

# The National Coral Reef Institute





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## A MESSAGE FROM THE DIRECTORS

*Estimates of as much as 20 percent of the world's coral reefs already have been destroyed. If no action is taken to reduce threats, costly additional losses are predicted in the coming decades.*

With levels of biodiversity rivaling those of tropical rainforests, the complex framework and structure created by reef-building corals and their calcified skeletons are a unique and irreplaceable natural resource. Globally, coral reefs provide enormous economic benefits. In the United States alone, the economic value of coral reefs is valued in the billions of dollars annually. They serve as important fishery resources and physical barriers to coastal erosion, offer recreational and tourist areas, and are repositories to a myriad of described and undescribed species of great value to humankind.

Yet coral reefs are rapidly being degraded by pollution, overfishing, climate change, coastal development, ship-related injuries, recreational overuse, and the introduction of exotic species. Estimates of as much as 20 percent of the world's coral reefs already have been destroyed. If no action is taken to reduce threats, costly additional losses are predicted in the coming decades.

The mission of the National Coral Reef Institute (NCRI) is to be a center of excellence for management-relevant coral reef research and is advanced through its status as part of the Oceanographic Center at Nova Southeastern University, which provides administration, facilities, and support within an academic research university setting. Knowledge, ideas, and experience in all relevant disciplines are consolidated, expanded, and used

to help identify and solve the challenges that beset our coral environments. NCRI seeks to provide a focus where academia, government, and commerce may communicate, plan, and act to preserve, restore, conserve, and manage these fragile ecosystems.

NCRI's research is directed at building comprehensive baseline information for scientific and management use by conducting targeted research into aspects of coral reef assessment, monitoring, and restoration. In this process, information is collected and evaluated, often in collaboration with national and international partners and funding agencies. The results of this work are already improving the nation's ability to determine the status of its coral reefs and emerging trends that might affect their future as a viable resource. NCRI will continue to strategically target areas of coral reef research that have particular relevance during these times of global climate change and an increasingly problematic human ecological footprint.

A hallmark of NCRI also has been the efficient dissemination of important scientific information and research or computational tools to members of the worldwide scientific community, resource managers, and conservationists concerned with coral reefs. Evaluation, synthesis, and sharing of relevant scientific information and tools are being achieved through

national and international scientific conferences, presentations, and publications, as well as an expanded presence on the Internet, which allows access to NCRI's latest research and software.

Despite being a young organization, NCRI scientists already have produced more than 70 scientific papers, nearly 100 abstracts, and 35 technical reports. In addition to funds from the U.S. Congress, administered through the National Oceanic and Atmospheric Administration (NOAA), NCRI has limited support from other federal, state, county, and corporate sources that complements and augments its assessment, monitoring, and restoration efforts.

Coral reefs are not only beautiful, but also important economic resources that provide protection from coastal erosion, make wonderful tourist destinations, and offer a home to a myriad of species of marine life. By conducting management-oriented research, NCRI is working to do its part to help conserve these invaluable assets for generations to come.

Richard E. Dodge, Ph.D.  
Executive Director

Bernhard M. Riegl, Ph.D.  
Associate Director



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# NCRI OPERATIONS



The organizational structure of NCRI includes an executive director who determines strategic direction, engages additional scientific and technical staff as needed, and ensures that scientifically correct, ethical, and sound activities are conducted at the institute. The associate director is responsible for working closely with the executive director to initiate, direct, seek, and manage research projects, as well as act as a principal investigator on a variety of key research initiatives. An administrative program coordinator administers the NCRI office functions and makes arrangements for conferences and other special events. Scientific staff (research scientists, students, and technicians) conduct active research on a variety of projects.

As part of its mission for research excellence in coral reef studies, NCRI conducts projects independently or in collaboration with other organizations and agencies. These take place at NCRI or at various institutions around the world. Activities are geared toward the development of innovative hypotheses and tools to provide service and information that can be employed by the academic and management communities.

A portion of NCRI's research allocation is annually disseminated externally in a competitive grant-allocation process to researchers who are conducting relevant research around the nation. Hence, NCRI also provides a source of funding to marine scientists outside the institution following a rigorous peer-

