

Coral Reef Assessment, Monitoring, and Restoration: NCRI Report to the 12th Meeting of the U.S. Coral Reef Task Force

Fall 2004

NCRI Scientists Make 21 Presentations at 10th International Coral Reef Symposium in Okinawa



Executive Director Richard Dodge flanked by Terry Done, former president of the International Society for Reef Studies (ISRS) from Australia, and Kiyoshi Yamazato, President of the 10th International Coral Reef Symposium (ICRS) from Japan, together perform the ceremonial opening the lids of the saké barrels at the welcome reception.

Scientists and staff members from NCRI traveled 25 hours and 8,500 miles to make 21 oral and poster presentations at the 10th International Coral Reef Symposium (ICRS) in Okinawa during summer 2004. Attending were approximately 1,500 coral reef biologists, ecologists, economists, environmentalists, geologists, biochemists, resource managers, and others working in coral reefs worldwide. The ICRS occurs only once every four years, under the auspices of the International Society for Reef Studies (ISRS). Each meeting rotates to a different country to provide for sharing the latest knowledge and to advance coral reef science on a global scale.

“Coral reefs provide sustenance, recreation, and the economic framework for many tropical regions around the world. They also supply important refuge and food sources for various life stages of many ecologically and economically important marine species, *(continued on page 8)*

Fort Lauderdale, Florida, USA Chosen as Site for the 11th International Coral Reef Symposium in 2008 NCRI Executive Director Chairs Organizing Committee

Dr. Nicholas Polunin, President of the International Society for Reef Studies (ISRS), announced in Okinawa that the next International Coral Reef Symposium (ICRS) will be held in Fort Lauderdale, Florida, from July 7 through 11, 2008. Every four years, coral reef biologists, ecologists, economists, environmentalists, geologists, resource managers, and others working in coral reefs worldwide, meet together at an ICRS to share the latest knowledge and to advance the science on a global scale. The society’s decision of host country for this conference was announced during closing ceremonies of the 10th ICRS. Each meeting rotates to a different country to provide for sharing the latest knowledge *(continued on page 7)*

NCRI Science Addresses Challenges of Reef Resource Management

NCRI provides a center of coral reef research excellence that is geared toward the development of innovative hypotheses and tools thus providing service to the management and academic communities alike. This lead article is an overview of NCRI’s science/management relations. Other articles within amplify and expand.

The National Coral Reef Institute is housed at Nova Southeastern University’s Oceanographic Center, on a 10-acre campus adjacent to the southeast Florida reef tract in Dania Beach, Florida. It was formed by 104th Congressional mandate to provide hypothesis-driven and innovative research in coral reef science that aids in the management of the nation’s coral reef resources. It also provides international partners with assistance in the management of their coral reefs. NCRI’s main research directions are:

- Assessment
- Monitoring
- Restoration

ASSESSMENT

Reef Habitats

Three basic necessities of resource management are to know the “what?”, “where?”, and “how much?” of habitats in an area.

NCRI Mapping and Remote Sensing provide reef resource maps in various forms and formats that meet these needs.

Reef Resource Functions

For appropriate management reaction, resource managers need to be able to recognize if (and which) stress is causing observed change in the resource and to assess (and understand) the effects of various natural and man-induced environmental processes and disturbances.

NCRI’s Reef Stress Research Program is developing tools to discern pinpoint signa-

(continued on page 2)

tures of specific stresses and to detect vulnerability of certain potentially endangered species. Some of these tools include use of stress indices, population ecology studies of *A. cervicornis*, enzymatic biomarkers, and histology studies.

Molecular Genetic Assessment of Reef Populations

Unique spatial challenges of dispersal and population connectivity in oceanic resources confound what might otherwise be similar demands to those faced by terrestrial resource managers when establishing conservation areas such as marine protected areas (MPAs).

NCRI's Molecular Genetics Program is helping to assess patterns of biodiversity and population connectivity that may help in more effectively locating and designing MPAs.

Coral Reef Fishes

Fishes are one of the most highly prized resources of any coral reef area. However, like other resources, the management of fish communities requires baseline data for comparison to determine change in response to any impact. To determine if a management strategy is effective or if a ship grounding impacted fish populations, requires pre/post comparisons.

NCRI's Marine Fishes Surveys provide extensive baseline data critical for resource managers in Southeast Florida.

Software for Image Analysis

Rapid methods of analysis are always in high demand.

