



## **Acropora Recovery Implementation Team**

### **Annual Report January 2018**

#### ***Executive Summary***

The *Acropora* Recovery Implementation Team (ARIT) was created in 2017 to advise NOAA Fisheries Southeast Regional Office (SERO) on progress and needs within the context of the *Acropora* Recovery Plan. ARIT consists of members of academia, government, and non-government organizations who are experts on *Acropora cervicornis* and *A. palmata* and the stressors that threaten these populations. To date, ARIT has held one in-person meeting and six conference calls to complete several tasks and deliverables.

ARIT has compiled an inventory table of research projects and management applications that address specific actions called for within the *Acropora* Recovery Plan. This project inventory has been posted on the SERO [website](#). ARIT acknowledges some limitations associated with the inventory list, particularly that information outside of US jurisdiction is sparse, and that delineating *Acropora*-specific actions was challenging as many projects and actions focus on coral reefs or coastal areas in the broader sense. Efforts were documented within each recovery action, but the greatest amount of effort was associated with Action 6, which calls for active population enhancement of these two coral species. Substantial reductions in efforts to curb climate change such as the repeal of the Clean Power Plan and the US departure of The Paris Agreement, however, signifies retrogression in the potential recovery of these corals. Coral bleaching and disease outbreaks, both linked to climate change, are key threats to these species' survival.

ARIT also compiled a list of 16 priorities for near future action and investment, which were characterized on feasibility of significant progress, consideration of what has already been accomplished, and the timeframe likely needed for completion. Suggested methods for making progress within each priority are also identified. Particularly, ARIT recommends collaborative partnerships with already established working groups, the establishment of ARIT-led working groups, and the reactivation of previous research and management efforts with solid foundations already in place. The 16 priority actions are:

- Action 16: Study organismal response to nutrients and contaminants and implement remedies
- Action 5a:ii: Demographic monitoring reactivation
- Action 3d: Research host – symbiont relationships
- Action 5b: Genotyping and tracking
- Action 20: Reduce impacts from planned physical disturbances - no net loss from development projects

- Action 6a and 6ai: Scaling up restocking efforts and implementing a comprehensive restocking plan
- Action 11: Research and develop mechanisms to enhance adaptation/acclimation of elkhorn and staghorn corals to increases in climate stress
- Action 18/16b: Tightening the regulatory pathway for water quality
- Action 9: Reduce atmospheric CO<sub>2</sub> to a level compatible with coral recovery
- Action 8: Respond to, control, and minimize effects of disease events
- Action 4a: Develop, implement, and maintain a comprehensive species inventory database
- Action 2b: Create and maintain a central elkhorn and staghorn coral project/data repository
- Action 5ai: Implement a habitat-stratified random sampling approach for abundance assessment
- Action 6d: Develop ex situ conservation of corals and related organisms
- Action 5aiii: Evaluate robust reference populations

Finally, ARIT recognizes limitations and obstacles associated with the recovery of acroporid corals, including a limited amount of funding, global threats that are difficult to manage on local scales, and large disturbances such as Hurricanes Irma and Maria in 2017, which caused significant setbacks in *Acropora*-based research and restoration.

## **Background**

*Acropora cervicornis* and *A. palmata* were listed as threatened under the Endangered Species Act in 2006. In 2015, NOAA Fisheries released a final Recovery Plan for these two species. The following year, SERO appointed ARIT composed of members of academia, government, and non-governmental organizations with expertise on the species and threats affecting them.

ARIT's purpose is to advise SERO on issues related to the status and conservation of *Acropora* and to coordinate and guide Recovery Plan implementation via recommendations to SERO. ARIT is responsible for submitting a brief annual summary to SERO on the status and progress of the individual recovery actions listed in the *Acropora* Recovery Plan along with any recommendations, discrepancies, major accomplishments, and major obstacles encountered. This report summarizes the progress to date on the individual recovery actions and ARIT's recommended prioritization of actions in the plan and how they might be accomplished.