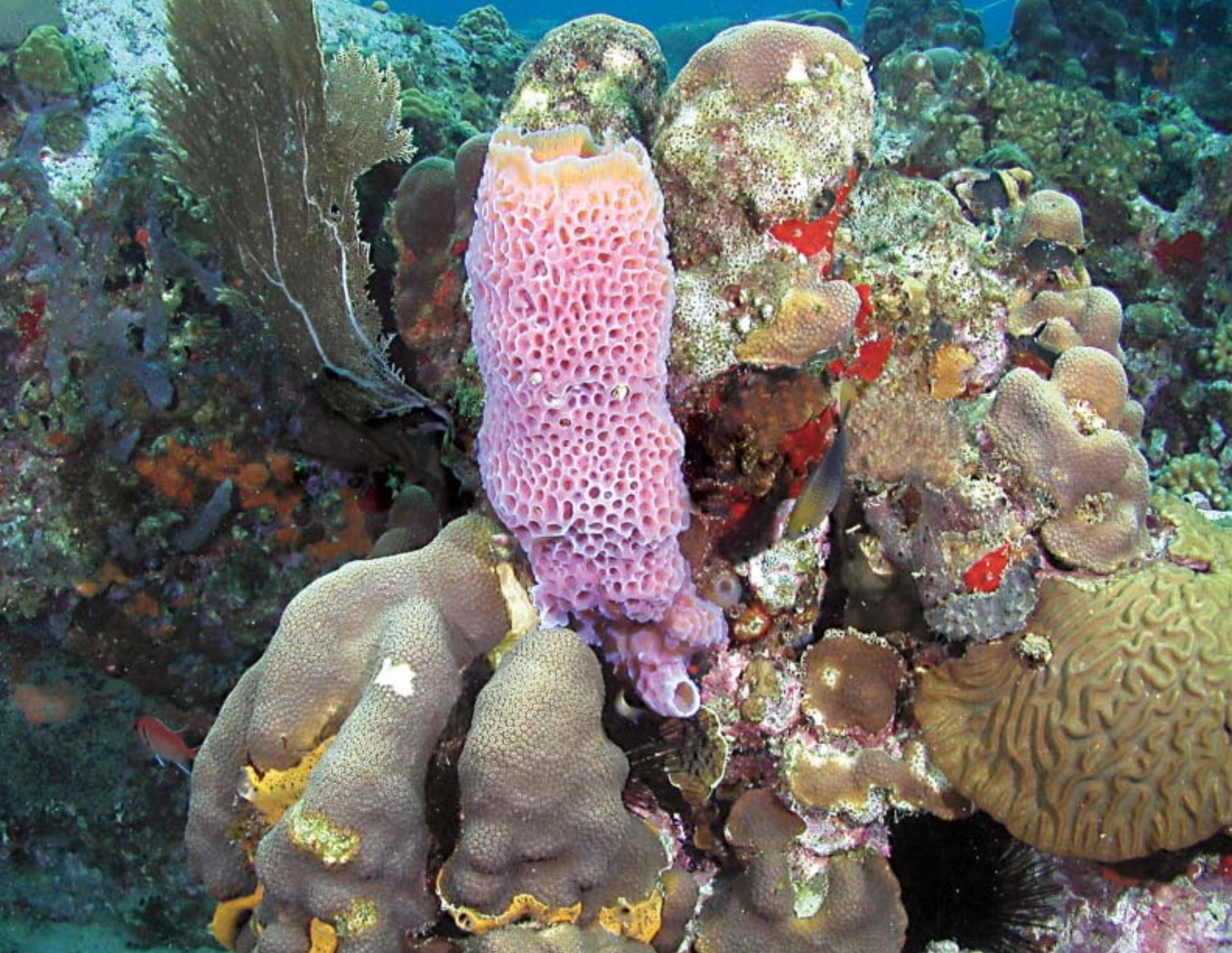


Pictured left to right are Michael J. Dowgiallo, Ph.D., NOAA/NOS/CSCOR program manager; Bernhard M. Riegl, Ph.D., NCRI associate director; David Hilmer, NOAA/NOS/CSCOR associate program manager; Robert E. Magnien, Ph.D., NOAA/NOS/CSCOR director; Richard E. Dodge, Ph.D., NCRI executive director; and Felix A. Martinez, Ph.D., NOAA/NOS/CSCOR.

review process. NCRI is aided in decision-making by a technical advisory committee. This committee reviews proposals and the results of the peer reviews and also provides input into the selection of grantees and new research directions for NCRI. The members of the technical advisory committee are (in alphabetical order): Terry Done, Ph.D., senior principal research scientist at the Australian Institute for Marine Sciences; Peter Glynn, Ph.D., at the University of Miami Rosenstiel School of Marine and

Atmospheric Science; Ian Macintyre, Ph.D., curator of carbonate sedimentology at the National Museum of Natural History, Smithsonian Institution; and Marjorie Reaka-Kudla, Ph.D., at the University of Maryland.

NCRI provides a fellowship for deserving student projects. This is typically a one-year stipend, which may be extended, to support a deserving student's tuition and/or living/research costs.



# NCRI AT NOVA SOUTHEASTERN UNIVERSITY OCEANOGRAPHIC CENTER

*The mission of the Oceanographic Center is to carry out innovative, basic, and applied research and to provide high-quality graduate and undergraduate education in a broad range of marine-science and related disciplines.*

*The Center also serves as a community resource for information, research, and education on oceanographic and environmental issues.*



NCRI is part of the Oceanographic Center at Nova Southeastern University. Situated on a 10-acre campus in Dania Beach, Florida, on the ocean side of Port Everglades, the Oceanographic Center has a 1-acre boat basin, and its location affords immediate access to the Gulf Stream, the open Atlantic Ocean, and the southeast Florida reef tract. Research vessels include a variety of outboards and inboards for general science diving and use. The William Springer Richardson Library located on campus contains 3,000 books and more than 100 periodicals covering the various disciplines of marine and aquatic science. A computer center operates as a resource for modeling and scientific computing.

Besides NCRI, the Guy Harvey Research Institute for the research and conservation of fish is another integral component of the Oceanographic Center.

Faculty, staff members, and students at the Oceanographic Center pursue research in biological and physical oceanography. Areas of interest include modeling of large-scale ocean circulation, coastal dynamics, ocean-atmosphere coupling, coral reef research, benthic ecology, marine biodiversity, calcification of invertebrates, marine fisheries, marine microbiology, and molecular ecology and evolution.

The Oceanographic Center is part of Nova Southeastern University (NSU), the largest independent nonprofit university

in the southeastern United States. NSU has more than 25,000 students and awards associate's, bachelor's, master's, educational specialist, doctoral, and first-professional degrees in a wide range of fields. The university is comprised of undergraduate, graduate, and professional schools of osteopathic medicine, pharmacy, optometry, allied health and nursing, medical sciences, dental medicine, law, marine biology and oceanography, business and entrepreneurship, computer and information sciences, humanities, conflict resolution, family therapy, interdisciplinary studies, education, psychology and counseling, and family programs.



# PARTNERSHIPS AND COLLABORATIONS

NCRI develops and maintains partnerships with a wide variety of organizations and researchers to fill gaps in scientific knowledge of coral reefs as they relate to issues of assessment, monitoring, and restoration. The institute leverages funding for projects by working with local, regional, national, and international organizations on common concerns. NCRI particularly emphasizes collaboration with management authorities to ensure the optimal transfer and application of knowledge obtained through its research programs. Below is a partial listing of NCRI's valued partners.

## Local and Regional Partners and Collaborators

- Biscayne National Park
- Broward County Environmental Protection Department
- College of Charleston
- Florida Atlantic University
- Florida Institute of Oceanography
- Florida Institute of Technology
- Florida International University
- Florida Keys National Marine Sanctuary
- Florida Sea Grant
- Georgia Institute of Technology
- Harbor Branch Oceanographic Institution
- Kansas Geological Survey
- Miami-Dade County Department of Environmental Resources Management
- Ocean Watch Foundation
- Palm Beach County Department of Environmental Resources Management
- Southeast Florida Coral Reef Initiative
- South Florida Water Management District
- Smithsonian Marine Station
- St. John's River Water Management District

- State of Florida Department of Environmental Protection
- State of Florida Fish and Wildlife Conservation Commission
- State of Florida Fish and Wildlife Research Institute
- University of Boston
- University of Central Florida
- University of Florida
- University of Georgia
- University of Kansas
- University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS)
- University of North Carolina at Wilmington
- University of South Florida

## U.S. Partners and Collaborators

### Other States and Territories

- Commonwealth of the Northern Mariana Islands Department of Environmental Protection
- Commonwealth of Puerto Rico
- Roatan Institute of Marine Science
- U.S. Virgin Islands

### Federal Agencies and National Organizations

- National Center for Caribbean Coral Reef Research
- National Fish and Wildlife Foundation
- National Science Foundation
- U.S. Coral Reef Task Force
- U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA)
  - Coastal Center for Sponsored Coastal Ocean Science
  - Office of Response and Restoration (ORR)/Coral Reef Conservation Program
  - Center for Coastal Fisheries and Habitat Research

- Center for Coastal Monitoring and Assessment/Biogeography Program
- Center for Coastal Environmental Health and Biomolecular Research
- National Oceanographic Data Center
- National Marine Fisheries Service
- U.S. Department of Defense
  - U.S. Army Corps of Engineers
  - U.S. Navy
- U.S. Department of Interior
  - National Park Service
  - U.S. Geological Survey
- U.S. Environmental Protection Agency

## International Partners and Collaborators

- Bahamas Department of Fisheries
- Bermuda Biological Station for Research
- Federated States of Micronesia
- International Union for Conservation of Nature and Natural Resources/World Conservation Union
- Karl-Franzens University of Graz
- National Polytechnical Institute of Mexico
- Petroleum Institute of the University of the United Arab Emirates
- Qatar Supreme Council for the Environment and Natural Reserves
- South Africa
- The Nature Conservancy
- United Arab Emirates Environmental Research and Wildlife Development Agency
- University of Cape Town
- University of Qatar
- World Bank Global Environment Fund
- World Wildlife Fund



## OVERVIEW



NCRI projects are focused, according to the institute's mission, on:

- Assessment
- Monitoring
- Restoration
- Information Dissemination

related to coral reef ecosystems.