NCRI's CPCe software provides rapid and efficient benthic image analysis.

NCRI Objectives

- Assessment
- Monitoring
- Restoration

of coral reefs through basic and applied research

MONITORING

Global

The world's reef resources are perceived to be in a state of serious decline. Repeatable, quantitative scientific data are needed to document the true state of the global reef resources on a broad spatial scale in a cost-effective way.

The NCRI Monitoring Network provides, through its integrated, global coral reef system monitoring, a better understanding of the complex issues of global climate change and local perturbations affecting reef resources. Through this program, NCRI is active in the Mariana Islands, Micronesia, Puerto Rico, and the Arabian Gulf.

NCRI, WWF, and ERWDA (Environmental Research and Wildlife Development Agency) partner in the United Arab Emirates to build a countrywide monitoring system permitting the tracking of changes in reef health.

Regional

NCRI provides managers with information needed to evaluate not only catastrophic but even subtle changes to regional reef resources on a regular basis.

NCRI's SECREMP (Southeast Florida Coral Reef Evaluation and Monitoring Program) provides information to state resource managers on an annual basis from Southeast Florida for the Florida CREMP initiative.

Local

On a local scale, NCRI provides reef managers with specific information about the condition and health of local reefs and reef systems in response to natural and man-induced impacts.

NCRI's annual Broward County monitoring at 25 reef sites on local reefs provide county resource managers with information on diversity, coverage, and change of the reef habitat.

Over Time: Decades to Centuries

Managers need a historical perspective of environmental effects and change in order to better evaluate the long-term impacts of management decisions.

NCRI conducts long-term research on annually banded coral skeletons utilizing a variety of tools to garner information on historical relationships between coral growth, climate change, atmospheric carbon dioxide rise, eutrophication, and other environmental events of interest. A new computer program, NCRI's CoralXDS+, facilitates data acquisi-

tion of coral growth (extension, density, and calcification) and comparison of isotope, trace element, and other information.

RESTORATION

Hypothesis-Based Design

NCRI provides managers faced with natural or anthropogenic degradation of reef resources the information needed to evaluate the effectiveness of different forms of restoration and remediation.

NCRI advocates a hypothesis-based approach towards reef restoration. Projects currently underway include examination of effectiveness of coral transplantation and substrate conditioning on coral larval recruitment as well as the role of substrate complexity on reef-associated fish assemblages.

Habitat

Managers need to know options for restoration or mitigation of damaged fishery or other habitat, as well as information on relative success that can be expected from different coral species in order to make appropriate choices.

NCRI's Coral Reef Nursery is a nursery for corals of opportunity (corals salvaged from sites that have or are going to experience habitat degradation) that may be used to help restore damaged reefs in the future, and it provides reef managers with coral species-specific and colony-size specific transplantation success information.

Compensatory Restoration

Anchor draggings and groundings of ships and recreational boats are some of the management challenges requiring systematic determination of adequate compensation for damages incurred by the reef system.

NCRI's Visual_HEA software program provides managers with a graphical-interface tool for determination of the amount of reef (or other) habitat that must be compensated for by those that injure reef resources.

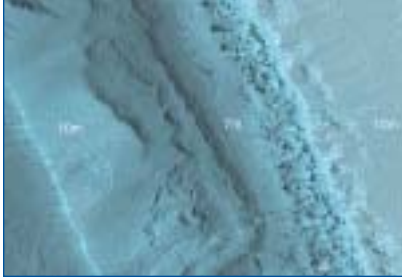


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ASSESSMENT

Assessment of Reef Structure

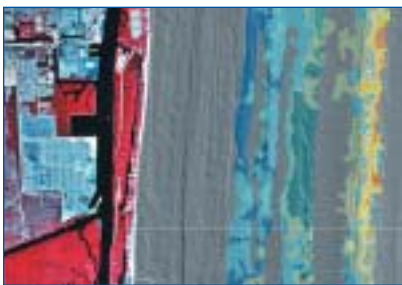
Innovative Large-Scale Coral Reef Mapping Incorporates the Latest Computer and Mapping Technologies



Sunshaded bathymetric image of a portion of the Inner reef, Southeast Florida (Broward County). Reef axis is north-south. Spur and groove morphology is present seaward of the crest. Overwash backreef rubble accretion is seen landward of the crest.

