

An underwater photograph of a coral reef. In the foreground, there are various types of coral, including some with pinkish-purple tips. The reef extends into the distance where several divers are visible, their bubbles rising towards the surface. The water is clear and blue. A white rectangular box is in the top right corner containing the organization's name and report title. A thin orange horizontal line is above the main title, and a thin yellow vertical line is on the right side of the reef.

CORAL  
RESTORATION  
FOUNDATION

ANNUAL REPORT

2017

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# A NEXUS OF EXPERTISE



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Now, more than ever before, we need to work together to save the world's coral reefs from extinction. The world's largest coral restoration organization, the Coral Restoration Foundation (CRF), provides an opportunity to do just that – spearheading unprecedented collaborative efforts in the service of this mission.

In 2017 the Coral Restoration Foundation cemented its reputation as a nexus of expertise, informing and supporting national and international initiatives to protect and restore coral reefs around the world.

We are guiding the scientific research and best practices necessary for long-term, large-scale coral reef restoration. Bringing together government agencies, non-profits, academic institutions, and private companies, the Coral

Restoration Foundation is the only marine conservation organization in the world with the knowledge, techniques, and network necessary to effectively facilitate the response to the crisis facing our planet's coral reefs. Welcome to our world. 🌊



## FROM OUR CEO

Never before has humanity faced the loss of an entire ecosystem. And yet today, this is a very real possibility.

With all shallow water coral reefs projected to disappear in the next 80 years, it is beyond the capacity of any one individual agency to save them.

The importance of collective action was never more apparent than in the aftermath of Hurricane Irma. Together with NOAA, the Florida Keys National Marine Sanctuary, and other groups including Force Blue, we were an integral part of a coordinated effort to understand the impact of the storm, and this collective action resulted in our ability to rescue a significant number of damaged coral colonies. Coral Restoration Foundation was tasked with administering the funding from the National Fish and Wildlife Foundation for the reef assessments and triage.

At Coral Restoration Foundation, we are in the unique position of having proven technologies and methodologies for large-scale coral reef restoration, as well as a reputation as a highly-credible organization at the center of a large network of expertise. Recognizing the value of this role at the heart of the reef restoration community, in the past year our work has been ever-more directed towards providing a focal point around which wider coral restoration efforts can coalesce; our network has continued to expand.

We continue to serve as a resource for the scientific community. The corals we cultivate in our offshore nurseries, the nurseries themselves, as well as our restoration sites, are all being used by scientists researching questions that will help support international restoration efforts. With the formation of the Coral Restoration Consortium, we have now helped to create a framework that will expedite the dissemination of knowledge and resources, and will facilitate crucial, coordinated action at multiple levels.

If our grandchildren are to inhabit a planet that hosts functional coral reefs, it is critical that we work together to protect and restore this vital ecosystem. 🐠

**R. Scott Winters**

Coral Restoration Foundation, Chief Executive Officer

### 2017 AT A GLANCE

**March 23**  
**STAGHORN RESTORATION WATCH**  
Oris launches their Limited Edition Staghorn Restoration Watch to support the work of the Coral Restoration Foundation

**April 1**  
**RAISE THE REEF 2017**  
Coral Restoration Foundation's 5th Annual Gala

**May 31**  
**CORAL RESTORATION CONSORTIUM**  
First meeting of the CRC

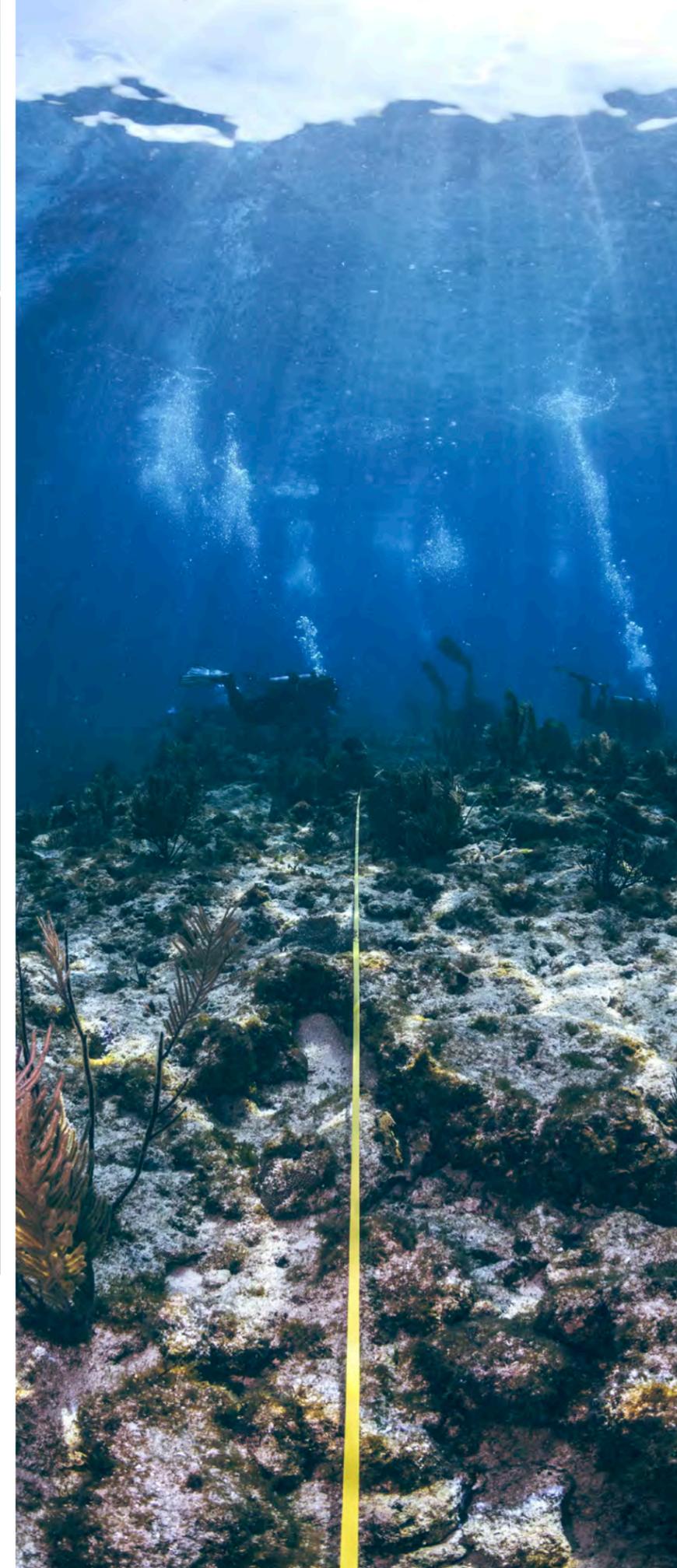
**June**  
**PHOTOMOSAICS**  
Mapping project to increase functionality of CRF outplant monitoring begins