Coral reef ecosystems are among the most productive and diverse in the world. Countless species coexist because of the constant renewal of framework and structure created by reef-building organisms. Coral reefs serve as buffers from effects of storm activity on coastal features, and the natural chemical and biological breakdown of reef structures produces abundant sediments that nourish beaches. In many areas, reefs are an important economic resource, creating habitat for commercially and recreationally important species of fish and a recreational locale for diving and tourism activities.

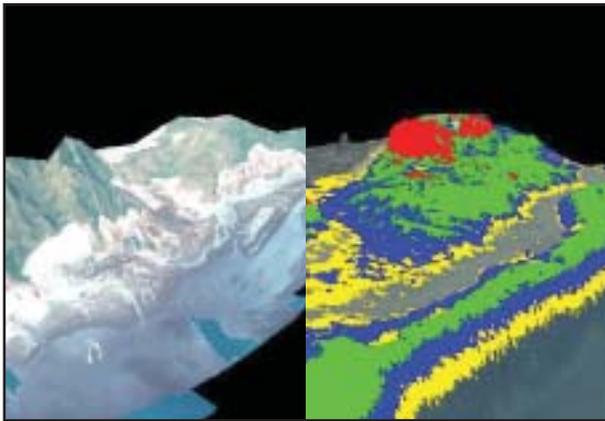
Coral reefs are impacted worldwide by a host of natural and human-induced factors. Natural and human-made climatic variations, including those from El Niño, heat, stress, and hurricane forces, cause substantial damage to coral reefs. Dynamite and

chemical fishing, anchor damage, dredging, sediment runoff due to deforestation and eutrophication, bleaching, and disease can devastate coral reef ecosystems. Coral reefs in the proximity of shipping lanes also are susceptible to ship groundings.

Globally, coral reefs are undergoing large-scale ecological and physical changes. Scientists and marine resource managers are exploring scientifically sound approaches to restore and mitigate damaged coral reefs. Progress has been gradual because of the complexity of tropical systems, the unpredictable occurrence of human impact, and the extended time needed to monitor and assess recovery. Scientific solutions and intuitive quick fixes have provided some encouraging results, but additional sustainable approaches and technologies are needed for efforts to be successful.



## Coral Reef Mapping



NCRI mapping activities are applicable to the goals of the U.S. Coral Reef Task Force and South Florida Coral Reef Initiative/Southeast Florida Action Strategy Team. NCRI has produced reef maps both in Florida and other U.S. states on the Atlantic and Pacific, as well as overseas.

### Large- to small-scale morphology

Responsible management of reef resources cannot be accomplished without detailed knowledge of the size and distribution of the reefs themselves. Thus, coral reef maps are an indispensable management tool. NCRI mapping projects center around the integration of different data layers into coherent maps that aid in visualizing and explaining the spatial dynamics of organisms as they react to geomorphology. Acoustic ground discrimination, Sonar, and LIDAR help to develop classification schemes based on subsea topography. By integrating community mapping with geomorphological mapping, NCRI provides tools that visualize the spatial heterogeneity of the reef environment, as well as the community dynamics of its organisms, giving managers powerful information upon which to base decisions.

### Benthic habitat maps

Benthic habitats have distinct physical, geochemical, and biological characteristics. Information gained from coral reef mapping includes identifying essential fish habitat and other ecologically sensitive areas, calculating volumetric or area measurements of anthropogenic impacts, identifying gaps for submarine cable placement, and locating areas for artificial reef enhancement.

NCRI's benthic maps are being included in the South Florida Electronic Area Contingency Plan that is being developed by the Florida Fish and Wildlife Research Institute in cooperation with the U.S. Coast Guard to support oil spill response and planning. The maps also will support state and county permitting activities related to sand mining and the minimization of impacts by submarine construction and excavation.



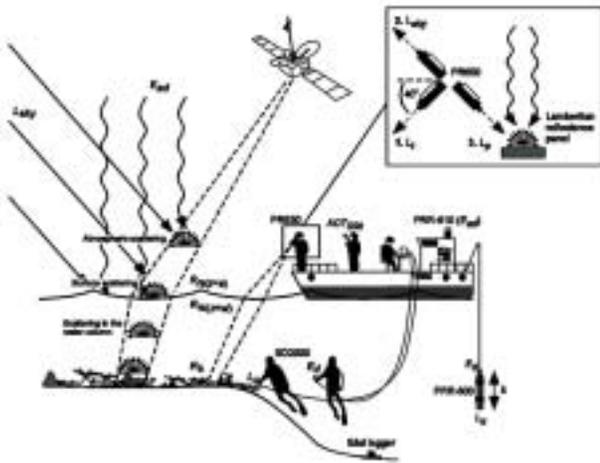
Remote-sensing data was compiled to map the benthic habitat features of Broward County, Florida, USA. Approximately 112 km<sup>2</sup> of nearshore seafloor was mapped, which included nearly 57 km<sup>2</sup> of coral reef and colonized hardbottom.

## Coral Reef Mapping (cont.)

### Mapping coral reefs from space

Considering the rapid demise of coral reef diversity over the last decade, the need for an accurate audit of reef distribution is greatly needed. Satellite remote sensing is both cost-effective and offers quantitative information at ecologically meaningful scales. When combined with traditional field-based techniques, passive optical satellite imagery provides the link between individual coral communities and the functional dynamics of the coral reef system.

Providing a baseline from which to evaluate the condition of sensitive reef ecosystems at a snapshot in time, remote sensing has the capacity to guide environmental decision-making and to revolutionize the management strategy for coral habitats on a global scale.



NCRI's research focuses on the development of algorithms that help to successfully delineate reef substrates from satellite imagery, effectively correcting the disruptive influence of the water column on the spectral signature of the seabed.

## Assessment of Reef Function



Demographic surveys indicate that Broward County staghorn coral is the largest extant population of this species in the continental U.S., providing critical habitat for numerous species of invertebrates and fishes.

### Evaluating local success of regionally threatened staghorn coral

Due to the dramatic decline of *Acropora cervicornis* (staghorn coral) throughout the Florida Keys and the Caribbean, notable structural and functional changes have occurred in many reefs, leading NOAA Fisheries to propose listing staghorn (and elkhorn) corals as threatened species under the Endangered Species Act. In contrast to much of the rest of its geographic range, the persistence and growth of dense thickets of staghorn coral off of the coast of Fort Lauderdale are noteworthy. NCRI's research program investigates the interplay between *A. cervicornis* demographics and reproduction and environmental disturbances. These studies contribute toward the assessment of species status, vulnerability, resilience in the region, and the establishment of a baseline against which to compare future change.



NCRI's multilayered approach combines community- and organism-based biomonitoring attributes, thus providing researchers and resource managers with a broader set of tools for defining coral and coral reef health status in field conditions.

### Developing tools to assess and diagnose stress on stony corals

Excessive sedimentation and elevated turbidity are two sources of stress to coral reefs worldwide. Both of these stressors are potential impacts of borrow dredging in beach renourishment projects that use sand as fill for eroded areas. Working with the Broward County Environmental Protection Department, scientists at NCRI are developing a ranking scale to assess the health status of natural coral populations to these stressors.