## **Progress to Date**

ARIT held its first meeting on May 16-17, 2017 to discuss the Recovery Plan and to prioritize the actions listed within the document. Upon convening, ARIT determined that its first task should be to document the research and management accomplishments to date that address actions identified in the Recovery Plan. ARIT began cataloging projects and accomplishments that were known among the team's network and constituencies as well as

those documented in the scientific literature. ARIT also sought direct input from the permit coordinator of the Florida Keys National Marine Sanctuary and the projects funded by the NOAA Coral Reef Conservation Program. Individual contact was made with project managers to clarify relevance and outcomes with regard to *Acropora* recovery actions as well as identify specific publications or other documentation. After this initial compilation by ARIT, further input was solicited from the broader Caribbean coral research and conservation community via CoraList, an email listserv with thousands of members.

Tremendous, though uneven, accomplishments have been made and are articulated in the Inventory Table (available on the SERO [website](#)). Some of the actions address very broad issues (e.g., outreach, overfishing, MPA management and general governance, seagrass/mangrove restoration, curtailing CO<sub>2</sub> pollution and climate change) and as such, present challenges in delineating the specific *Acropora*-recovery related actions. However, ARIT made its best attempt to do so, emphasizing those actions most relevant to *Acropora* recovery, with some acknowledged bias to US territories.

The greatest degree of novel, *Acropora*-focused activity has revolved around various aspects of Action 6, calling for active population enhancement of *Acropora* spp. Both government and non-government entities have invested significant time and effort, yielding the establishment and operation of *in situ* *Acropora* nursery stocking and outplanting efforts at scales of tens of thousands per year. Strides have also been evident in land-based culture and larval culture/restoration of *Acropora* corals. The general effort of *Acropora* population enhancement has also been accompanied by substantial and effective coordination and management planning efforts to enhance risk-minimization. Examples include the Smithsonian-hosted *Acropora* Coral Conservation/Restoration Workshop in 2009, the American Recovery and Reinvestment Act-sponsored collaboration establishing a US *in situ* *Acropora* nursery network, the development of a NOAA Management Plan for Caribbean *Acropora* Population Enhancement (2016), and the 2016 Workshop To Advance The Science & Practice of Caribbean Coral Restoration and resulting Coral Restoration Consortium (CRC). In some jurisdictions, *Acropora* nurseries and restoration is being integrated with mitigation of physical damage (Actions 19 and 20).

The progress on the several actions related to research and monitoring (e.g., Actions 3-5, 7, 11, 16) has been more mixed. Substantial progress in genetic studies, including inventory and tool development, is evident. In the years following the listing, additional investments in monitoring were made. However, sustainable funding for these efforts has not emerged, and many monitoring efforts have been reduced from lack of funds. Effective understanding of predominant disease etiologies and tools to reduce disease impacts in *Acropora* spp. remain elusive. Meanwhile, some research and monitoring actions remain largely unaddressed, such as testing the effects of contaminants and conducting basic water quality monitoring within areas of critical *Acropora* habitat (Actions 5aiv and 16a). A key exception is recent work documenting detrimental effects of certain sunscreen chemicals (Downs et al. 2015). However, even in this case of experimental demonstration of contaminant effects (Action 16a), the translation of this result to 'implement appropriate remedies' has not been accomplished, either at state or federal levels.

In surveying other threat reduction and management actions for recovery, there is also a mixed report. The Paris Agreement under the UN Framework Convention on Climate Change

promises unprecedented progress in curtailing climate change (Action 9), and 168 of 197 parties have ratified it. However, the US has announced intention to withdraw. The repeal of the US Clean Power Plan, which was established to encourage the use of renewable sources of energy, may also rollback progress towards reduced carbon emissions. Climate change remains an existential threat to *Acropora* recovery, as observed in the 2014 (Florida) and 2015 bleaching effects. ARIT believes these frequent and severe bleaching events are leading to the current exploration and expansion of more interventionist measures as called for in Actions 8, 10, and 11).

Identified management actions that reduce land-based sources of pollution on coral reefs (Actions 14 and 15) largely revolve around the development of watershed management plans in Puerto Rico and US Virgin Islands. Many projects associated with these plans aim to reduce sediment runoff through site-specific actions like road stabilization and erosion control. Additionally, projects funded or implemented through the NOAA Restoration Center have restored mangroves and seagrass at specific sites.

