and regulating factors that act on populations. In various crustacean groups latitudinal gradients have been used to explain intra-specific variations of several features. In this paper we summarize a large body of information about *Aratus pisonii*, a highly plastic arboreal brachiuran that lives on mangrove trees, that provides an interesting subject to examine the range of local, regional, and geographical variations. Life histories and population features of the brachiuran *A. pisonii* were investigated on several localities of the Venezuela coast (10°-12° S) (seven sites), in Bertioga, Brazil (24° S) (two sites), and Florida, USA (26° N) (one site). The last two locations are close to the limits of *A. pisonii* Atlantic distribution. Populations examined included crabs from riverine, estuarine, marine and hypersaline mangroves. Variations in size of cephalothorax (mean, maximum, range), population structure, size at the onset of maturity, and other features, were significantly larger locally, in several populations spread over an almost equititudinal stripe, than geographically. The largest differences in size and other traits were found in two populations that inhabit two mangrove forests that grow in a hypersaline lagoon in the Venezuelan coast. A similar relation was found in two estuarine populations in Bertioga, Brazil. Marine populations features did not show geographical gradients.

**DESCRIPTION OF SOME
ASPECTS OF THE ANATOMY
OF THE HELMET
Cassia tuberosa AND
*C. madagascarensis***

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Our interest in mariculture of *Cassia* has led to the study of the food sources of the animals as indicated in previous publications. The next step is the exposition of the reproductive anatomy and behavior.

In this paper a description and presentation of illustrations and photographs of anatomy will be given with the emphasis on the reproductive system.

Specimens of *Cassia tuberosa* were obtained from habitats around San Salvador Island. These animals were removed from the shells and immersed in 10% alcohol to anesthetize and relax them before they were dissected. Several incomplete specimens of *Cassia madagascarensis* were contributed by Mr. David Lee of Nassau. They had been pulled from the shells and then preserved in formalin. The dissections at the Bahamian Field Station were drawn by Mary Jantzi and Jeffrey Stegal and photographed by the author.

**NUTRITIONAL EVALUATION
OF *Artemia nauplii* (strain
Las Cumaraguas, Venezuela)
AS FOOD FOR *Penaeus
vannamei* LARVAE**

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Selection of a suitable *Artemia* strain to

be used as food for larviculture not only depends on the quality of the strain itself (hatching percentage, efficiency, output) but also on the nutritional value in terms of its contents of highly unsaturated fatty acids (HUFA).

The effect of *Artemia* (strain Las Cumaraguas-Paraguáná, Venezuela) wild nauplii diet on the growth of survival of *Penaeus vannamei* larvae was studied. Larvae of *P. vannamei* were reared on 3 different diets; 2 based on *Artemia nauplii*: OSI Pro-80 (USA) and strain Las Cumaraguas-Paraguáná, Venezuela. A control group was fed a mixture of *Chaetoceros* and *Tetraselmis chuii*. Fatty acid profiles were obtained through gas-chromatography.

Results showed that the difference in survival was significant at $p < 0.50$ level. No significant difference was found for developmental rate. Survival rate of *P. vannamei* larvae fed Las Cumaraguas strain through PL 1 was superior to that of OSI Pro-80; a 54.16% survival was attained in 10 days of culture as contrast with *Artemia* OSI Pro-80 that in 11 days reached a 16.66% and control 10.41%, respectively. Survival and development results might be related to levels of n-6 serie (161.5%) and n-3 serie (21.87%). The n-3/n-6 proportion (1.36) is responsible of the efficiency in the bioconversion route of the serie C:18 - C:20 - C:22. These fatty acids are essential for marine animals. Arachidonic acid (20:4W6) was present in Las Cumaraguas strain and it is considered to be essential in hormonal activity of penaeid shrimps.

These results may have proven *Artemia* Las Cumaraguas strain to be useful in the larviculture of penaeid shrimps.

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