**June 3**  
**3<sup>RD</sup> ANNUAL CORALPALOOZA**  
Brings 156 volunteers to CRF in a single day

**August 10 & 12**  
**CORAL SPAWNING**  
Observation of outplanted elkhorn and outplanted staghorn spawning

**September 10**  
**HURRICANE IRMA**  
Hurricane Irma makes landfall in South Florida as a Category 4 hurricane

**October**  
**POST-IRMA TRIAGE**  
Groups collaborate on post-Irma reef assessments and triage



A NEXUS OF  
**EXPERTISE**

**CORAL**  
**RESTORATION**  
FOUNDATION

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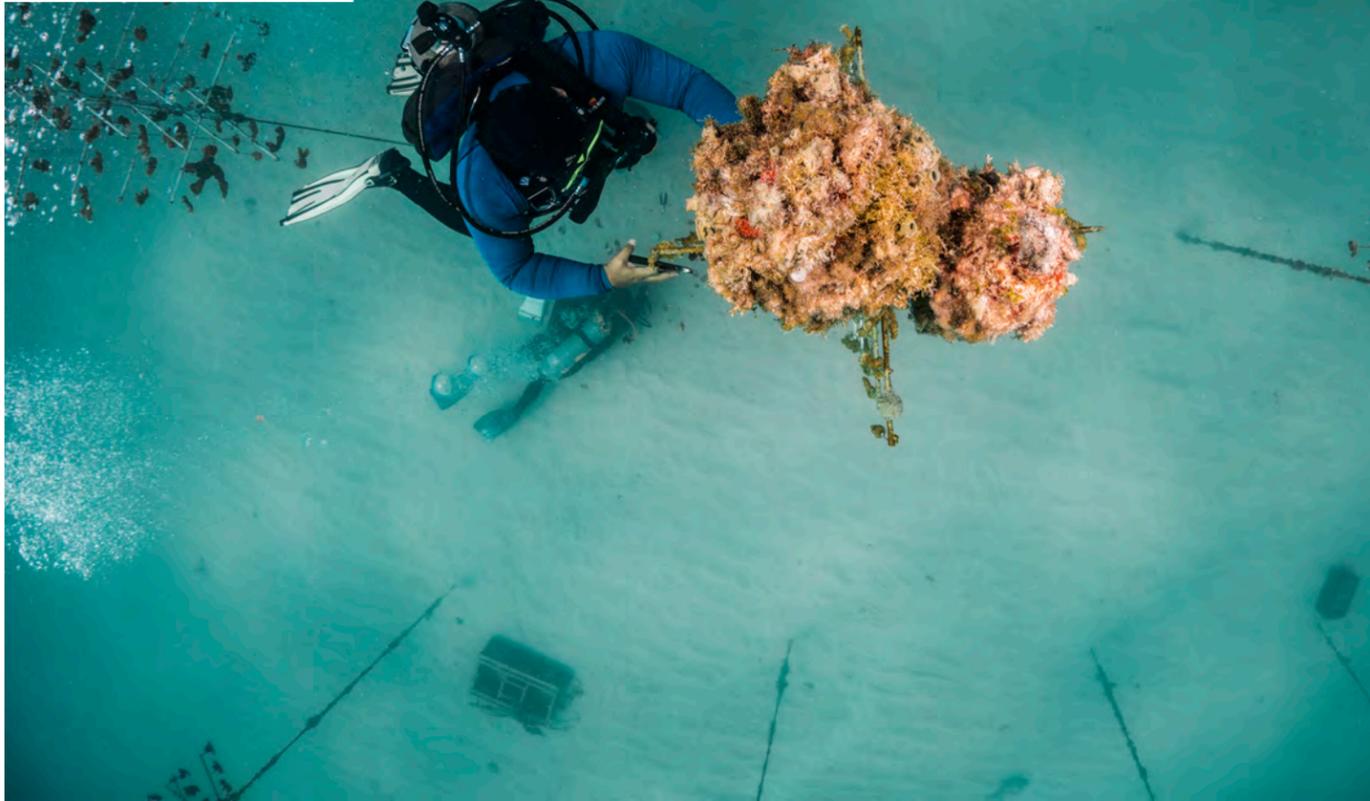
**Steven Miller, Director**  
Senior Research Scientist, NOVA Southeastern University Oceanographic Center

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## A COMMUNITY OF PRACTICE

To address the urgent crisis facing our coral reefs, it is imperative that we work together, simultaneously at multiple scales.

To accomplish this, the Coral Restoration Foundation has helped to co-found the **Coral Restoration Consortium (CRC)** – a high-level community of practice that comprises scientists, managers, coral restoration practitioners, and educators dedicated to enabling coral reef ecosystems to adapt and survive the 21st century and beyond.



The CRC's mission is to foster collaboration and technology transfer among participants, and to facilitate scientific and practical ingenuity to demonstrate that restoration can achieve meaningful results at scales relevant to reefs in their roles of protecting coastlines, supporting fisheries, and serving as economic engines for coastal communities.

The CRC has been formed with full recognition that saving the world's coral reefs will require a multi-pronged approach.

Immediate and aggressive action on climate change is paramount for the long-term survival of reefs; however, carbon already committed to the atmosphere will continue to warm ocean waters to a level inhospitable to corals for decades to come.

The CRC's mission is to foster collaboration and technology transfer among participants, and

- Globally, aggressive action is required to reverse climate change
- Regionally, integrated networks of protected reef ecosystems are needed to ensure that corals can survive and adapt.
- Locally, as threats such as overfishing and pollution are managed, we need to repopulate target reefs with resilient, genetically diverse and reproductively viable corals.

to facilitate scientific and practical ingenuity to demonstrate that restoration can achieve meaningful results at scales relevant to reefs in their roles of protecting coastlines, supporting fisheries, and serving as economic engines for coastal communities.

The CRC has been formed with full recognition that saving the world's coral reefs will require a multi-pronged approach.

Immediate and aggressive action on climate change is paramount for the long-term survival of reefs;

- Scaling up in-water, land-based, and larval propagation
- Designing projects to demonstrate multi-species ecosystem functioning and coastal protection
- Coordinating and fostering genetics science into adaptive restoration
- Developing restoration monitoring guidelines and common-access data platforms

however, carbon already committed to the atmosphere will continue to warm ocean waters to a level inhospitable to corals for decades to come.

The problem needs to be simultaneously addressed at multiple scales:

This active and targeted coral repopulation using novel ecological interventions is one



### THE CRC STEERING COMMITTEE

- Scott Winters**, Coral Restoration Foundation (Co-Chair)
- Tom Moore**, NOAA Restoration Center (Co-Chair)
- Tali Vardi**, NOAA Fisheries Office of Science and Technology (Coordinator)
- Jessica Levy**, Coral Restoration Foundation (Coordinator)
- Luis Solorzano**, The Nature Conservancy
- Dirk Petersen**, SECORE International
- Diego Lirman**, University of Miami
- Ilsa Kuffner**, U.S. Geological Survey
- Les Kaufman**, Boston University
- Monica Borobia and Lucie Labbouz**, UN Environment-Caribbean Environment Programme
- Dave Vaughan**, Mote Marine Laboratories
- Phanor Montoya**, Corales de Paz
- Anastazia Banazak**, Universidad Nacional Autónoma de México
- Andrew Ross**, Seascape Caribbean
- Gabriela Nava**, Oceanus AC

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## RESTORATION

We are actively restoring coral reefs on a large scale. Our innovative methods are cost-effective and scalable.

- We grow and outplant genetically diverse, critically endangered corals to restore reef sites to a healthy state.
- Our outplanted corals are spawning naturally, kick-starting the reefs' natural processes of recovery.
- Our program partners include government agencies, non-profits, academic institutions, and private enterprise.
- As a result of our program's success, the Coral Restoration Foundation has become a resource for other organizations seeking to implement reef restoration programs in their local waters.
- In 2017, we provided restoration infrastructure and training to organizations from 12 countries.

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## SCIENCE

Our approach is guided by rigorous scientific research into coral propagation, growth, and survivorship.

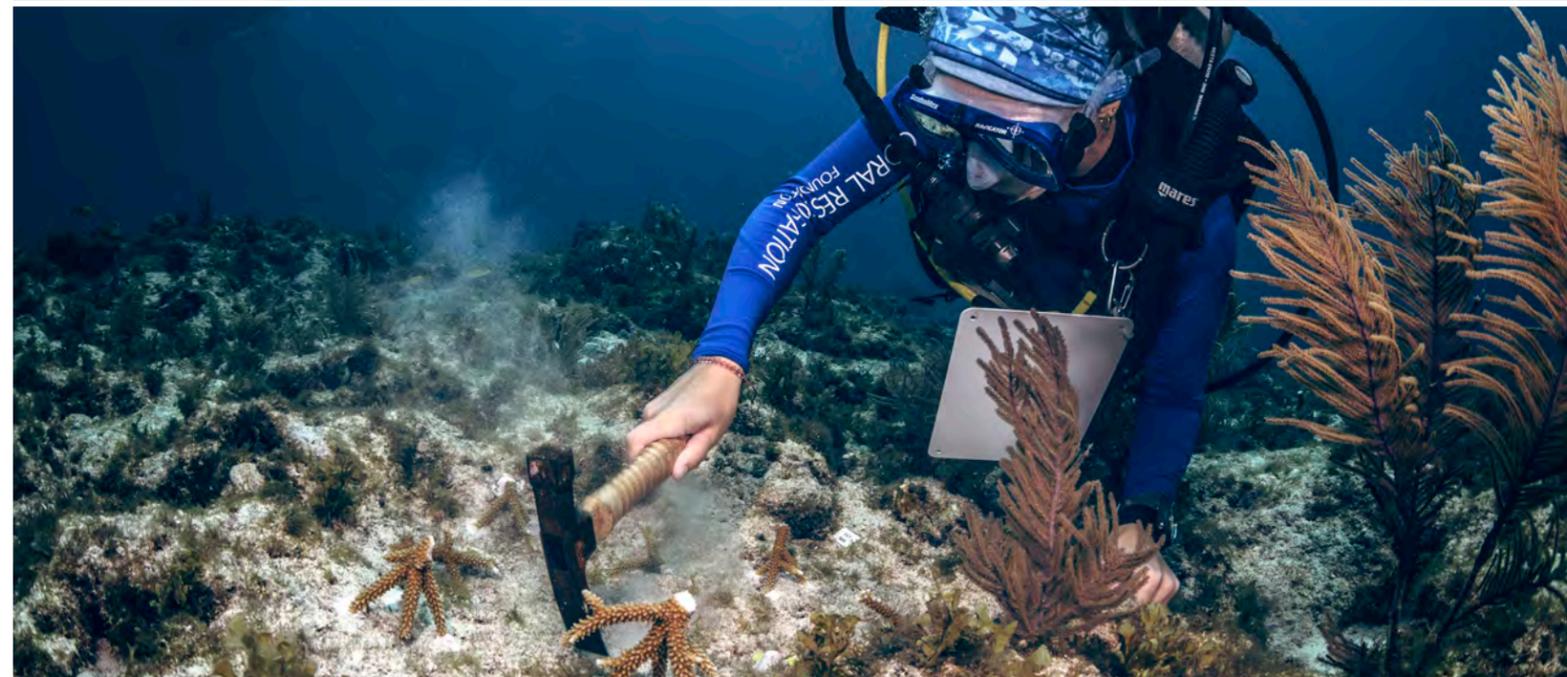
- We currently work with 296 coral genotypes across nine species to ensure that we are restoring the reefs' genetic diversity and resilience.
- We rigorously monitor our outplanted corals and reef sites, and are involved in research into the wider ecological impact of our work.
- This data informs our strategic development, and the research provides a focal point for collaborations with government agencies including NOAA, universities, NGOs, and others.
- Our work offers infrastructure that supports other marine science initiatives.
- We are supplying scientists from around the world with a unique resource for research into coral reefs.