Project goals are to: (1) use higher-resolution tools to quantify thresholds of sedimentation stress in corals; (2) validate laboratory results; (3) try to link a particular stressor with a measurable level of change, injury, or physiological dysfunction; (4) further our understanding with regards to the evaluation of coral reef health condition; and (5) provide alternative tools for resource managers to assess and diagnose stress in field conditions.

## Fishes

### Fish census of selected artificial reefs

Used mainly by recreational fishers and divers, there are more than 500 vessel-reefs in Florida waters alone. Despite their popularity, few studies have rigorously examined fish assemblages on these artificial reefs and compared them to natural reefs. Six vessel-reefs and neighboring natural reefs off the coast of southeast Florida were censused quarterly to characterize the associated fish assemblages. A total of 114,448 fishes of 193 species were counted on natural and vessel-reefs combined.

Fish abundance and species richness were significantly higher on vessel-reefs in comparison to natural reefs. Haemulidae (grunts), the most abundant family on vessel-reefs, represented 46 percent of the total population. Whereas on natural reefs, Labridae (wrasses) were the most abundant family, accounting for 24 percent of total abundance.



NCRI research indicates that the effects of deploying vessel-reefs on the natural environment are complex and not a simple aggregation from neighboring habitat. The juvenile phase of two deep-water, economically important species repeatedly recorded on the vessel-reefs has never been observed on natural reefs in this study area, possibly indicating that vessel-reefs supply ancillary nursery/juvenile habitat for these animals that may be unavailable or limited on surrounding natural reef.



Through this comprehensive survey of the coral reef fishes of Broward County, NCRI has created a baseline database with which to compare future changes in the local fish assemblage in response to anthropogenic or natural causes.

### Survey of the fishes of southeast Florida

Resident and transient coral-reef fishes in Broward County, Florida, are subject to multiple environmental insults including heavy fishing pressure, effluent from Fort Lauderdale and Port Everglades, and habitat destruction from anchoring and ship groundings. Multiple local, state, and federal management decisions are being implemented, or considered, to alleviate the current situation or to mitigate damage. Knowledge of current stocks is critical to the effective management of these habitats.

For an 18-nautical-mile coastline section, fishes were censused using the Bohnsack-Bannerot point count method to record fish abundance, species richness, size, and general habitat characteristics. During a four-year period, a total of 667 count sites was censused by NCRI researchers. The findings revealed 86,463 fish belonging to 208 species (52 families) recorded along Broward County's shores. Of immediate management interest, the results include a surprising scarcity of legal-size groupers and snappers was over the entire survey area.

### Nearshore hardbottom fishes of Broward County

Some shallow (less than 7 meters of water depth) nearshore hardbottom areas of southeast Florida have been reported to function as important juvenile fish habitat. In order to evaluate the impact of planned beach renourishment projects (sand fill to offset erosion), baseline data on hardbottom coral reef fish assemblages adjacent to the beach was collected along a 30-kilometer stretch of coastline, primarily in Broward County. In total, 164 species and over 72,000 fish were recorded in 2001; a total of 7,555 fish consisting of at least 130 species were recorded in 2003. Fish exhibited a 62.8-percent decrease in abundance between the 2001 and 2003 surveys. *Haemulon* spp. (juvenile grunts) alone decreased 72.8 percent in abundance. The second most abundant species, *Halichoeres bivittatus* (slippery dicks), also primarily juveniles, showed a significant decrease between the 2001 and 2003 surveys. Species richness declined significantly with slightly fewer species noted in 2003 and eight fewer total species between years.



NCRI results provide critical baseline data for determining the effects of beach renourishment on nearshore fishes in Broward County. In addition, the large variation in fish abundance and species richness noted between years has widespread implications for determining potential anthropogenic change in fish assemblages (e.g., caused by beach renourishment).

## Assessment Software



### CPCe software breaking new ground

CPCe (Coral Point Count with Excel Extensions) is a standalone Windows-based program that automates the random point count method commonly used with frame-grabbed video or still images in the assessment of coral reef communities. It provides statistical analysis of coral coverage and diversity from voluminous numbers of underwater images. Coral code data for each frame is stored, and the accumulated data of several frames are combined and saved as a transect dataset which can be statistically analyzed to give quantitative measurements over the area of interest.

Analysis spreadsheets are automatically generated and provide coverage estimates and diversity indices at the species level. CPCe allows the user to calibrate the analysis images and thereby determine lengths and areas of photographed features. CPCe continues to be refined, pending feedback from researchers worldwide. CPCe is available free of charge to researchers affiliated with scientific institutions for noncommercial use.

## Assessment of Molecular Genetics of Reef Populations



### Using molecular genetics to help identify biodiversity hotspots for MPA design

NCRI has received nearly 400 inquiries regarding the CPCe software from researchers worldwide since its launch in 2003.

Selection of marine protected area sites for conservation, recovery, and management of coral reef ecosystems requires an understanding of the dynamics of population connectivity among reef tracts and identification of biodiversity hotspots. NCRI is developing and using new molecular genetic approaches to assess dispersal potential, population connectivity, and biodiversity in a variety of reef organisms.

NCRI's genetic research shows that expanses of deep open water create substantial barriers to gene flow, and many populations of species are reproductively isolated. These results show that assumptions regarding the dispersal potential of reef invertebrates based simply on life history characteristics may be misleading and need to be empirically tested. In addition, there is a need to integrate traditional morphological taxonomy with new genetic techniques in order to reveal the full extent of coral reef biodiversity.