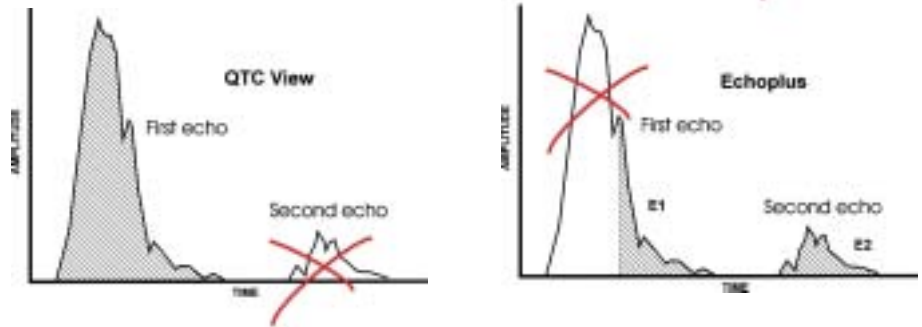
Detailed bathymetric data for Southeast Florida reefs, from 0—100' depth, serve as the basemap for overlaying the results of biological and geological inventories, assessments, and monitoring. The maps integrate several datasets including detailed multi-beam acoustic (U.S. Navy) and laser-based (Broward County Department of Planning and Environmental Protection) depth soundings. NCRI is helping to provide base mapping products useful for a variety of management functions of the reefs.

Classification of Reef Habitats and Environments Using Remote-Sensing Technologies



NCRI is developing, planning, and initiating a shallow-water biodiversity inventory, associated biogeological assessments, and a monitoring program of southeast Florida shelf reefs. An integral outcome is an accurate and detailed map of biological and geological resources, useful for management and for ecological understanding. Further work regarding the groundtruthing as well as an expansion of the available datasets is currently in progress.

Mapping Southeast Florida Reefs Using Acoustic Technology



Different ways of processing acoustic returns for seafloor mapping. NCRI uses several systems, among them QTCView and Echoplus.

Mapping of southeast Florida (Broward and Palm Beach counties) reefs are being conducted in partnership with the State of Florida Department of Environmental Protection (FDEP) and the Florida Fish and

Wildlife Conservation Commission (FWCC) Fish and Wildlife Research Institute (FWRI). Mapping will utilize acoustic technology to identify key reef habitats.

Assessment of Reef Function

Ecology, Genetics, Propagation, and Population Dynamics of *Acropora cervicornis* off Fort Lauderdale, FL



Key management concerns include the vulnerability of this species, being considered as a candidate under the Endangered Species Act. NCRI studies on its reproduction and diseases may help to shed light on the recent and catastrophic Caribbean-wide population decline. In contrast, thriving thickets of this species occur off Fort Lauderdale, despite significant natural and anthropogenic impacts, including thermal stress, pollution, increased freshwater discharge, periodic ship groundings, and extensive coastal urbanization. Ongoing larval ecology work may help contribute to the repopulation of this species.

Coral Sedimentation Stress Index

An experimental sedimentation stress index is being developed for scleractinian corals. This index is a tool to help assess the effects of sedimentation in the field. It is specifically designed to be used as part of the biological monitoring for the Broward County (Florida) beach renourishment project scheduled for late 2004 and 2005. Results will likely also be applicable to other sediment-stress situations derived from dredging.

Additionally, further investigations on the effects of sediments and nutrients are also underway, while further collaborative studies are anticipated to assess pollution in coral reefs.

STRESS

To a reef resource, stress could lead to loss of:

- ecosystem integrity
- diversity
- function
- resource services (and money)

(Assessment of Reef Function continued)

Enzymatic Biomarker

In a partnership with NOAA, Florida DEP, the SEFCRI (Southeast Florida Coral Reef Initiative), the University of Central Florida, the College of Charleston, and Broward County, Florida, a pilot study has been initiated to test the feasibility of using enzymatic biomarkers to link land-based sources of pollution with the degradation of coral reef health. In this case, the biomarker would be used to investigate potential stress to the Broward County reef systems from freshwater discharge (FWD) from local waterway inlets as well as sewage from sewage outfalls.

NCRI scientists and Envirtue Technology will conduct another study to look at the

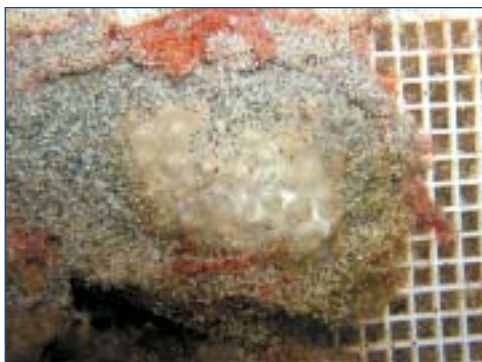


Image of *Montastraea cavernosa* specimen severely sediment-stressed in experimental trials.

connection between stress and health that is reflected in the organism response to a specific stress.