Fishery management actions addressed in Recovery Action 12 (and 18) include reduction in the allowable annual take of grazers (parrotfish and surgeonfish) in all waters of the U.S. Caribbean, with the largest cuts implemented in waters surrounding St. Croix where parrotfish are targeted. Harvest of the three largest parrotfish species (midnight, blue, and rainbow) has been prohibited throughout the region. Minimum size limits have been implemented for parrotfish in St. Croix waters. In the wider Caribbean, parrotfish harvest has been banned in Belize, Antigua, Barbuda, and the Dominican Republic, and surgeonfish harvest has been banned in Belize and the Dominican Republic. Some of these bans are only temporary. Restrictions on urchin harvest are in place in the U.S. Caribbean, the Dominican Republic, Antigua, Barbuda, St. Lucia, Grenada, Barbados, and Martinique.

The current accomplishments compilation is admittedly incomplete, and likely still biased to US efforts. However, ARIT intends to maintain, improve, and update the accomplishments inventory as a living document, with additional assistance from the coral conservation and research community.

## **Priorities**

The following actions from the *Acropora* Recovery Plan have been identified by ARIT as priorities for near-future action and investment (Table 1). Starting with an inventory of accomplishments to-date under the Recovery Plan, ARIT arrived at these priorities based on importance, feasibility of significant progress, and consideration of what has been accomplished so far. Some suggestions for how progress might be made are also included, though subject to capacity and availability of resources. ARIT recognizes that developing realistic cost estimates and (for some) performance measures for these priority actions may be a helpful tool in encouraging implementation by both agencies and partnering organizations, but is beyond our scope to date.

**TABLE 1:** Summary of Recovery Actions identified as priorities for upcoming action due to lack of progress so far, importance, and/or feasibility of progress. An explanation for each priority action is given in the paragraphs below.

Recovery Action Number	Description	Priority	Time Frame	How could progress be made?
16	Ecotoxicology	High	Near	ARIT Working Group
5aii	Demographic monitoring	High	Near	Reactivate previous efforts in territories; identify sustainable funding stream
3d	Microbiome	High	Near	ARIT Working Group
5b	Genetic identity tracking/database	High	Near	Coral Restoration Consortium (CRC) Genetics Working Group
20	No net loss from planned projects	High	Near	SERO Working Group
6ai	Comprehensive restocking plan - scaling up	High	Near	CRC 'Scaling Up' Working Group(s)
11	Proactive climate adaptation/ acclimation enhancement	High	Near	NOAA-sponsored National Academy of Science review for science/risk assessment; NOAA Fisheries Office of Protected Resources with SERO to undertake policy review
18/16b	Tightening the regulatory pathway for water quality	High	Intermediate	ARIT/EPA Working Group to include representatives from relevant regulatory agencies
9	CO <sub>2</sub>	High	Long	International, national, local, and personal changes
8	Disease mitigation	High	Long	Existing disease intervention Work Group in Florida and USVI
4a	Geo/abundance databases	Medium	Near	ARIT Working Group
2b	<i>Acropora</i> recovery project database	Medium	Intermediate	ARIT
5ai	Monitoring,	Medium	Intermediate	Strategic enhancement of

	synoptic surveys			existing monitoring programs (NCRMP, FRRP, USVI-TCREMP)
6a	Comprehensive restocking plan - population genetics planning approach	Medium	Intermediate	CRC Genetics Working Group
6d	Cryo-archiving, live banking	Medium	Intermediate	ARIT Working Group
5aiii	Id reference populations	Medium	Intermediate	Targeted supplemental effort to demographic monitoring efforts