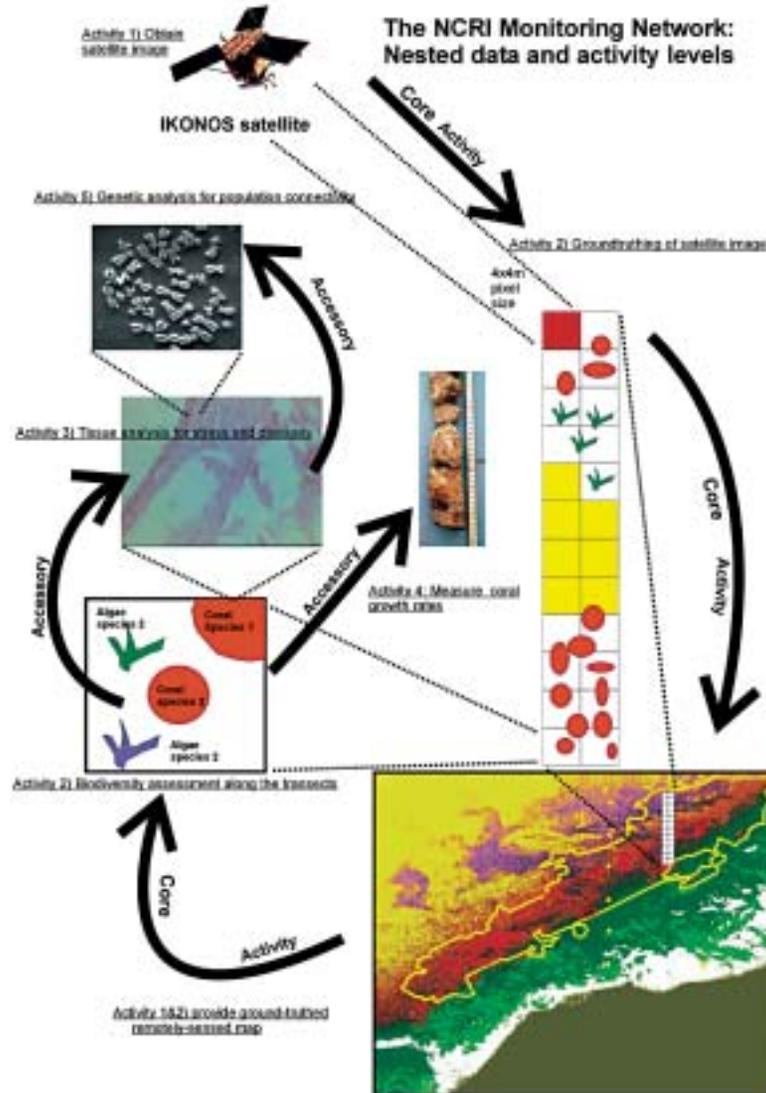
# MONITORING

## Global Monitoring

### NCRI monitoring network

Wide areas of coral reefs have witnessed serious degradation and repeated large-scale bleaching and coral mortality over the last decade. This has been linked to the effects of global climate change, and it is widely believed that similar strong perturbances may repeatedly affect coral reefs in the near future, possibly leading to severe losses of these vital ecosystems. By investigating coral reefs around the globe, the NCRI Monitoring Network hopes to discover whether reefs in different regions are following the same trajectory or whether each reef reacts uniquely. For this, a combination of remote-sensing and traditional monitoring methods is used. Components of the Monitoring Network assess landscape patterns as proxies for medium-scale ecological processes, biodiversity within landscape patches, and clonal patterns of key organisms within patches. Tissue indices or biomarkers are used to assess the stress levels of organisms at the time of sampling. The Monitoring Network is an interdisciplinary initiative aimed at gaining maximum insight into the ecological and health dynamics of monitoring sites.

A better understanding of these large-scale patterns will facilitate the selection of priorities that could lead to the development of evasive actions or countermeasures to avoid potentially catastrophic degradations.



## Regional Monitoring

### Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP)



This partnership between NCRI and FWRI expands local capacity for maintaining long-term monitoring sites which will assist in filling gaps of knowledge about coral reef ecosystems nationwide.

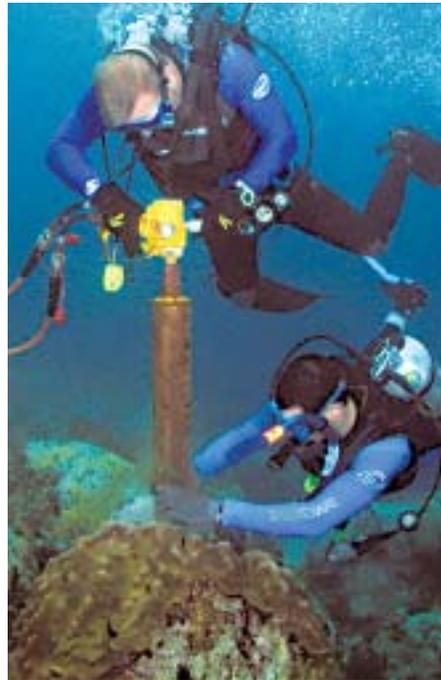
Southeast Florida's reef system is located just offshore of a highly urbanized region. SECREMP is a long-term monitoring program along the coasts of Miami-Dade, Broward, Palm Beach, and Martin Counties that serves as an extension of the Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP). Utilizing the same sampling protocols, SECREMP ensures important parameters are being monitored for the full extent of the Florida coral reef ecosystem.

Established in partnership with the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) and the Florida Department of Environmental Protection, the goal is to detect changes in coral cover, species richness, and diseases of coral over time. CREMP and SECREMP will continue to provide valuable information on status and trends in the Florida reef system from the Dry Tortugas through the Keys into southeast Florida.

# Monitoring Over Time

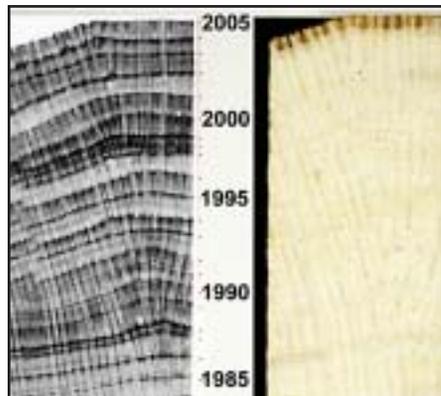
## Coral skeletal density

Skeletal density and calcification of corals has gained attention because of the impact from global climate change and the corals' unique ability to record this change over their long lifespans. Historical skeletal growth rates, including extension, density, and calcification, have become useful for testing hypotheses regarding variations in growth attributable to climatic changes, such as rising carbon-dioxide levels and sea-surface temperature. Coupled with skeletal geochemistry (in partnership with University of Miami Rosenstiel School of Marine and Atmospheric Science [UM RSMAS]), annual coral density banding provides a history of what climatic conditions coral has encountered and how it has responded to those conditions.



## CoralXDS+

NCRI researchers have developed methods for accurately measuring bulk-density from x-radiographed coral skeletal slabs in order to obtain annual and subannual data of extension, density, and calcification. To more efficiently obtain these data, NCRI researchers designed the Coral X-radiograph Densitometry System (CoralXDS+), a Windows-based program which provides measurements rapidly, objectively, and with a high degree of accuracy.

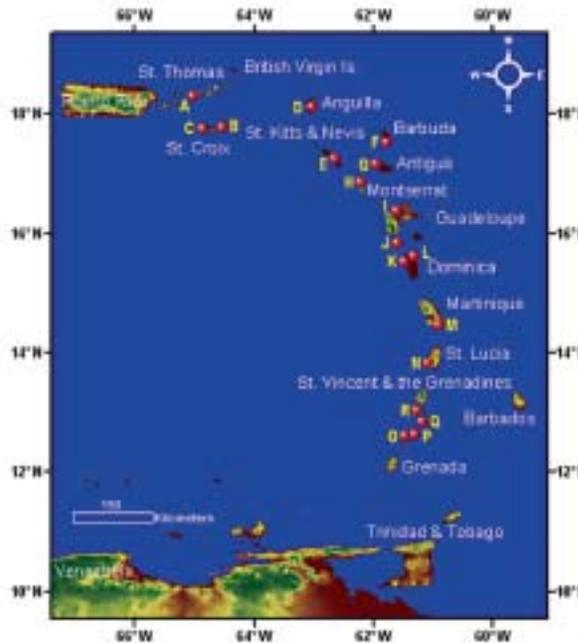


## Caribbean Salinity Experiment (CASE)

The Caribbean Salinity Experiment (CASE) is aimed at reconstructing long-term historical salinity and temperature profiles from coral skeletons along with records of coral extension, density, and calcification. NCRI researchers section and x-radiograph coral cores to reveal the quality and length of the annual density-band record from which appropriate cores can be chosen for isotopic and elemental analysis.