Indices and Biomarkers

Dipsticks to determine specific stress signatures?

Indices and biomarkers can assist resource managers to pinpoint signatures of specific stresses to better react and more effectively manage reef resources.

Assessment of Molecular Genetics of Reef Populations

Molecular Genetic Assessment of Dispersal Potential, Population Connectivity, and Biodiversity in Coral Reef Organisms: Applications to Marine Protected Area (MPA) Design

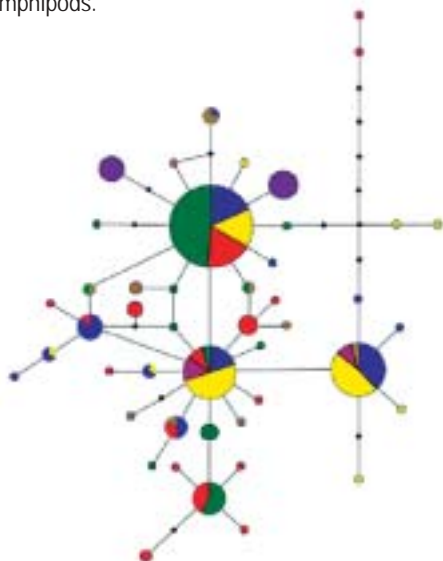


Leucothoe spinicarpa (morphotype 4)

Establishment of marine protected areas (MPAs) is widely advocated for conservation, recovery, and management of coral reef ecosystems. Selection of biologically optimal MPA sites and delineation of their spatial boundaries by the management community require a robust understanding of the dynamics of population connectivity among reef tracts and identification of biodiversity hotspots.

This information is largely lacking for most U.S. reefs. To provide this information for the management community, NCRI is

Below: 95% probability 8-step parsimony network depicting the relationship among individual amphipods.



developing and using new molecular genetic approaches to assess dispersal potential, population connectivity, and biodiversity in a variety of reef organisms.

This research will also help identify reef regions that are the sources of population recruitment, providing managers with critical biological data on which to base decisions about establishment of MPAs.