**Action 16: Study organismal response to nutrients and contaminants and implement remedies**

Action 16, specifically the study of contaminants using an ecotoxicology approach, was ranked as a high priority by ARIT with the potential to conduct research and progress our current understanding of this topic within the near-term. Exposure of *A. palmata* and *A. cervicornis* to land-based sources of pollution or to personal care products (PCPs) from direct human interaction has not been well studied. Research has suggested that PCPs, such as some sunscreens that contain oxybenzone, can cause coral bleaching and mortality. However, there are many other endocrine-disrupting compounds and contaminants that have not been tested. Understanding the effects of exposure to contaminants can provide the information needed to guide biocriteria levels essential for management action, control, and mitigation. Ecotoxicology experiments are also relatively easy to accomplish within a laboratory setting, which can determine the approximate lethal dose, and concentration thresholds that cause negative effects on corals once surpassed. Funding support by the Environmental Protection Agency (EPA) has been provided in the past to test the effects of endocrine-disrupting compounds on corals and future EPA support may occur. ARIT recommends that a working group could advance this priority via the following goals: 1) compile information from previous published literature, white papers, and grey literature to establish a current state of knowledge, 2) identify and prioritize gaps within this topic that need to be researched, and 3) conduct or encourage the support of research focusing on identifying the effects of land-based sources of pollution and other contaminants that may cause harm to acroporid corals.

**Action 5aii: Demographic monitoring**

ARIT ranked demographic monitoring of *Acropora* spp. populations throughout U.S. Jurisdiction as a high priority. While a large-scale demographic monitoring program in Florida, Puerto Rico, and the U.S. Virgin Islands (funded by NOAA Species Recovery Grants to States) established the infrastructure to determine a baseline for U.S. populations, funding lapsed in 2013. A small-scale effort to monitor *A. palmata* populations in Florida (funded by NOAA) is

ongoing through 2020, but funds are needed to revive sister monitoring programs in the U.S. territories to truly address Recovery Criterion 1 (understanding current trends in abundance and distribution of both species). Coral population status and trends can drastically change in a short timeframe, and re-evaluating the current size distribution, abundance, and habitat occupation of *Acropora* spp. comprise easily obtainable metrics by which to evaluate recovery actions. Sustainable funding is needed to reactivate and maintain demographic monitoring.

### **Action 3d: Research host – symbiont relationships**

Action 3d, understanding the host-symbiont relationships and ultimately the microbiome of acroporid corals, was ranked as a high priority by ARIT with the potential to conduct research and progress our current understanding of this topic within the near-term. The microbiome of the coral, which contains bacteria, archaea, viruses, fungi, and *Symbiodinium* algae, influences the coral host's physiological state, potentially acting as transient partners, commensals, pathogens, or symbionts. Much recent research has focused on the bacterial communities of corals as well as the algal components within the microbiome. ARIT recommends that a working group could advance this action by compiling and synthesizing information already published, as well as identifying research that is in progress, which focuses on key functional aspects of the microbiome of Atlantic *Acropora* corals. Potential research gaps, such as characterizing lesser-known components of the microbiome, how environmental and ecological variables cause shifts in the microbiome, and the consequences of such shifts for coral health, as well as other research gaps, will be identified.

### **Action 5b: Genotyping and tracking**

While extensive progress has been made in genotyping individuals within both monitoring and population enhancement activities, ARIT identified the need for a comprehensive database for tracking individual genotypic identities as a high priority that must be addressed in the short term. ARIT is also convinced that this genotype/identity database needs to be a distinct tool from the inventory/abundance database described under Action 4a (this is a slight modification from the description in the Recovery Plan). This action needs to be comprehensively addressed sooner rather than later as the importance of tracking individual genotypes, particularly in the context of population enhancement, has led to multiple autonomous efforts already underway (e.g., Coral Restoration Foundation, Baums lab of Penn State University, State of Florida). The longer that comprehensive coordination is delayed, the harder the job will be to pull these competing efforts together, or at minimum cross-link them. A genetics working group has been formed within the incipient CRC that also has comprehensive genotype cataloging and tracking as a goal. ARIT suggests that this group is best positioned to make progress on this action, but the identification of resources to sustain the catalog over the long term remains an unmet need.