NCRI collaborated with UM RSMAS and the University of South Florida in a 52-day cruise to collect coral cores

from a dozen of the Windward and Leeward Islands in the Caribbean. The CASE collection, along with current holdings, spans a 15-degree latitudinal range of the Caribbean. This range is equivalent to the length of Australia's Great Barrier Reef—an unprecedented survey of the Caribbean. By increasing the sample size and expanding the sampling range, the effects of recent climatic change can be better distinguished from the background of natural variability.



Historical coral growth and proxy records provide one means of identifying the in situ response of corals to past environmental change. By expanding the range of coral collections throughout the Caribbean, coral growth will be assessed across a broader environmental gradient while providing proxy data to better understand the historical conditions to which coral have been exposed.

# RESTORATION

## Hypothesis-Based Design



Species-specific differences in transplant growth and mortality indicate the need for an adaptive-management approach to restoration, and that species selection must be an important consideration in future coral reef restoration efforts.

### Restoration design and post-restoration monitoring

NCRI works on developing a sound, multivariate hypothesis base to provide local reef resource managers with information helpful to understanding how to undertake reef restoration. Managers faced with results of natural or anthropogenic destruction of reef resources need the ability to evaluate the effectiveness of different forms of restoration and remediation.

In one such case, the U.S. nuclear submarine *Memphis* grounded in 30 feet of water on a coral reef off southeast Florida causing extensive physical and biological damage to the reef substrate and to the coral community. NCRI has undertaken a hypothesis-based experiment providing the design and placement of

concrete structures with associated monitoring. Over 160 standardized modules (Reef Balls®) were organized into 40 four-unit arrays. This allowed comparison of coral settlement on four different substrate treatments and examination of effects of fish communities on modules containing different levels of internal complexity. Results from this continuing study indicate the need to utilize an ecosystem approach to restoration that involves corals, fish, and other organisms. Consideration needs to be given to species, their placement, and habitat complexity, all important management decisions when considering the restoration of an injured reef.

## Habitat Restoration Tools



An alternative source of donor colonies for transplantation into injury areas are “corals of opportunity,” stony corals that have been detached from the reef through natural processes or unknown injury events.

### Establishment and maintenance of a coral nursery

The Coral Nursery Project (CNP) is a collaboration among NCRI, Broward County Environmental Protection Department, and the Ocean Watch Foundation, a volunteer NGO dive group. Objectives of the CNP are to: (1) create a “corals of opportunity” nursery to be used to help restore injured reefs; (2) provide reef managers with coral transplantation success information; and (3) recruit diving volunteers from the community with interests in the marine environment to assist with and learn about coral identification, data collection, and transplantation procedures, while also increasing public awareness and education.

Initiated in 2001, this highly successful project has helped to collect dislodged coral colonies and transplant more than 300 corals of opportunity (corals found loose and broken on the seafloor), representing 17 species, to the nursery. These colonies have a survival rate of 96 percent and are available for use as donor colonies for restoration activities.

# Restoration Software

## Visual\_HEA software to calculate compensatory restoration

When there is a loss of natural resource services from injury, management agencies are faced with the task of determining, in a quantitative sense, the extent of the damage and the compensatory actions required. This requires a knowledge of the ability of the injury and mitigation areas to provide services throughout the recovery period. Visual\_HEA, developed at NCRI, is a computer program that facilitates input of Habitat

Equivalency Analysis (HEA) assumptions and parameters and calculates the compensatory action required for a given set of assumptions. The ability to formulate many scenarios using the graphical interface is useful to evaluate alternative compensation strategies.

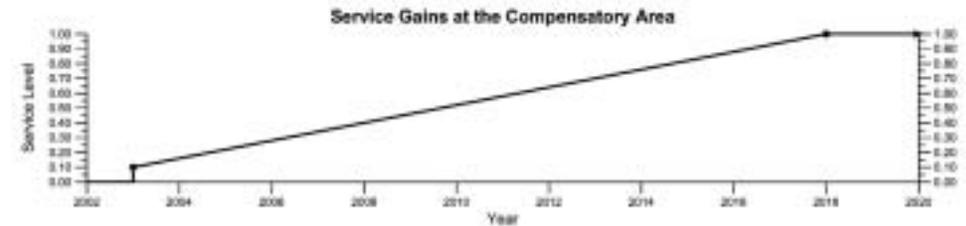
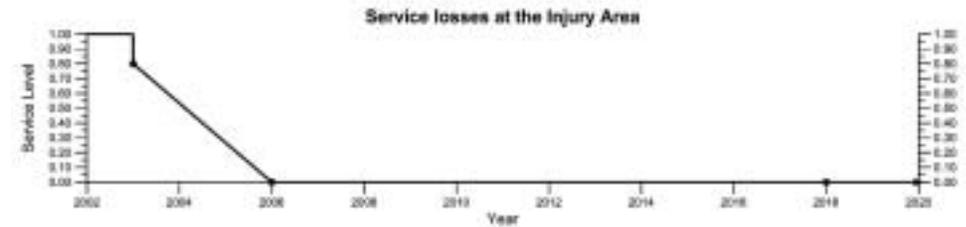
Visual\_HEA is available free of charge to researchers affiliated with scientific institutions for noncommercial use only.



NCRI conducts a variety of restoration field activities.

### HABITAT EQUIVALENCY ANALYSIS

Scenario: <b>Waynes County Beach Renourishment</b>	Current year: 2003	Discount rate(%): 3.00
Run date: 9/26/2005 10:18:26	Number of area units injured: 13,130	Pre-injury service level: 1.00
Proj file: C:\HEA\Visual_HEA\restorby as	Area units: acres	Pre-restoration service level: 1.00
HEA Assails: C:\HEA\Visual_HEA\restorby.as	Time units: year	Value rate (mgd/acre/year): 1.00



#### Service losses at the Injury Area

Year	% Service Level (End of year)	% Service Loss (End of year)	Effective area lost (acres)	Discount factor	Discounted effective area lost (acres)
2002.00	100.00%	0.00%	0.000	1.000	0.000
2003.00	52.59%	47.41%	4.713	1.000	4.713
2004.00	28.60%	71.40%	7.427	0.971	7.191
2005.00	0.00%	100.00%	13.130	0.945	8.520
2006.00	0.00%	100.00%	13.130	0.915	8.243
2007.00	0.00%	100.00%	13.130	0.886	8.834
2008.00	0.00%	100.00%	13.130	0.865	8.712
2009.00	0.00%	100.00%	13.130	0.837	8.459
2010.00	0.00%	100.00%	13.130	0.813	8.212
2011.00	0.00%	100.00%	13.130	0.789	7.873
2012.00	0.00%	100.00%	13.130	0.766	7.741
2013.00	0.00%	100.00%	13.130	0.754	7.918
2014.00	0.00%	100.00%	13.130	0.722	7.290
2015.00	0.00%	100.00%	13.130	0.701	7.084
2016.00	0.00%	100.00%	13.130	0.681	8.870
2017.00	0.00%	100.00%	13.130	0.661	8.577
Beyond					222.576
<b>Total discounted effective acres-years lost:</b>					<b>338.790</b>