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## EDUCATION

We work with schools, the public, and other NGOs to generate engagement around marine conservation issues.

- Recreational Dive Programs let all ocean lovers make a difference, while enjoying fun days out on the water working alongside our team.
- Presentations at our Exploration Center, or by Skype, can be tailored for any group.
- Our new educational materials complement US state standards, and can be easily incorporated into teachers' lesson plans.
- Internships provide university-level students with vocational training and experience. Our interns go on to launch exciting careers in related fields.
- Volunteers drawn from the local community contribute to our daily work, both on and off the water. 🌊





## CORAL PROPAGATION

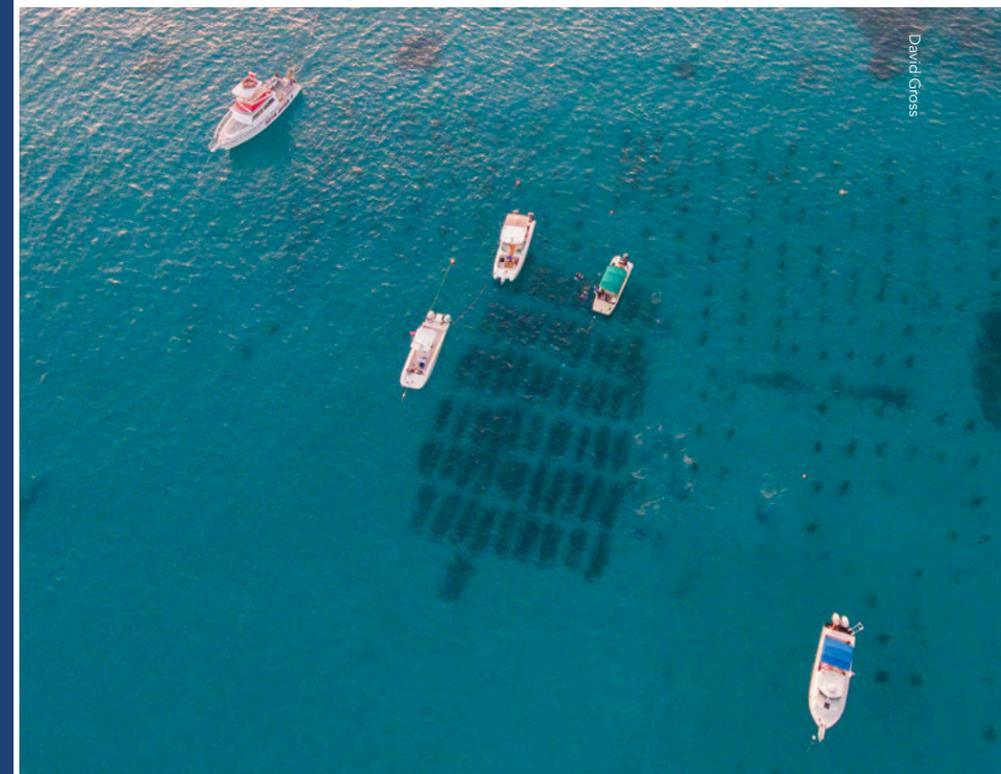
### CORAL TREE NURSERIES

To efficiently propagate large numbers of corals, we developed the Coral Tree Nursery™ design. This technology allows us to raise huge numbers of coral fragments in large, offshore nurseries. Nurseries are used for both coral colony production and genetic preservation of numerous coral species.

The Coral Trees are tethered to the ocean floor and buoyed with a subsurface float. Coral fragments are hung from the branches of the trees using monofilament line.

The trees float in the water column and are able to move with storm-generated wave surges. This helps to prevent damage to the tree structures and corals by dissipating wave energy.

Suspended in the nutrient- and sunlight-rich water column, the fragments of *Acropora* corals on our Coral Trees grow into colonies that are large enough to be **planted onto the reef in just six to nine months.**



## INSPIRING HOPE

The Coral Restoration Foundation is the largest coral reef restoration organization in the world.

Our Restoration Program inspires hope for the future of coral reefs by addressing these key areas:

-  The active restoration of wild coral populations.
-  The preservation of genetic diversity of coral species.
-  The promotion of all restoration efforts that work to ensure the increased resilience of the world's coral reefs.

### FACTS & FIGURES 2017

- **13,435** corals outplanted:
  - *A. cervicornis* 11,320
  - *A. palmata* 2,115
- **7** coral nurseries
- **22** reef sites received outplants
- **8,166** hours underwater
- **500+** Coral Trees™

### ADAPTING TO SUCCESS IN 2017

In the last few years, our propagation techniques have been so successful that we are now growing an overabundance of corals in our nurseries. We have had to adapt our infrastructure to better manage our coral stock; overcrowding in a nursery setting can lead to a host of problems.

To adapt to this problem, we redesigned the layout of each nursery, as we now need to differentiate between coral production and genetic preservation.

This transition began in 2017 with the establishment of the genetic bank within the Tavernier Nursery.

## RESTORATION PROGRAM

### DIVERSITY IN OUR NURSERIES

Healthy reefs rely not only on a diversity of species but also on genetic diversity within each species. High diversity creates functional redundancy and thus resiliency to environmental and anthropogenic disturbance. Genetic diversity is vital in mitigating risks associated with inbreeding, including genetic mutations and the inability of coral populations as a whole to adapt to dynamic environmental conditions.

In order for restoration efforts to be successful in the long term, it is essential that the corals we outplant are genetically diverse. We are currently working with **296 coral genotypes** across **nine species**.

Our nurseries have now become a vital repository of genetic diversity for corals whose populations are in a spiral of decline – our genetic ark comprises the world’s largest genetic “bank” of corals. Some of these genotypes can now only be found within our genetic bank, as they have unfortunately been lost in the wild.



## ACTIVE RESTORATION

### CORAL OUTPLANTING

Over the last 10 years, we have planted more than **66,000** corals onto the Florida Reef Tract. We are currently working to **fully restore eight reef sites** along its length.

Our focus is on outplanting populations of the critical reef-building genus, *Acropora*, 95% of whose populations have been lost due to stressors such as climate change, nutrient pollution, and other acute, physical disturbances.



After the corals cultivated in our nurseries have reached a substantial size, they are tagged and taken to a carefully selected site where they are attached directly to the substrate using a two-part marine epoxy.

We **initially used 20 sites** to pilot outplanting efforts. After monitoring coral growth and survival rates, we **selected the eight most varied and robust sites** on which to begin a focused restoration effort.

We will now be planting greater numbers of corals, across diverse genotypes, onto these selected sites. This will help us ensure long-term success – allowing us to create significant impact on a meaningful ecological scale.