Assessment of Coral Reef Fishes

Fish Censuses of Southeast Florida

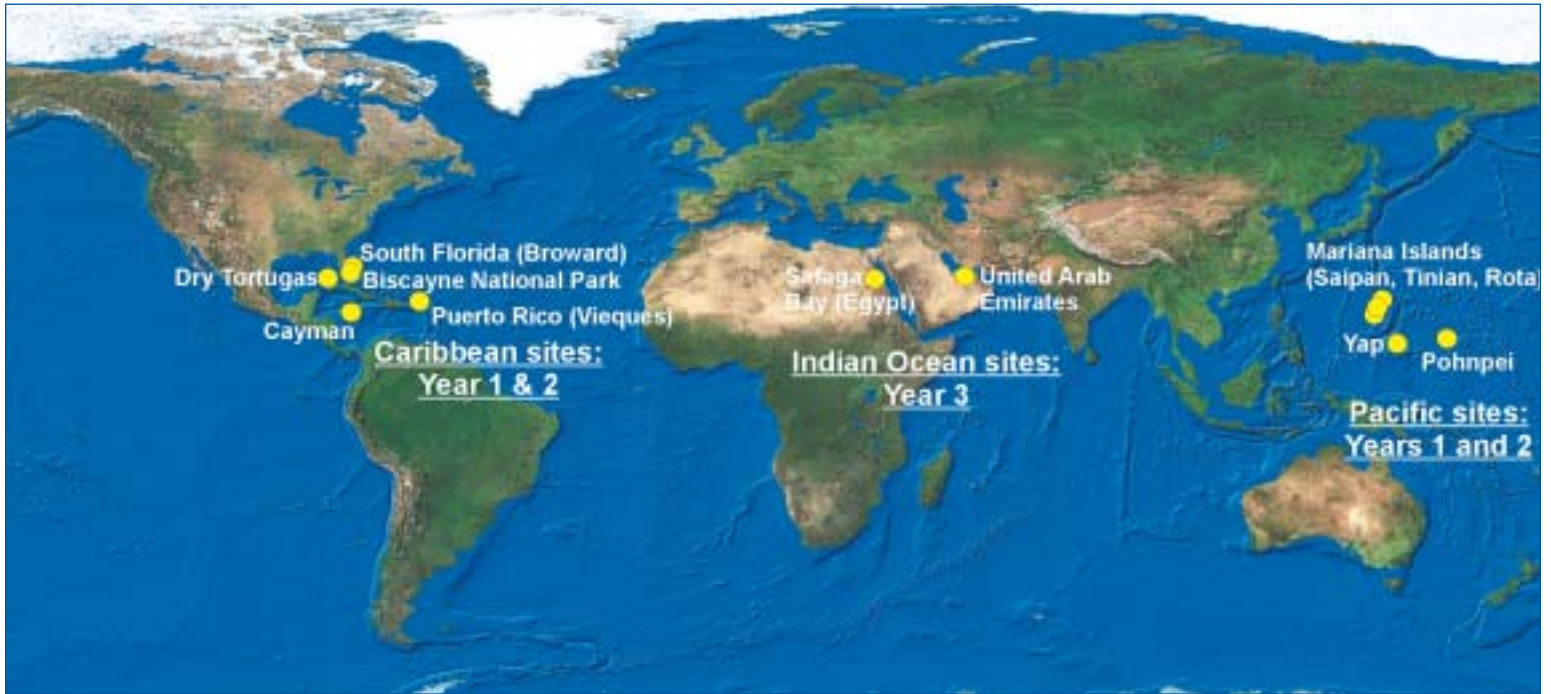
Building upon more than 1,200 natural reef surveys to date, local resource managers now have an extensive database on the current shallow coral reef fish assemblages. This database already suggests that local snapper and grouper populations are extremely low and in need of immediate attention. Additional fish surveys are ongoing to determine natural seasonal and annual changes in fish assemblages as are fish surveys of the deep reef seaward of the third reef (90–150 m) using an ROV. These databases are critical for comparisons to assess the effects of coral reef damage on fish assemblages as well as to provide a list of target species for coral reef restoration.



MONITORING

Monitoring on a Global Scale

The NCRI Monitoring Network: Monitoring and Assessment of Coral Reefs to Assess Impacts of Global Climate Change



Amidst reports of doom and gloom, reef resource managers are also hearing about remarkable differences in the degradation of individual coral reefs and their apparent recovery, which is in step with observations in the terrestrial realm. Managers are therefore faced with the question of whether there is a uniform global coral reef response to global climate change or whether each reef “is on

its own” and where its impacts may vary. NCRI has just inaugurated the Monitoring Network, which uses a large-scale, integrative approach in a global monitoring and assessment scheme to assess, monitor, and better understand the complex issues of global climate change and local perturbations affecting coral reefs. The ultimate goal of the NCRI Monitoring Network is readily available information

obtained from each NCRI monitoring network site, offered in a multi-disciplinary and multi-layered form that is available both spatially and temporally. The data thus collected will be contributed to NOAA’s CoRIS database, thus being universally available to resource managers and others as needed.

Monitoring on a Regional Scale

Southeast Florida Coral Reef Evaluation and Monitoring Program

NCRI is partnering with the state of Florida Department of Environmental Protection (FDEP) and Florida Fish and Wildlife Conservation Commission (FFWCC) Fish and Wildlife Research Institute (FWRI) to conduct yearly monitoring at 10 permanent sites in Miami-Dade, Broward, and Palm Beach Counties. Broward County DPEP, Miami-Dade County DERM, and Palm Beach County ERM are local management collaborators.

The monitoring follows the formal protocols developed by FWRI for the CREMP (Coral Reef Evaluation and Monitoring Program) used in the Florida Keys. The Southeast Florida effort is termed SECREMP.



Locations of 43 Coral Reef Evaluation and Monitoring Program (CREMP) sites within the Florida Keys, and the 10 additional new sites located among the reefs in Southeast Florida. Insert shows sunshaded bathymetric map of detail for three SECREMP sites.