#### Service Gains at the Compensatory Area

Year	% Service Level (End of year)	% Service Gain (End of year)	Discount factor	Discounted effective acres gained per acre
2002.00	0.00%	0.00%	1.000	0.000
2003.00	16.96%	83.04%	1.000	0.900
2004.00	22.06%	77.94%	0.971	0.214
2005.00	28.00%	72.00%	0.943	0.266
2006.00	34.90%	65.10%	0.915	0.311
2007.00	40.00%	60.00%	0.886	0.355
2008.00	46.00%	54.00%	0.865	0.397
2009.00	52.00%	48.00%	0.837	0.438
2010.00	58.00%	42.00%	0.813	0.472
2011.00	64.00%	36.00%	0.789	0.508
2012.00	70.00%	30.00%	0.766	0.536
2013.00	76.00%	24.00%	0.744	0.560
2014.00	82.00%	18.00%	0.722	0.602
2015.00	88.00%	12.00%	0.701	0.617
2016.00	94.00%	6.00%	0.681	0.643
2017.00	100.00%	0.00%	0.661	0.667
Beyond				22.017
<b>Total gain in discounted effective acre-years (acre):</b>				<b>24.763</b>

<b>Replacement habitat size (acres):</b>	<b>11,770</b>
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# DISSEMINATION OF INFORMATION

## Conferences and Meetings

NCRI facilitates conferences and meetings to evaluate and synthesize scientific information relevant to scientists and marine resource managers, on both regional and global levels. Only by sharing the latest and best scientific information can resource managers protect and conserve coral reefs and their associated habitats. These ecosystems are connected regionally and globally, so information must be shared thusly.

### International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring and Restoration (1999)

One of NCRI's first projects was the International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring and Restoration, held in April 1999 in Fort Lauderdale, Florida. The event drew nearly 500 coral reef scientists, resource managers, technicians, and conservationists from 34 countries, Guam, Puerto Rico, Commonwealth of the Northern Mariana Islands, and the U.S. Virgin Islands. In 2001, peer-reviewed proceedings were published in a dedicated issue of the *Bulletin of Marine Science*.

In addition to 140 papers accepted for oral presentation, 130 scientific posters were presented in 18 sessions. Outcomes of the conference were reported in the summary article "Experts List Quick Action Among Needs of World's Declining Coral Reefs," subsequently published in *Earth System Monitor*.



ReefBase and the International Society for Reef Studies endorsed the scientific program of the meeting.

### Ninth International Coral Reef Symposium (2000)

NCRI staff created and maintained the meeting's interactive Web site for more than a year. The Web site provided all conference information and allowed interactive registration and abstract submittal.

In addition, NCRI scientists gave nine oral and nine scientific poster presentations at the International Coral Reef Symposium (ICRS) in October 2000 in Bali. Attended by 1,300 people, the ICRS is a prestigious international scientific meeting conducted under the auspices of the International Society for Reef Studies (ISRS). NCRI's executive director served as co-convenor of two mini-symposia, each of which was composed of more than 24 oral presentations by scientists from 15 countries.

### Southeast Florida Coral Reef Initiative (2003)

NCRI was invited to host the organizational meetings for the formation of the Southeast Florida Action Strategy Team (SEFAST) to create the local action strategy for coral reefs north of the Florida Keys National Marine Sanctuary. This action came about as a direct result of Resolution One, adopted at the Eighth Meeting of the U.S. Coral Reef Task Force, October 2–3, 2002, in San Juan, Puerto Rico. As mandated by the resolution, representatives of federal, state, and county agencies met to create the structure leading to the formation of four focus groups that would eventually develop the Southeast Florida Coral Reef Initiative (SEFCRI). In addition to the initial two-day organizational meeting, NCRI also hosted the inaugural stakeholder workshop and several other workshops and meetings.

### Tenth International Coral Reef Symposium (2004)

In 2004, NCRI participated in the 10th ICRS in Okinawa, Japan, in several ways. NCRI scientists co-chaired a mini-symposium, made 14 oral and 8 poster presentations, and was one of only 20 exhibitors. During the conference, it was announced that the United States was successful in its bid to host the 11th ICRS in Fort Lauderdale in 2008. The latter was accomplished with the leadership of the NCRI executive director and the endorsement and support of the U.S. Coral Reef Task Force (USCRTF) and Governor Jeb Bush of Florida.



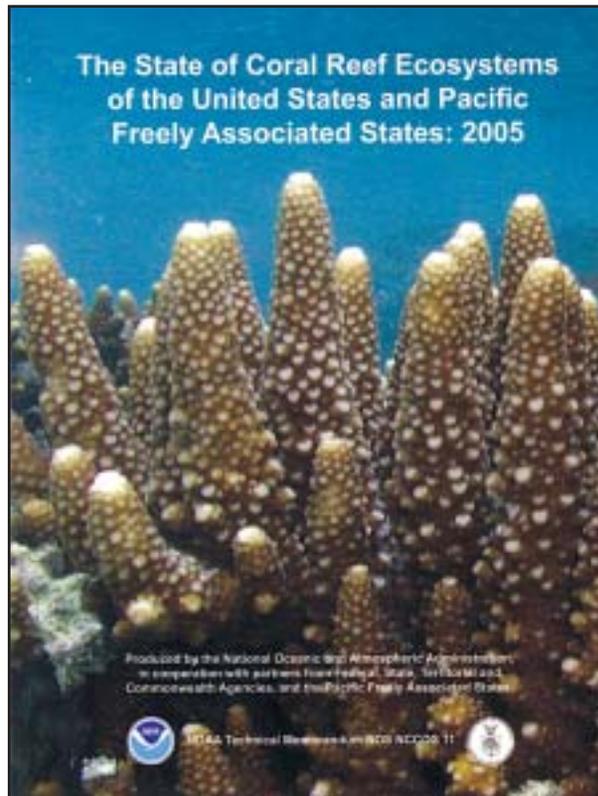
## Conferences and Meetings (cont.)

### U.S. Coral Reef Task Force

Through its attendance and active participation at each of the 14 meetings of the USCRTF and its working partnership with the Florida Fish and Wildlife Conservation Commission on several reef-related projects in Florida, NCRI scientists have been invited to help author reports made to Congress on the status of U.S. coral reefs—*The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002 and 2005*, published by the National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science.

### NOAA-sponsored coastal ocean research meetings

NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) administers five coral reef programs—three Congressionally directed programs and two long-term coral reef ecosystem study (CRES) programs. They are the Hawaiian Coral Reef Initiative (HCRI), the Caribbean Coral Reef Institute (CCRI), the National Coral Reef Institute, and the CRES programs in Micronesia and the Caribbean. In March 2005, NCRI hosted the third annual summit, which was convened by NOAA/CSCOR program officials to review the activities of each program.



### NCRI takes lead in U.S. hosting of 11th International Coral Reef Symposium (2008)

Led by the executive director of NCRI, the United States won the bid to host the 11th ICRS in Fort Lauderdale, Florida, in July 2008. It will have been more than 30 years since the ICERS was held on the U.S. mainland. Every four years, the ICERS convenes to provide the latest scientific knowledge about coral reefs worldwide. Natural scientists, resource managers and users, conservationists, economists, and educators meet to advance coral reef science, management, and conservation. The ICERS, the largest society focused on coral reefs worldwide, officially sanctions ICERS meetings.