### ACROPORIDS

The majority of our nursery stock consists of the reef-building, branching corals *Acropora cervicornis* and *Acropora palmata*.

These were once the Caribbean’s dominant reef building corals. Populations of both have **declined by as much as 95%** in the Caribbean in the last **40 years**, and both species are now listed as “Threatened” under the U.S. Endangered Species Act (ESA), and as “Critically Endangered” on the IUCN Red List of Endangered Species, one step away from “Extinct in the Wild”.

### STAR CORALS

In the last year, we have scaled up our research into the propagation of two species of star corals: *Orbicella annularis*, and *Orbicella faveolata*. Star corals are important reef stabilizers.

Within the past **20 years**, the boulder star coral has seen more than a **50% decrease** in population and is now listed as “Endangered” on the IUCN Red List. We aim to develop outplanting methods for star corals to begin repopulating Carysfort Reef with these species in 2018.

### PILLAR CORAL

Populations of pillar coral, *Dendrogyra cylindrus*, are in decline around the world. In 2016, we were part of a Keys-wide effort in collaboration with Summerland Marine Lab, Florida Aquarium, FWC, FKCC, and Mote Marine Lab to safeguard the remaining pillar coral genotypes present on the Florida Reef Tract.

During 2017, these colonies were fragmented and attached to our Coral Trees. Protected in our nurseries and growing well, these **10 genotypes** have now been saved from extinction.

### OTHER SPECIES

As part of mitigation work carried out in partnership with the Florida Keys Electric Co-op, in 2017 we rescued a number of colonies of *Porites porites* (a finger coral), *Porites astreoides* (a massive), *Occulina diffusa* (a branching coral), and *Siderastrea siderea* (another massive) from Long Key Bridge, and moved them into our nurseries.

*P. porites*, *P. astreoides*, and *S. siderea* are very important species, contributing to the reef building process and providing critical structural diversity to reef systems.



### REEF RESTORATION SITES

We outplanted corals to **22 reef sites** in 2017. In 2018, we are shifting our focus to concentrate on the full restoration of **eight reef sites** (shown here) over the next **three years**.

### CORAL OUTPLANT SURVIVORSHIP

Ongoing monitoring has provided extremely encouraging data regarding the survivorship of our coral outplants.

Our results from corals outplanted in 2016 that were monitored through 2017 showed an average of **91% survivorship** across all sites and all species after one to three months, and **77% survivorship** across all sites and species after one year.

#### Elkhorn survivorship:

1–3 months: **88%** survival  
9–12 months: **84%** survival

#### Staghorn survivorship:

1–3 months: **92%** survival  
9–12 months: **76%** survival

## PROGRAM PARTNERS 2017

**NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA):** NOAA has continued to fund our 3-year restoration plan coinciding with the needs of the NOAA-published *Acropora* Recovery Plan.

**THE FLORIDA FISH AND WILDLIFE COMMISSION (FWC) & THE FLORIDA KEYS NATIONAL MARINE SANCTUARY (FKNMS):** The permits that make our work possible are provided by FWC and FKNMS.

**OCEAN REEF CLUB:** The ORC has been a key partner in the ongoing restoration of Carysfort Reef, one of the healthiest reefs along the Florida Reef Tract.

**GEORGIA AQUARIUM:** Our solid partnership with the Georgia Aquarium around our restoration efforts continues, with joint quarterly trips during which we focus on nursery maintenance, expansion, and outplant efforts.

**NATIONAL FISH AND WILDLIFE FOUNDATION (NFWF):** NFWF provided the funding for post-Irma assessment and triage work which the Coral Restoration Foundation administered.

**THE FLORIDA AQUARIUM:** Florida Aquarium and FWC teamed up with us to collect multiple genotypes of rapidly disappearing pillar coral, *Dendrogyra cylindrus*, and house them in the Tavernier Nursery in an effort to preserve the genetic diversity in the declining populations of this species.

**OCEANUS & FUNDEMAR:** Staff from Oceanus A.C. and Fundemar traveled from Mexico and the Dominican Republic, respectively, to participate in two, week-long, Coral Restoration Foundation fellowships, during which they learned about our experiences and practices.

**FLORIDA KEYS ELECTRIC CO-OP:** FKEC engaged us to harvest corals from an offshore structure they were modifying, to mitigate the ecological impact of their work, and provide us access to new genotypes that could be moved into our nurseries.

**FLORIDA KEYS COMMUNITY COLLEGE:** Our internship program with FKCC enables three interns to assist in our nursery and restoration operations based in Key West, which include guiding divers, outreach events, and monitoring efforts.

**FORCE BLUE:** After providing initial training for Force Blue in coral propagation and outplanting techniques, our relationship with them continues to grow. Force Blue provided essential human resources during post-Irma triage work.

**OCEAN DIVERS:** During the post-Irma assessment and triage work, Ocean Divers provided important water access (dockage support) so we could continue our restoration and recovery operations.



## INNOVATION FOCUS

Moving forward, our Restoration Program will focus on ensuring large-scale ecological impact. This will be accomplished by driving forward innovations around four key issues:

### 1) FOCUSED RESTORATION OF CRITICAL SITES

As of 2017, we will be focusing our work on eight sites. Staghorn and elkhorn outplant numbers will increase to **1,050 individual corals per species per site** for 2018. These numbers will increase further in 2019 to reach our outplanting goals for the second and third years of the NOAA-funded restoration plan.

### 2) CREATING NOVEL OUTPLANTING METHODS

In order for *Acropora* restoration efforts to occur at an impactful ecological scale and to reach the CRF outplanting goals for the second and third year of our NOAA-funded restoration plan, we have begun the process of devising novel ways to increase our outplant capacity, using the same or fewer resources than the traditional methods of hammers and epoxy. Another challenge has been balancing our overabundance of nursery stock with our capacity to outplant corals, specifically staghorn coral. New outplanting methods will help us to address this bottleneck.

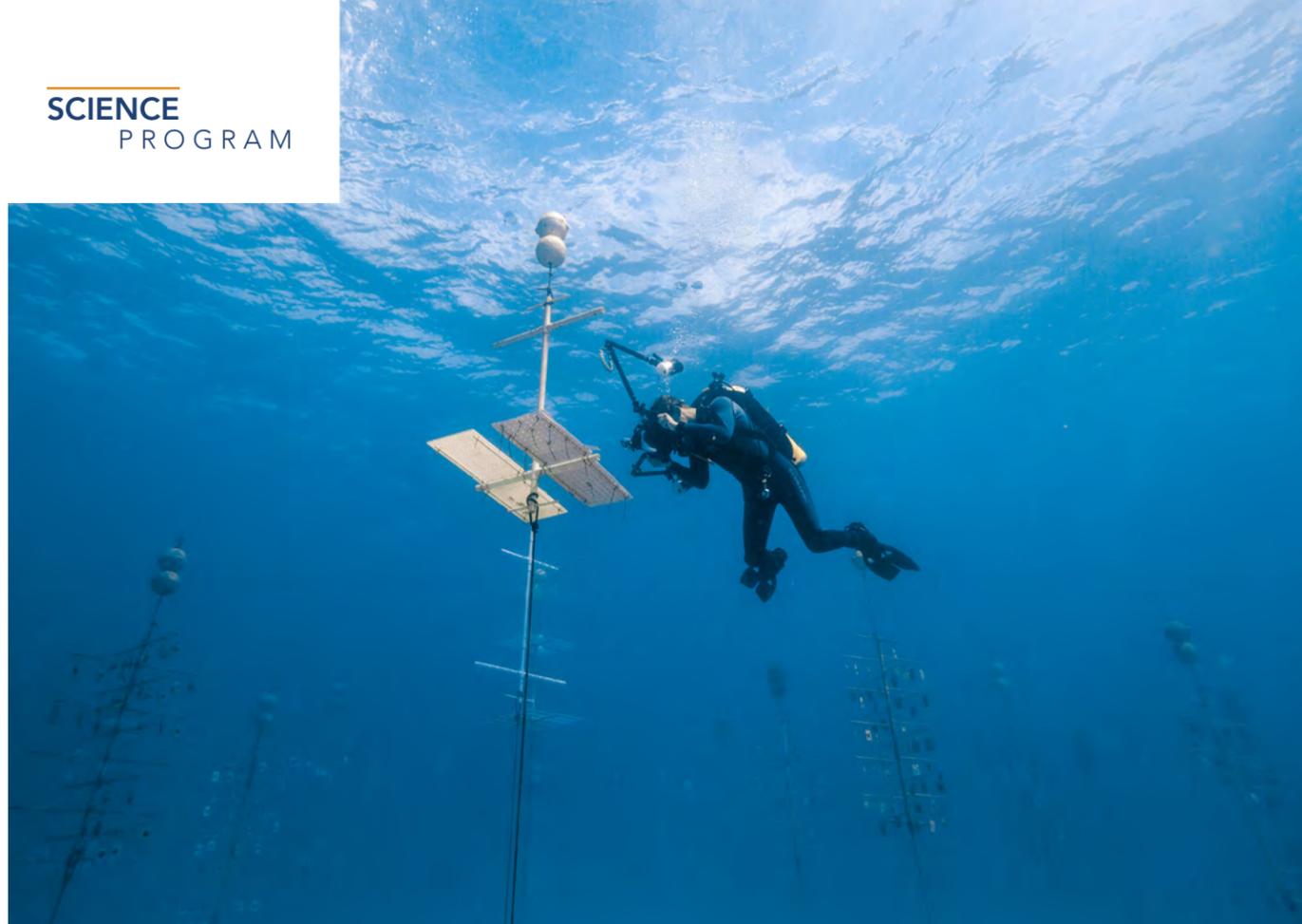
### 3) USING PHOTOMOSAICS FOR MONITORING