Monitoring on a Local Scale

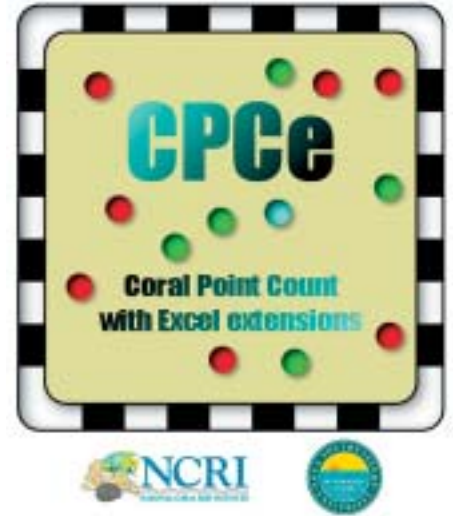
Broward County Monitoring

NCRI's annual Broward County monitoring at 25 reef sites on local reefs provide County resource managers with information on diversity, coverage, and change of reef habitat.

Data are taken *in situ* along a 20 m² belt transect at each site, which includes assessment of coral diversity and coverage of stony corals, sponges, and soft corals. The transect is photographed for later detailed laboratory study. *In situ* fish transects are also accomplished.

NCRI's Coral Point Count Software (CPCe)

NCRI has developed CPCe (Coral Point Count with Excel extensions) software that allows for rapid and efficient benthic image analysis. The software generates random points on images of the reef. The user then identifies what lies beneath each point. Information can be quickly assembled into a database and statistically analyzed for coverage of benthic category of interest. This program aids long-term monitoring efforts by creating datasets of reef resources from benthic images using random point count methodology. The software is provided free to non-business users. The Web site is: <http://www.nova.edu/ocean/cpce/>.



Monitoring Over Time: Decades to Centuries

Coral Calcification and Climate Change: Sclerochronology Analysis, Development of Data Extraction and Comparison Tools, and Temperature Monitoring

Skeletal density and calcification of corals have recently gained attention because of the potential impacts from global climate change and their unique ability to record this change over their long lifespan (often 100+ years). Historical skeletal growth rates (extension, density, and calcification) thus become useful for testing hypotheses regarding variations in growth attributable to climatic changes such as rising carbon-dioxide levels and sea-surface temperature. This information provides reef resource managers with a historical perspective in which to interpret current measurements.

Coral growth rates, based on annual density bands, serve as indicators of environmental change as well as a chronological template for isotopic and elemental analysis of the skeleton. National Coral Reef Institute investigations of these density bands led to development of the Coral X-radiograph Densitometry System (CoralXDS+), a Windows-based program that facilitates the rapid and accurate assessment of long-term growth records from coral skeletons. This program is freely available for download through the NCRI Web site: www.nova.edu/ocean/coralxds/, and links to this can also be found on NOAA's Paleoclimatology Program web page (through connections listed on www.ngdc.noaa.gov/paleo/corals.html and

www.ngdc.noaa.gov/paleo/softlib/othersoft.html). The relationships between coral growth rates, global warming, and atmospheric carbon dioxide rise are being evaluated, using CoralXDS+ measurements of coral extension, density, and calcification. NCRI investigators will be

deploying *in situ* temperature loggers at globally distributed long-term monitoring sites in order to provide valuable baseline data necessary for calibrating skeletal growth and geochemistry to seawater temperature.



RESTORATION

Hypothesis-Based Design

Restoration Design and Post-Restoration Monitoring Project



A hypothesis-based, multivariate restoration experiment will 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 United States nuclear submarine *Memphis* grounded in 30' of water on a tropical coral reef off southeast Florida in February 1993, causing extensive physical and biological damage to the reef substrate

and to the coral community. NCRI has undertaken a hypothesis-based experiment that provides for design and placement of concrete structures with limited monitoring. Data collection was initiated in October 2001. Donor colonies for the coral transplants were identified, cored, and transplanted into the modules. Monitoring and analysis will continue through 2004. Results from this study will be published in appropriate scientific journals and made available to other programs that are involved in restoration of damaged reefs.