The Local Organizing Committee (LOC) for this conference is composed of a core group of coral reef scientists and managers who serve as committee chairs. The executive and associate directors of NCRI are both members of the LOC. Other committee and subcommittee members include broad national and international representation from the marine management, coral reef science, and education communities. The LOC has the full endorsement of the U.S. government and the state of Florida to host the 11th ICERS. The USCRTF, composed of representatives of 12 federal agencies and 7 governors' offices with jurisdiction over U.S. coral reefs, endorsed a proposal for the United States to host the 11th ICERS in 2008 at its February 25, 2004, meeting in Washington, D.C.

## Capacity-Building

### Capacity-building for sustainable coral reef management

While coral reef conservation and management has found its way into the laws of most countries, many places lack the trained personnel to effectively enforce sustainable management of coral reef resources, particularly in countries with significant economic pressure on reef resources and a relatively small population. The Arabian Gulf harbors extensive coral areas that are among the most heavily impacted in the world. In order to avoid significant losses of coral reefs in this high-latitude environment, improved management of the resource is required.

Together with the World Wildlife Fund (WWF), NCRI is engaged in capacity-building and training of officials and staff for the environment-management agencies of Abu Dhabi and Qatar. The goal is to transfer the latest scientific information and technology applicable to the region's reefs to local managers to ensure they have the most efficient tools available to safeguard the future of their respective country's coral reefs and fulfill their legal mission of sustainable marine resources management.

## Filling Gaps in Knowledge

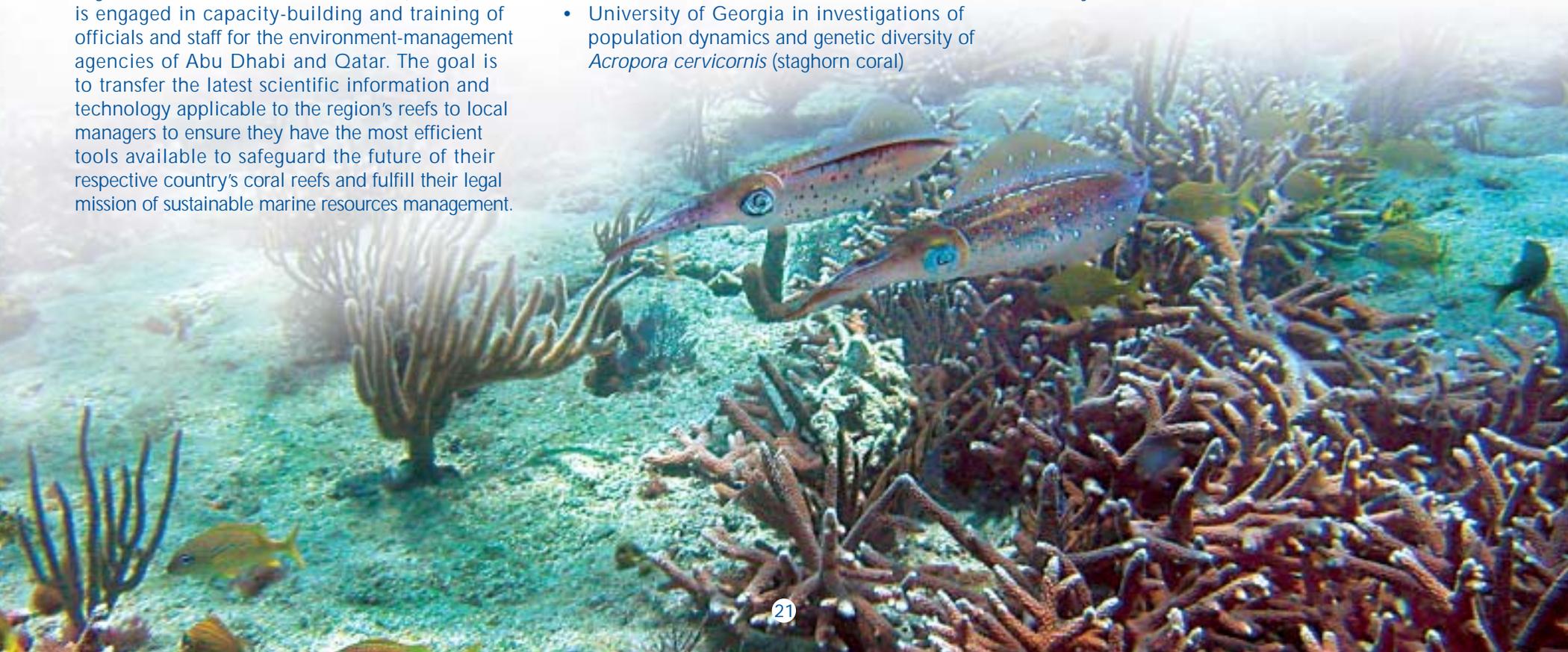
### Filling gaps in specific knowledge areas

NCRI funds external projects identified as filling gaps in specific knowledge areas by its Technical Advisory Committee (TAC). Each year, the TAC recommends an area of study to focus upon, and a request for proposals is issued. Proposals are accepted from a variety of U.S. institutions for short-term (one-year) support.

Previously funded projects include the following:

- University of Kansas in a global analysis of coral reef vulnerability and the development of an electronic environmental database
- University of Georgia in investigations of population dynamics and genetic diversity of *Acropora cervicornis* (staghorn coral)

- Boston University investigated connectivity among Caribbean stomatopod populations
- Florida International University in evaluating the role of a coral pathogen in the ongoing coral mortality in coral reefs of Florida
- The University of Florida in research assessing the biodiversity and endemism of reef cryptofauna
- Bermuda Biological Research Station in the evaluation of molecular biodiversity in semi-isolated octocoral-zooxanthellae symbiosis of Bermuda



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# ABOUT THE NATIONAL CORAL REEF INSTITUTE

## History

The United States Congress mandated the creation of the National Coral Reef Institute (NCRI) in 1998. It has entrusted the responsibility to the Oceanographic Center at Nova Southeastern University (NSU), one of the nation's largest independent, nonprofit research and doctoral universities.

## Mission

NCRI's mission is to identify gaps and constraints in scientific knowledge of reef structure and function as they relate to issues of assessment, monitoring, and restoration. Through active research and collaborative funding, NCRI undertakes and facilitates hypothesis-based scientific research in emerging reef issues and technologies. NCRI provides scientific synthesis and evaluation criteria of existing programs for use by the research and management community. These include the study of minimally impacted, stressed, and imminently threatened and endangered reefs. Assessing and monitoring biodiversity is a priority, especially as it affects and interacts with ecological processes, overall reef function, reef recovery, and restoration. NCRI's primary capability is that of offering a strong scientific focus as well as innovative approaches to relevant scientific issues in all aspects of coral reef biology.

## Objectives

Assessment • Monitoring • Restoration

## Funding

Pass-through operating funds are received through the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) National Centers for Coastal Ocean Science (NCCOS) Center for Sponsored Coastal Ocean Research (CSCOR) Coastal Ocean Program (COP) from Congress. NCRI scientists leverage additional funding from national, state, local, and corporate sources.

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## Directions to the National Coral Reef Institute and the Oceanographic Center at NSU



(Map is not to scale.)



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# NOTES







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