In addition to fulfilling the current monitoring requirements, photomosaics will also offer the opportunity to expand the scale of these monitoring efforts from the individual coral level to the ecosystem level.

### 4) DIVERSIFYING CULTIVATED SPECIES

We continue to work towards developing novel methods for the other, non-Acroporid, species within the nursery. For example, boulder corals cannot be grown in the same manner as branching corals, so we have worked to evolve our nursery techniques for the propagation, mounting, and growing of boulder corals within the Tavernier Nursery. This new design involves a modified coral tree design with flat trays and allows the boulder corals to face upwards for maximum sunlight exposure. Our aim is to outplant at least **2,000 boulder corals** to Carysfort Reef in 2018. 🌊





## DATA DRIVEN

The Coral Restoration Foundation's Science Program drives the organization's innovation, development, and research collaborations. The Science Program is concerned with:

- Monitoring the impact of our work on the reef sites we are actively restoring, utilizing traditional monitoring methodologies and cutting-edge photomosaic techniques to get a better understanding of our spatial impact.
- Facilitating scientific research partnerships to better understand the wider ecological impacts of our methodologies.
- Establishing an open-access, global genetic database for critical coral species.
- Investigating novel outplanting methods to enable us to outplant corals more efficiently.

## GENETIC BANK

We have been collecting and collating detailed genetic information on every coral that passes through one of our nurseries. We now manage the world's largest ark and database of coral genotypes.

We have exhaustive information on all nine of our coral species including genotypes, collection location, phenotypic observations from within our nurseries, locations within nurseries, and genetic sequencing data.

This information has been provided by Steve Vollmer (haplotype and ddRADSeq) and Iliana Baums (microsatellite) but is still incomplete.

In the coming year, it is our goal to sequence every coral and make this information publicly accessible through a genetic database that will be used as the focal point for all genetically-conscious coral restoration.



## RESEARCH FOCUS

The focus of our research falls into six main categories:

### 1) CORAL NURSERIES

Data we collect around our coral propagation methodologies for the nine species we work with helps us increase our efficiency and the number of nursery-raised corals that can be successfully outplanted.

### 2) OUTPLANTING METHODS

We are currently involved in research and development to allow us to move the overabundance of corals we are cultivating into the wild more efficiently.

### 3) RESTORATION SITES

Ongoing research seeks to better understand why some sites exhibit a higher survival rate for outplanted corals than others. Identifying increasingly suitable restoration sites is a priority that was highlighted by the Coral Reef Ecosystem Restoration Working Group, during a review of the Florida Keys National Marine Sanctuary management plan.

### 4) GENETIC RESILIENCE

Our research tracks how different coral genotypes (and their associated microbes and symbionts) correlate with growth and condition, and the success of different outplant methodologies.

### 5) ECOLOGY

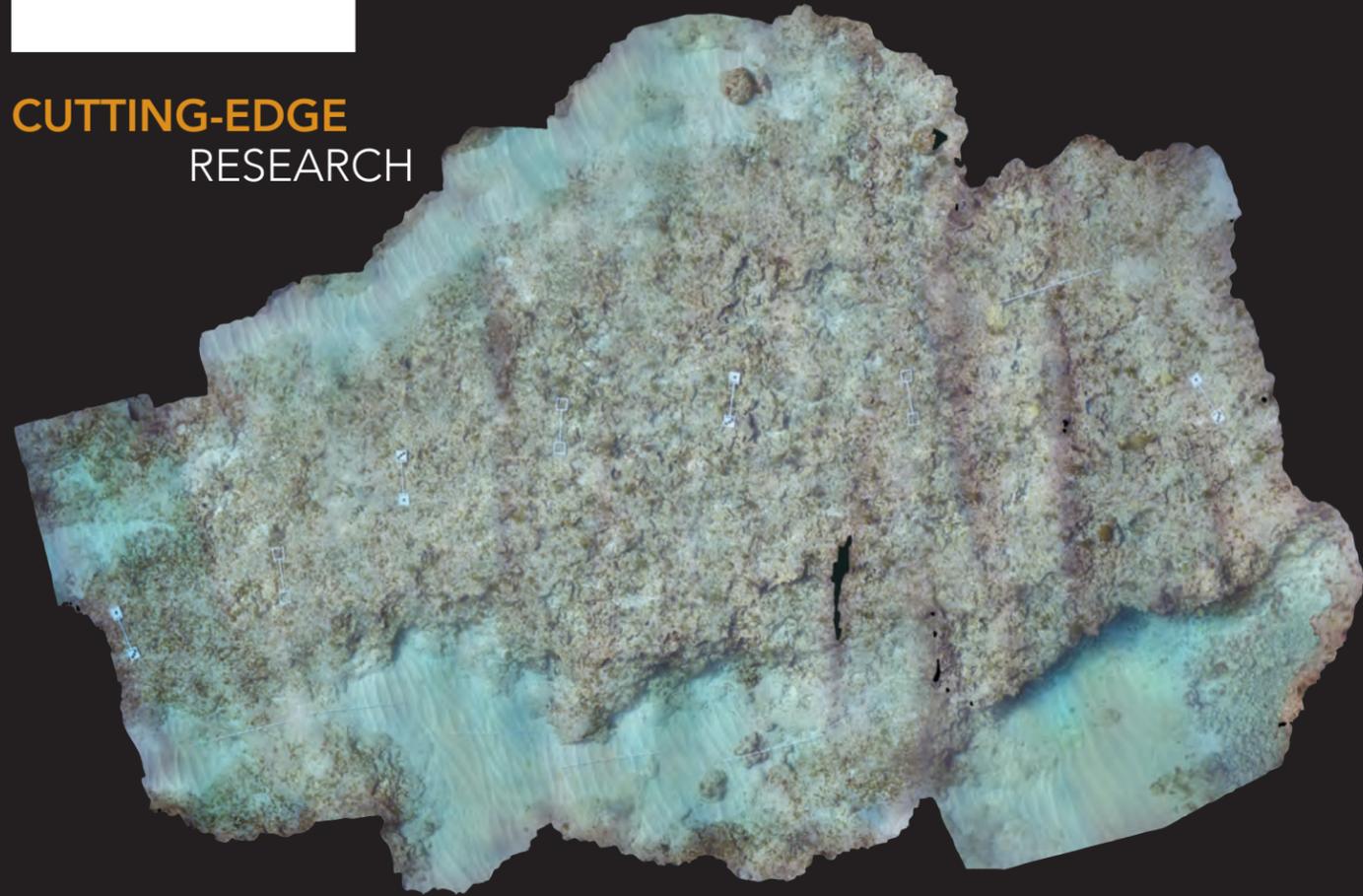
The monitoring of our outplanting sites demonstrates how ecology impacts restoration success. Specifically, we can assess how other organisms and reef topography affect the condition of outplanted corals.

### 6) DISEASE & BLEACHING

Projects that address coral disease or coral bleaching, that have direct application to coral restoration ecology, are considered high priority.



## CUTTING-EDGE RESEARCH



### PHOTOMOSAICS

Recent advances in imaging and image processing technology are now being applied to underwater data collection. Using specialized computer software and basic underwater cameras, we are beginning to map reef sites throughout the Florida Keys into “photomosaics”.