Habitat Restoration Tools

Establishment and Maintenance of a Coral Nursery Using Community Outreach and Education

The Coral Nursery Project promotes coral reef conservation and fishery habitat restoration in a time when natural and anthropogenic pressures on coral reef fishery habitat are a growing concern for managers and scientists. The Coral Nursery Project was established in 2001 as a cooperative effort among scientists from Nova Southeastern University National Coral Reef Institute, marine resource managers from the Broward County (Florida) Department of Planning and Environmental Protection (DPEP), and community members from Ocean Watch Foundation Dive Club (OWF), with funding being provided by the National Fish and Wildlife Foundation (NFWF) and its federal partner, the National Oceanic and

Atmospheric Administration (NOAA) Fisheries Community-Based Restoration Program for 2001–2002. NCRI and its partners (DPEP and OWF) have committed to continuing the project. The project was designed with three main objectives in mind: to create a nursery for corals of opportunity that may be used to help restore damaged reefs in the future, to provide reef managers with coral species-specific and colony-size specific transplantation success information, and to recruit volunteers from the community with interests in diving and the marine environment to assist with the project and to learn about coral identification, data collection, and transplantations procedures while also increasing



public awareness and education. As of February 2004, 239 of the 249 transplanted colonies were alive and securely attached to the nursery substrate.

(Hosting 2008 ICERS, continued from page 1)

cohosted by the Japanese Coral Reef Society and ISRS. The previous ICERS was held in Bali in 2000.

Richard E. Dodge, Ph.D., dean of the Nova Southeastern University (NSU) Oceanographic Center and Executive Director of the National Coral Reef Institute (NCRI), heads the United States Initial Organizing Committee. The Committee includes eminent coral reef scientists from NSU/NCRI (including Dr. Bernhard Riegl, NCRI Associate Director), the University of

Miami, University of South Florida, Florida Institute of Oceanography, Florida Institute of Technology, University of Georgia, University of North Carolina at Wilmington, National Oceanic and Atmospheric Administration (NOAA), as well as representatives from the State of Florida, Florida Keys National Marine Sanctuary, and USCRTF member agencies.

The United States and Florida were awarded this honor following an exhaustive international selection process, somewhat similar to the one used to decide sites for the Olympic Games. The criteria, though, were

primarily science content, venue, and capacity. It will have been more than 30 years (1977 in Miami) since the ICERS has been held on the U.S. mainland.

Governor Jeb Bush applauded the decision, saying "The Sunshine State is a natural location for this prestigious gathering of ocean scientists." Drawing millions of visitors each year, Florida's clear waters, sandy beaches, and coral reefs support a \$53 billion tourism industry and a \$14 billion marine industry.

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Timothy R.E. Keeney, deputy assistant secretary for oceans and atmosphere, co-chair of the United States Coral Reef Task Force (USCRTF), reported in a letter to Polunin and selection committee chair Michel Pichon that the task force had passed a resolution at its last meeting in February, strongly supporting the submission of the U.S. proposal to host the meeting. The endorsement included commitments from several task force members including the National Oceanic and Atmospheric Administration and its task force cochair, the U.S. Department of Interior. The 22-member task force is composed of representatives of 12 federal agencies, the governors of seven states and territories with jurisdiction over U.S. coral reefs, and the presidents of the Freely Associated States.

“Coral reefs provide sustenance, recreation, and the economic framework for many tropical regions around the world. They also supply important refuge and food sources for various life stages of many ecologically and economically important marine species, and serve as important barriers against storm damage to coastal areas,” said Dodge. “This conference provides an excellent opportunity for coral reef scientists throughout the world to share their knowledge of these fragile and varied ecosystems, and to promote their con-

servation and protection. Small-island and developing nations with reef resources are dependent upon their sustainable use, for their own survival as independent states. Hosting this meeting in South Florida will facilitate participation of our Caribbean neighbors”

Nicki Grossman, president and CEO of the Greater Fort Lauderdale Convention and Visitors Bureau, was instrumental in helping the U.S. team offer the Selection Committee the venue, hotel accommodations, and other accouterments required to put on a successful ICRS. Site for the week-long meeting will be the 600,000 square-foot Greater Fort Lauderdale/Broward County Convention Center.

(Okinawa, continued from page 1)

and serve as important barriers against storm damage to coastal areas,” said NCRI’s executive director, Richard E. Dodge, Ph.D. “This conference provides an excellent opportunity for the National Coral Reef Institute and other organizations throughout the world to share their knowledge of these fragile and varied ecosystems, and to promote their conservation and protection.”