### **Action 20: Reduce impacts from planned physical disturbances - no net loss from development projects**

ARIT ranked “Reducing impacts from planned physical disturbances - no net loss from development projects” (Action 20) as a high priority in the near term. ARIT considers this action

highly achievable because SERO has direct influence over this action through the interagency consultation process and because of the existing coral nurseries throughout US jurisdiction that can receive and provide colonies for propagation and transplantation. It is ARIT's understanding that SERO regularly negotiates for impact avoidance, minimization, and for colonies to be moved out of impact areas but that some mortality is authorized for various reasons such as transplantation mortality. ARIT recommends that SERO continues to negotiate for impact avoidance, minimization, and transplantation out of impact areas and further addresses this action through a SERO working group. The SERO working group should identify and track how much mortality has occurred due to coastal construction projects, use this information to inform future consultation impact avoidance and minimization, and strive to achieve the "no net loss" portion of the action. Various strategies, such as using coral nurseries for both accepting colonies that will potentially be impacted and for outplanting colonies to replace any that may be lost due to construction and related activities, are available to achieve the no net loss goal. Implementation of 'no net loss' should consider population and ecosystem function of impacted colonies (e.g., species and size structure, reproductive contribution) not just simple census counts.

#### **Action 6a and 6ai: Implementing a comprehensive restocking plan: Scaling up using a population genetics planning approach**

Tremendous growth in effort, scale, and effective nursery culture and restocking has occurred since the inception of the Recovery Plan (see Accomplishments inventory). This effort is dominated by asexual propagation in field-based nurseries followed by outplanting to local reefs. There is now recognition that these successful efforts need to be 'scaled up', including development of techniques with reduced labor/effort to reduce costs, in order to better address reef-scale recovery across the range as required to meet the population-based recovery criteria. ARIT rated this action as a high priority over the near term, and this action will be accomplished in conjunction with the recently formed CRC that has identified a working group to address this topic.

Over time, there has also been greater effort and growing success in both land-based propagation and larval propagation/restoration. The strategic integration of these different population enhancement approaches is also identified as a priority. As the overall proportion of the total population derived from enhancement efforts increases, along with the consideration of more assertive genetic interventions, the need for comprehensive and wise genetic planning of these integrated population enhancement efforts is also identified as a medium priority over an intermediate timeframe.

#### **Action 11: Research and develop mechanisms to enhance adaptation/acclimation of elkhorn and staghorn corals to increases in climate stress**

This action was rated as a high, near term priority. As with several other priority actions, the interest and need for this action is markedly more acute than when the Recovery Plan was originally drafted. The recent global coral bleaching event (2014-2016) and resultant mass coral mortality has raised awareness that conventional conservation strategies are not effective in



protecting corals from climate stressors. This realization has been accompanied by increasing discussion in the scientific and popular literature for the consideration and development of more novel interventions to enhance coral resilience. Strategies that have been proposed for consideration range from translocation of corals (or potentially coral gametes if available in cryo-archives) from more thermally tolerant to more thermally sensitive populations, manipulation of coral symbioses, or more radical types of genetic modification.

NOAA has commissioned a review study by the National Academy of Science (NAS) to evaluate this range of potential coral interventions and provide an assessment of risks as well as benefits. The outcomes of this review (interim report available June 2018 and final in fall 2019) should provide a very useful framework regarding both research needed to narrow uncertainties and risks as well as any steps that may be appropriate to move toward implementation on any of this range of intervention strategies. However, there is a very important need for policy review and considerations (separate from the NAS study which is focused on science underpinnings and risk assessment) in terms of what subset of intervention strategies under discussion are compatible with ESA recovery. It seems likely that some are and some may not be. This policy evaluation needs to be undertaken sooner rather than later in order to make best and timely use of the NAS review outcomes. ARIT recommends that SERO takes the lead in identifying the need within the agency for a policy review of intervention strategies that are or are not acceptable within the context of the ESA.

#### **Action 18/16b: Tightening the regulatory pathway for water quality**

This action was rated as a high-importance, intermediate-term priority for ARIT. Currently, it is clear that there is some level of disconnect between researchers generating data regarding reef threats and health, and the agencies responsible for creating and enforcing regulations protective of reef systems, including ESA-listed species such as *Acropora*. Tightening the regulatory pathway for water quality ensures that researchers and regulators are communicating with each other in a clear and effective manner, that the best available scientific information is being incorporated into regulations (e.g., water quality standards), and that data gaps and needs are being communicated and addressed. In order to help streamline the regulatory pathway, ARIT, along with the Environmental Protection Agency (EPA), could form a working group comprised of state, federal, and local environmental regulators, as well as researchers. As currently envisioned, the purpose of the working group would be to (1) clarify how researchers can generate and report data that can be incorporated into regulations at the federal, state, and local level; (2) ensure that regulatory agencies are communicating with researchers and each other regarding emerging contaminants, threats, etc. and potential regulatory fixes; and (3) attempt to create a network of consistent, equally protective standards and regulations for *Acropora* within US jurisdiction. The working group should also coordinate with the ecotoxicology working group to help achieve these goals, and to ensure that the best available scientific information is being utilized.