These mosaics encompass several thousand square meters of reef area and can be used to compare the growth and health of outplanted corals over time, while also documenting changes to the reefscape and other underwater habitats.

Traditional monitoring methodologies are time and resource heavy, requiring many hours spent underwater to generate data for a limited area. Additionally, the most valuable metrics for coral restoration – such as percentage of coral cover or coral thicket volume – are nearly impossible to accurately measure in the field.

We were fortunate enough to capture photomosaics of outplanted

reef sites in the weeks immediately before and after Hurricane Irma.

While these photomosaics showed the destructive forces that Hurricane Irma unleashed on our corals and our reefs, they also showed the power of photomosaics to accurately document coral health and growth in new and improved ways. In the coming years, this technology will allow us to increase the scope of our monitoring program. The mosaics

created by CRF staff and volunteers in the past year have already demonstrated that the use of photomosaics:

- Reduces the number of man-hours needed on-site
- Collects the same monitoring metrics collected in the past
- Offers the potential for the collection of metrics previously unobtainable underwater

These improvements translate to demonstrable increases in the efficiency of CRF’s data collection and scientific knowledge.

Lastly, photomosaics of entire reef sites have the power to engage the general public in a new, visceral way, and bring the story of coral reefs to new audiences.

### SUPPORTING THE STUDY OF CORAL SPAWNING

Our nurseries and restoration sites have now become invaluable resources for other organizations seeking to better understand this little-known process.

In 2009, Coral Restoration Foundation made history when corals we had planted off Molasses Reef on a site called “Wellwood”, became the first documented nursery-raised corals to spawn. Spawning has since been recorded by corals we have outplanted at multiple locations.

In August of 2017, we welcomed numerous research groups to collaborate on gathering data about coral spawning – the Florida Aquarium, Sea World, Georgia Aquarium, Columbus Zoo and Aquarium, Mote International Center for Coral Reef Research and Restoration, and the South-East Zoo Alliance for Reproduction and Conservation (SEZARC).

Our collaboration with these groups supports joint efforts to gain a better understanding of *Acropora* sexual reproduction and its role in restoration efforts.

During the event, we observed spawning by corals in our nurseries, as well as by corals we have planted at two mature reef restoration sites.

Sperm samples were collected from the corals spawning in our nurseries and cryopreserved by staff of SEZARC. The samples were transferred to the USDA Animal Germplasm to ensure the preservation of coral gametes for future restoration work.

The fact that spawning was observed by both the Snapper Ledge elkhorn block corals and by the Pickles Reef mature outplanted corals is strong evidence that our methods are working. Spawning is the foundation of the reefs’ natural process of recovery, and demonstrates that our work is contributing to future self-sufficiency within the population.





## RESEARCH COLLABORATIONS 2017

We work with leading researchers, universities, scientists, and other organizations to help answer the questions that will advance our coral restoration goals.

We are also in the unique position of being able to provide investigators with corals from our nurseries, as well as limited field support, for experimental work that aligns itself with our research priorities.

In the past year, we have worked to facilitate collaborations with these 11 research partners:

### DISEASE & BLEACHING Margaret Miller NOAA

Margaret Miller has worked with us on a number of projects involving coral disease. She has been involved with field screening assays to provide quantification of relative disease resistance in nursery stock of *Acropora* corals, and has looked at histology samples from *Acropora palmata* to quantify fecundity distributed among genotypes.

### Craig Downs Haereticus Environmental Laboratory

Craig Downs received coral samples from us to use in an ecotoxicology study, looking at how sunscreen chemicals, such as oxybenzone, preservatives, and pesticides impact *Acropora palmata*.

### ECOLOGY R. Sean Fitzpatrick Duke University

R. Sean Fitzpatrick set up structures in our nursery to assess the ability of natural buffers, i.e. seagrass, to act as Reef Defense Systems to protect reefs from impacts including climate change.

### Abigail Engleman FSU

Abigail Engleman used our nurseries to study the effect of synergistic settlement conditions on coral larvae recruitment onto artificial substrates. She 3D printed structures to mimic structural characteristics found on natural reefs and put them in the nursery to test for settlement.

### RESTORATION Kerry Maxwell FWC

Kerry Maxwell has used our outplanting sites to conduct surveys to determine long-term *Acropora* restoration success to help managers further understand habitat characteristics and causes of mortality for outplanted *Acropora*.

### Margaux Hein James Cook University

Margaux Hein combined underwater field studies and local stakeholder surveys to explore the potential socio-cultural and economic benefits associated with reef restoration, with a goal of developing best practices to inform future restoration management decisions.

### GENETIC RESILIENCE Steve Vollmer Northeastern University

Dr. Steve Vollmer has been pivotal in providing genetic data for the corals in our nurseries. In early 2017, he provided their haplotype information and later the ddRAD sequencing data. We were able to use the haplotype information to select the 50 most diverse staghorn and elkhorn genotypes with which to launch our NOAA outplanting study, which aims to fully restore eight reef sites throughout the Florida Keys by planting genetically diverse corals.

### SPAWNING Iliana Baums Penn State

Iliana Baums was involved with spawning studies in 2017. Her lab has developed 2,294 high-quality SNP loci that resolve genotypes, populations, and hybrid status of Caribbean Acroporids – helping inform selection of genetically diverse genotypes for nursery and outplanting. She is also working on chromosome-level sequencing and assembly of the *Acropora palmata* genome.

### Margo McKnight, Scott Graves, & Keri O'Neil FLAQ

FLAQ participated in spawning research at our facilities in 2017. They collected gametes from over 20 genotypes of staghorn and observed successful recruitment in their labs.

### Joana Figueiredo NSU

We supplied Joana Figueiredo with broodstock corals to spawn and collect gametes from at FLAQ. Her study used a high-resolution biophysical dispersal model to estimate larval dispersion and connectivity patterns in the Florida Reef Tract, to develop a model to assist in selecting optimal sites for restoration.

### Justin Zimmerman Seaworld

In collaboration with FLAQ and project CORL, Justin Zimmerman attended 2017's spawning event to collect gametes. He also received small fragments of *Acropora cervicornis* to act as zooxanthellae donors for the new coral larvae that are used for research, developmental studies, and to grow out new genetic individuals to someday return to the reef.

## PEER REVIEWED PUBLICATIONS 2017

Our expertise and infrastructure provided fundamental resources for studies published in three peer-reviewed publications in 2017.

- **JOURNAL OF EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY** Volume 486, January 2017  
*Intraspecific variation in phenotype among nursery-reared staghorn coral *Acropora cervicornis* (Lamarck, 1816)*  
Authors: Kathryn E. Lohr, Joshua T. Patterson
- **ECOLOGY AND EVOLUTION** June 30, 2017  
*Genomic patterns in *Acropora cervicornis* show extensive population structure and variable genetic diversity*  
Authors: Crawford Drury, Stephanie Schopmeyer, Elizabeth Goergen, Erich Bartels, Ken Nedimyer, Meaghan Johnson, Kerry Maxwell, Victor Galvan, Carrie Manfrino, Diego Lirman
- **RESTORATION ECOLOGY** September 12, 2017  
*Macroalgae reduces survival of nursery-reared *Acropora* corals in the Florida reef tract*  
Authors: Robert van Woesik, Kayla Ripple, Steven L. Miller 🌐





# EMPOWERING ACTION

The goal of the Education Program at the Coral Restoration Foundation is to inspire others to take action in order to improve the health of the world's reefs, using our work as an example.

We accomplish this through:

-  The implementation of an active learning program whereby anyone can participate in our work.
-  A passive learning program through which the story of our mission, and of hope through action, inspires and empowers others to contribute to saving coral reefs in whatever way is available to them.



## INTERNSHIPS

We offer vocational training to university-level interns, providing a structured learning environment as well as the opportunity to contribute on a professional level to a thriving, world-class non-profit.

Interns can expect to be challenged, mentored, and inspired, working with a dynamic team that is dedicated to helping them find their focus.

Many intern projects go on to become permanent features of the Coral Restoration Foundation.

We welcomed **10 new interns** in 2017, all of whom are now well on their way to launching exciting careers.

## OUTREACH & EXPLORATION

### EXPLORATION CENTER

The Coral Restoration Foundation Exploration Center is a vibrant, dynamic, informative space. Colorful engaging panels, audio-visual installations, and interactive games provide visitors with all sorts of compelling ways to become familiar with our mission.

Through presentations in our Exploration Center, our "Let's Talk Coral" Skype series, and various community-based events, we reached an estimated **8,325 people** with our message in 2017 compared to the 2,581 reached in 2016. We accumulated a total of **1,986 outreach hours** in 2017 – a **358% increase** from 2016.