Dodge and NCRI staff scientist David S. Gilliam, Ph.D., were two of the cochairs of a two-day mini-symposium on Coral Reef Restoration and Remediation, featuring 22 oral presentations and 26 scientific posters authored by scientists from more than a dozen countries. Two of these talks included reports on local NCRI work, one on “Coral Reef Restoration and the Use of Corals of Opportunity and Nurseries,” and the other “Growth and Survivorship of *Meandrina meandrites* [maze coral] and *Montastrea cavernosa* [large star coral] Coral Core Transplants and Effectiveness of Plugging Core Holes in

Transplant Donor Colonies.” Kevin Kohler, senior programmer for NCRI, presented a poster in this session, “Habitat Equivalency Analysis Software to Facilitate Calculation of Compensatory Restoration Following Natural Resource Injury.” Another restoration talk, “Hypotheses-Based Restoration Study for Mitigation of a S.E. Florida U.S.A. Coral Reef Damaged by the Grounding of a Nuclear Submarine” was presented in a different mini-symposium by T. Patrick Quinn.

An international as well as local component of NCRI’s research has to do with remote sensing in order to map and establish baselines for assessment of coral reefs, and to then monitor for any change. NCRI Associate Director Bernhard M. Riegl, Ph.D., who leads the mapping and remote sensing group at NCRI, presented his findings on the effects of temperature extremes on coral mortality, “Spatial and Temporal Dynamics of Arabian Gulf Coral Assemblages (U.A.E.) in Response to Temperature Forcing.”

In a mini-symposium devoted to Remote Sensing, two more NCRI projects, “Scale-Invariant Fractal Patterns of Coral Communities: Evidence from Remote Sensing (Arabian Gulf, Dubai, U.A.E.),” and “Acoustic Remote Sensing: A Useful Tool for Producing Maps of Highly Variable Coral Reef Communities in Southeast Florida (USA)” were also presented. These authors also presented posters, entitled “An Optical-Acoustic ‘Reef-Up’ Approach to Classifying Coral Habitats from Ikonos Imagery (Arabian Gulf, Dubai, U.A.E.),” and “Distribution of Deep-Water Corals on the Southwestern Margin of Little Bahama Bank, Bahama Islands.”

NCRI Oral Presentations to the 10th ICRS

Vargas-Ángel, B., Halter, H., and Hodel, E.: Histopathological indices as indicators for sedimentation stress on scleractinian corals.

Purkis, S.J., Riegl, B.M., and Dodge, R.E.: Scale-invariant fractal patterns of coral communities: evidence from remote sensing (Arabian Gulf, Dubai, U.A.E.).

Fahy, E.G., Quinn, T.P., Fahy, D.P., Dodge, R.E., Spieler, R.E., and Gilliam, D.S.: Growth and survivorship of *Meandrina meandrites* and *Montastrea cavernosa* coral core transplants and effectiveness of plugging core holes in transplant donor colonies.

Monty, J.A., Gilliam, D.S., Banks, K., Stout, D., and Dodge, R.E.: Coral reef restoration and the use of corals of opportunity and nurseries.

Jordan, L.K.B. and Spieler, R.E.: Implications of natural variation of fish assemblages to coral reef management.

Dodge, R.E. and Helmle, K.P.: Coral growth (annual linear extension) chronologies from high-latitude reefs of Southeast Florida: correlations within and between sites, species, and environmental records.

Helmle, K.P., Swart, P.K., and Dodge, R.E.: Temporal/spatial relationships between skeletal density $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ records in the reef-building coral *Montastraea faveolata*.

Quinn, T.P., Fahy, E.G., Robinson, J.L., Dodge, R.E., and Spieler, R.E.: Hypotheses-based restoration study for mitigation of a S.E. Florida U.S.A. coral reef damaged by the grounding of a nuclear submarine.

Lang, J.C., Wulff, J.L., Fretwell, C.R., and Roberson, K.A.: Coral reef conservation through outreach education.

Ferro, F.M., Jordan, L.K.B., Arena, P.T., and Spieler, R.E.: Coral reef fish assemblages

offshore Broward County, Florida: a baseline data set for determining need and evaluating effectiveness of management strategies.

Gilliam, D.S., Banks, K.W., Beaver, C.R., Dodge, R.E., Fisher, L.E., Jaap, W.C., Wheaton, J.L., Allen, P., and Andrews, K.: Long-term monitoring of a high-latitude coral reef system off Southeast Florida, USA.

Riegl, B.M., Purkis, S., Kohler, K., and Dodge, R.E.: Spatial and temporal dynamics of Arabian Gulf coral assemblages (U.A.E.) in response to temperature-forcing.

Richards, V.P., Thomas, J.D., Stanhope, M.J., and Shivji, M.S.: High levels of gene flow in commensal, brooding marine amphipods: mitochondrial DNA variation in Florida populations of the *Leucothoe spinacarpa* species complex.