### CURRICULUM-BASED WORKSHOPS

One of the most significant developments in our Education Program in 2017 was the hiring of a new Education Program Manager with a background in education and curriculum writing. He has been responsible for the dramatic scaling up of our Education Program in 2017.

We now have an open-access database of **27 STEAM-based workshops** that follow the Florida State Standards. These activity packs allow teachers to enrich their lessons while bringing our message to students across Florida and nation-wide.

## A WORLD OF SUPPORT

### VOLUNTEERS

Volunteers are a crucial part of every aspect of our work.

Through the Education Department, Coral Restoration Foundation volunteers work alongside our staff and interns on land and on the water, to further the overall mission of restoring coral reefs.

Volunteers not only help with day-to-day activities, but are also pivotal in sharing our vision with the wider community.

In 2017, the volunteer program saw a massive surge in interest from all demographics. The number of visiting volunteers increased, and the EC started seeing volunteers helping regularly through the day with EC operating needs.

Certain Dive Programs, such as the Florida Aquarium and the Florida Underwater Sports organizations, directly added volunteers to our organization. Through their experiences with our Dive Program, 5 new volunteers joined us in 2017.

In 2017, we had a total of **78 active volunteers**, accomplishing a total of **8,783 hours** of work, a **30% increase** from 2016.



## RECREATIONAL DIVE PROGRAMS

### DAYS ON THE WATER THAT MAKE A DIFFERENCE

Our Dive Programs are exciting days for recreational divers and snorkelers who want to dive with a difference.

Dive Programs help spread awareness that through collaborative, large-scale action we can save the world's coral reefs.

Days on the water with us give everyone the opportunity to take part in active reef restoration by helping with nursery maintenance, coral outplanting, and Citizen Science monitoring of our outplanting sites.

On World Oceans Day, every year, we take out an "army" of ocean lovers to get involved in our work on the water during our annual CORALPALOOZA – a festival of reef restoration that demonstrates what's possible when we work together.

In the last year, our dive programs have grown at an astonishing rate, involving more partners than ever before. 🌊

In 2017, we ran **58 full programs**, with **31 different organizations** for a total of **69 dive program days**.

During CORALPALOOZA 2017, we worked with **11 different operators** through Key Largo and Key West, plus Mote Marine in Summerland Key, UM in Miami, Bonaire, Oceanus in Mexico and Fundemar in the Dominican Republic.

Dive programs in 2017 involved a total of **736 different people** for a combined **5,588 hours** of activity. Between 2016 and 2017 we have seen a **46% increase in participants** in dive programs, and a **43% increase in hours!**



## NURSERY IMPROVEMENTS

At the Coral Restoration Foundation, we learned a great deal from Irma and have adjusted our nursery practices accordingly. Using Irma as a learning opportunity, we are hopeful that these adaptations will help our nurseries withstand future storms of this magnitude.

Our nursery stock now has a smaller chance of being displaced during storm surges and big waves, as all corals are now suspended from the trees on **stronger, 200lb, monofilament.**

Smaller coral colonies proved to be more resilient to hurricane conditions, and so we have **improved our management of the size** of coral colonies in the nurseries.

To prevent the loss of genotype specimens, we now house **multiple representatives of each coral genotype** in different locations – building in a redundancy stock.

# LEARNING FROM IRMA

Text by **Natalia Schoenberg**, Coral Restoration Foundation Lead Intern  
Images by Coral Restoration Foundation

I started my internship with the Coral Restoration Foundation on the very day that Monroe County issued its mandatory evacuation notice for Hurricane Irma. We were aware of the impending storm, but for all of us new to Florida, there was no way of fully internalizing what Irma would mean for us.

That is, until we received the call to action from our CEO: intern orientation was postponed indefinitely, and all staff had to report to the offices immediately for facility preparation. What followed was a whirlwind of frantic packing, unplugging, and securing everything that belonged to CRF, leading into a days-long scramble to travel safely out of Irma's path.

After two weeks of waiting and uncertainty, we were finally able to return to the Keys, unsure of what we would find upon arrival.

On the surface, the Coral Restoration Foundation was lucky to emerge from Irma relatively unscathed, with all of our facilities, vehicles, and vessels completely intact. Still, we suspected that the major fallout from the storm would be found during initial assessments of our nurseries and reefs.

As soon as conditions allowed, our primary focus was to assess damage within our coral nurseries in order to take stock and begin rebuilding production capacity to meet our established restoration goals.

While it was encouraging to see that almost all of the Coral Trees™ in the nurseries remained intact, we discovered that we had sustained significant losses in coral stock,

including the loss of 17 entire representative genotypes, of the 313 we had before the storm.

Once we were back up and running, we partnered with NOAA, the National Fish and Wildlife Foundation, and numerous coral management and restoration groups, including Force Blue (a nonprofit that utilizes the skills of Special Operations veterans for ocean conservation), to coordinate large-scale reef assessments and coral triage recovery efforts.

During our own reef assessments, we were able to calculate coral survivorship at 14 outplanting sites after the storm. This allowed us to see which sites were the most

impacted by the hurricane and which fared the best.

Though it was devastating to find many of our home reefs drastically changed, many of our outplanting sites gave us cause for hope with corals still present and now showing signs of recovery.

We were able to use the information gathered during post-storm surveys to inform the selection of eight NOAA restoration priority sites (in accordance with CRF and NOAA's endangered species restoration plan), and to educate others on the effects of hurricanes on coral reefs.

Hurricane Irma was undoubtedly a setback, but with the dedication of the staff and help from our

supportive Keys community, the storm became an opportunity for CRF to become a more resilient organization on the whole.

We were able to use the experience to improve our methods, ultimately leading to the development of my intern project – an Emergency Weather Plan that is now a fixture of the organization's official policy.

Major storms will always be part of life in the Keys, both on land and underwater, but by continuing to gain new knowledge from each disturbance and appropriately adapting our restoration strategies, CRF is confident in the future of coral reef recovery, even in this age of increasingly extreme weather. 🌊



## THANKS TO OUR CONTRIBUTORS IN 2017

No contribution is too small to make a difference, and so, while it is impossible to list every contributor to Coral Restoration Foundation, we thank everyone who has supported our mission.

The following individuals and groups contributed gifts of \$500 or more to the organization between January 1<sup>st</sup>, 2017 and December 31<sup>st</sup>, 2017:

- 4Oceans
- Diedre and Andrew Agustin
- Amazon Smile
- American Spirits Exchange
- Paul M. Angell Family Foundation
- Anonymous (13)
- Chad and Kate Armstrong
- Kelly Baker and Whit Ellerman
- Barrette Family Fund of the New Hampshire Charitable Foundation
- Dr. Sally E. Bauer
- Beastly Threads, LLC
- Benevity
- James J. and Mary L. Boilini
- Thomas J Brickley
- Michael and Karen Brisch
- Bristol-Myers Squibb Company
- The Buchanan Family Foundation
- Mike and Deborah Campbell
- Capital Divers Association
- Humberto Casariego and Teresa Carreño
- Lisa and Kevin Cassidy
- Castle Services
- Central Aquatics
- Michele Chan
- Chesapeake Marine Aquaria Society
- Cindi Clapp
- Clif Bar Family Foundation
- Cool Coral and Henry Hittle
- George and Patricia Crull
- Davis Island Garden Club
- Craig and Cristina Decker and Family
- Debbie and Ken Dewey
- Dive Rite / Hires Family
- Raphael Dobler
- David Dunleavy and Dave Schacht
- Kathy Echevarria
- Mike and Laurie Echevarria
- The Echevarria Family Foundation
- Wendy and Michael Esposito
- Fidelity Charitable Gift Fund
- The Fikes Family

- Firth-Link Family Foundation
- The Florida Aquarium
- Florida Federation of Garden Clubs
- Florida Keys Brewing Company
- Florida Keys Electric Cooperative
- Freeborn & Peters LLP
- Stephen Frink Photographic, Inc.
- Kevin Gaines
- Garden Group at Ocean Reef
- Georgia Aquarium
- Greater Sacramento American Association of Zookeepers
- Green Bay Aquarium Society
- Roger A. and Tricia Grimes
- David and Patti Gross
- Laura & Fred Hartner
- John and Sharon Hauk
- Edward Hotard
- Islamorada Charter Boat Association
- Jacobs at the NASA Johnson Space Center
- Jax Reef and Marine Club, Inc.
- Teri Johnson-Sapp and Kelsey Johnson-Sapp
- Kelly Foundation Inc.
- Ronald J. Kemperle
- The Kirages Family
- Anne and Michael Krazer
- Michael Krieger
- Dr. Richard Krieger
- Gabriel and Angela Kwentus
- Todd and Diane Lary
- Lary Foundation
- Kyle Lauderdale
- Jake R. Levow
- The Loudermilk Family Foundation
- Lululemon Athletica
- Paul D. MacDougal
- The Marine Aquarium and Reef Society of Houston
- Marine Aquarium Societies of North America
- The Edward and Gale McBride Foundation Inc.
- Megazoo
- Mary and Barry Menne
- Dr. Steven Miller
- Missouri Aquarium Society
- Monroe County Tourist Development Council
- Douglas Morrison
- The Charles Hazlehurst Moura Family Foundation
- Timothy J. Mullican, DVM
- Bob Murray and Barbara Overton
- Negley Flinn Charitable Foundation
- Curtis Ness (Red River Reef and Reptile Expo)
- Network for Good
- NOAA's Office of Habitat Conservation
- Ocean Pointe Suites Key Largo
- Ocean Reef Club
- Ocean Reef Conservation Association
- Oris Watches
- Ken and Denise Nedimyer
- The Richard Laurence Parish Foundation
- Patagonia
- Marc and Diana Pelath
- Petco Animal Supplies
- Davis and Laurie Poole
- Michael J Popso
- Quality Marine
- Rainbow Reef Dive Center
- Redwood Coast American Association of Zoo Keepers
- Reef Aquaria Design
- Reef Visions Community
- Drew Richardson
- Rochester Area Community Foundation
- Rock the Ocean Foundation
- Royce Family Fund
- Mr. Saltwater Tank/Reef-a-Palooza Orlando Go-Kart Challenge
- Schwab Charitable Foundation
- Seachem Laboratories Inc.
- SEA LIFE Trust
- Sea Lily
- SeaWorld & Busch Gardens Conservation Fund
- Segrest Farms
- Helen and Ritter Shumway Foundation
- The Shumway Fund of the Ocean Reef Community Foundation
- The Silver Foundation
- Sascha and Anika Simon
- Richard and Sharon Slosar
- Snappers Key Largo
- South Miami Garden Club
- Adam Spector
- David Splitt and Laurene McKillop
- Senator and Mrs. Paul Steinberg
- Summit Homes Construction, LLC
- Michael and Janice Talbert
- Debby and Scott Thomas
- Tom Thumb Food Stores Inc.
- Betty and Bill Topercer
- Triad Foundation
- Tri-Tech Construction Inc.
- Jeff and Joleen Turner
- Rob Unruh
- Curt Varner Family
- Vertex Water Features
- Karen and Don Waite
- Philip and Betsey Walker
- Washington DC Area Marine Aquarist Society
- Waterfront Fine Homes
- Glenn White
- The Wilson Family
- David and Donna Wing
- Dr. Scott and Janice Winters
- Sim and Currie Wooten
- The Woroch/Vobach Family
- World Pet Association
- Wyland Worldwide, LLC
- Mike and Leslie Zimmer

### In Kind/Service Donations

We are grateful to those who have donated goods and/or services to support our mission between January 1<sup>st</sup>, 2017 and December 31<sup>st</sup>, 2017:

- Caribee Boat Sales and Marina
- Anne Davis
- Forever Young Charters
- Jacob's Aquatic Center
- J & B Marine Repairs
- Keys Diver
- Kraken Sports
- Mangrove Marina
- Marine Aquarium Societies of North America
- Ocean Divers
- Reef Photo & Video
- Southeast Trailering
- Quiescence Diving Services Inc.

*We strive for accuracy and are appreciative of the generosity of our many supporters. Please accept our sincere apology for any omissions or errors and feel free to bring corrections to the attention of our Development Department at (305) 453-7030:*

# INCOME & EXPENSES

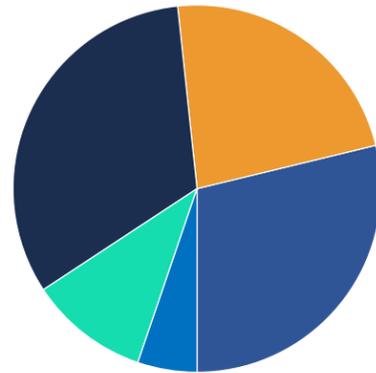
Our work at Coral Restoration Foundation is made possible by the generous support of individuals, corporations, private foundations, and government agencies.

The sources and allocation of our funding in 2017 are broken down as follows:

## SOURCES OF INCOME

Total Income: **\$2,200,543**

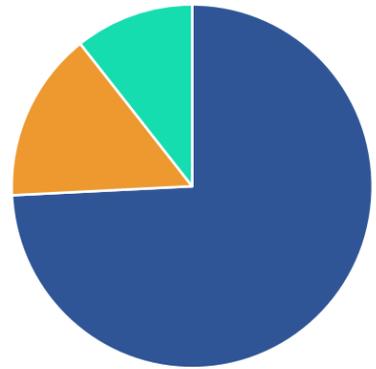
- Government **\$717,130**
- Foundations **\$633,638**
- Corporations **\$503,670**
- Individuals **\$231,356**
- Others **\$114,749**



## EXPENSES

Total Expenses: **\$1,956,853**

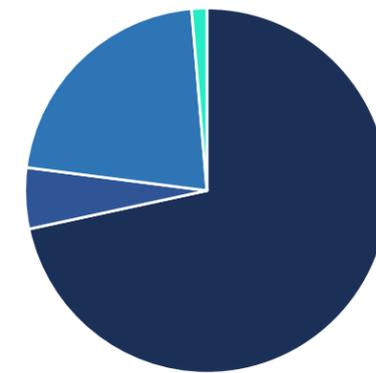
- Program Expenses **\$1,452,184**
- General & Admin **\$296,265**
- Fundraising **\$208,404**



## BREAKDOWN OF EXPENSES BY PROGRAM

Program Expenses: **\$1,452,184**

- Restoration **71%**
- Education **22%**
- Science **5%**
- International **2%**



Help preserve the legacy of our reefs. To make a gift, including those of stock or a bequest, please contact our Development Department by phone at (305) 453-7030, or send an email to [donors@coralrestoration.org](mailto:donors@coralrestoration.org).



**1.5 ACRES**

The size of the Tavernier Nursery, the largest in the world

**7**

Number of CRF Coral Tree Nurseries in the Florida Keys

**500+**

Total number of Coral Trees in the Florida Keys

**9**

Number of coral species we work with

**CORAL RESTORATION FOUNDATION**

**2017**  
IN NUMBERS

**66,000+**

Number of corals outplanted onto the Florida Reef Tract in the last 10 years

**77%**

Average survivorship across all sites and all species after one year

**13,435**

Number of corals outplanted to the Florida Reef Tract in 2017

**22**

Number of sites that received outplants in 2017

**296**

Number of coral genotypes that we work with



**8,325**

Number of people we reached through our presentations

**27**

Number of STEAM-based workshops developed for teachers

**10**

Number of graduate-level interns who joined us in 2017

**30+**

The number of institutions in our collaborative network

**11**

Number of research collaborations in 2017

**3**

Number of peer-reviewed studies for which we provided resources



**41,500**

Social media audience as this report goes to press in April 2018



**736**

Number of divers who joined our Dive Programs in 2017

**78**

Number of active volunteers in 2017

PLANT A CORAL, RESTORE A REEF

# CORAL RESTORATION FOUNDATION

Coral reefs are some of the world's most endangered,  
and yet most vital, ecosystems.

We are a non-profit ocean conservation organization working to restore  
our coral reefs, educating others on the importance of our oceans, and  
using science to further research and monitoring techniques.



Through the large-scale cultivation  
and outplanting of genetically diverse  
corals, we work to support the reefs'  
**natural recovery** processes.



CRF **engages and empowers others**  
in the mission to save our planet's coral  
reefs, with **dive programs, educational  
activities, scientific collaborations,**  
and **outreach**.



Come and visit us at our interactive  
**Exploration Center** at 5 Seagate  
Boulevard, Key Largo. Or you can  
go to our **website and follow us on  
social media:**

-  [www.coralrestoration.org](http://www.coralrestoration.org)
-  Coral Restoration Foundation
-  CoralRestorationFoundation
-  @CoralCRF

## HEADQUARTERS

89111 Overseas Highway  
Tavernier, FL 33070

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