#### **Action 9: Reduce atmospheric CO<sub>2</sub> to a level compatible with coral recovery**

Warming temperatures and ocean acidification are identified in the *Acropora* Recovery Plan as two of the top three factors inhibiting coral recovery. Hence, it is crucial to accomplish

this action to ensure survival of the species. Improvements can be made by international, national, local, and personal changes to convert to renewable energy sources, adjust land use, and reduce consumption of methane-producing diets. Implementation of this action is largely outside the purview of ARIT and NOAA Fisheries, but ARIT felt it was important to identify this action as a high priority given the magnitude of its effect on the ability of these two species to recover.

### **Action 8: Respond to, control, and minimize the effects of disease events**

Action 8, specifically minimizing the effects of coral disease events, was ranked as a high priority by ARIT with the ability to accomplish this goal over the long term. Coral disease, often caused by unknown infectious agents, is one of the greatest threats to *A. palmata* and *A. cervicornis*. Preventing disease outbreaks, which appear to be influenced heavily by the environment, will be a significant challenge that cannot be accomplished within a local scale. However, stopping or slowing disease progression within colonies and preventing transmission among colonies may be attainable. Support from the National Park Service has been provided for some initial testing at Buck Island Reef National Monument, and future funds may be allocated to expand the research to multiple coral diseases at multiple National Parks within the US Virgin Islands. A recent workshop (Oct 2017) sponsored by Florida DEP and FWCC has articulated suggested experimental interventions that should be tested as effective means for coral disease mitigation and control (report available [here](#)). Although the focus of this Florida effort is on mounding corals, these workshop recommendations provide a reasonable roadmap for advancing *Acropora* disease mitigation.

### **Action 4a: Develop, implement, and maintain a comprehensive species inventory database**

ARIT ranked action 4a, develop, implement, and maintain a comprehensive species inventory database, as a medium priority in the near term. In order to facilitate ongoing assessment of the status of both species and determining the efficacy of conservation actions, a central comprehensive database must be developed and implemented. There are currently multiple efforts underway through NOAA, Florida Fish and Wildlife Conservation Commission, and others. In order to better understand these efforts and possibly coordinate across them, a working group could be formed. The goal of the working group would be to 1) assure that all appropriate data are being deposited in a publicly available data repository and 2) coordinate between data repositories as much as possible to have the best understanding of both the availability of data as well as knowledge of where data gaps exist. The major hurdles to overcome with this effort are gaining access to data that are needed, but unwilling to be publicly available, and identifying capacity and infrastructure to help centralize this effort and sustain it over the long term. This is only of medium importance because this does not directly affect the monitoring itself, but helps to gain a better understanding of what is known overall.

### **Action 2b: Create and maintain a central elkhorn and staghorn coral project/data repository**

ARIT ranked action 2b, create and maintain a central elkhorn and staghorn coral project/data repository, as medium importance in the intermediate timeframe. To understand the breadth of work being done that contributes to the *Acropora* Recovery Plan, a database is needed to track the number of projects, the actions they contribute to, and to monitor their progress. Currently ARIT is tracking projects through a spreadsheet populated by projects known to the team members. It has been posted to the SERO [website](#) to allow the information to be circulated to fully capture and track all projects that are contributing to the *Acropora* Recovery Plan.

#### **Action 5ai: Implement a habitat-stratified random sampling approach for abundance assessment**

This action was rated as medium priority over an intermediate timeframe. This action, in concert with 5aia, is necessary for ongoing assessment of species status and recovery. Specifically, this action is needed to evaluate trends in population abundance parsed by specific habitat strata as required by Recovery Criterion 1. Considerable progress had been accomplished under this action, including synoptic surveys throughout St. Croix, USVI and Puerto Rico waters under the ESA Section 6 program funding, and synoptic surveys performed for the Florida Reef Tract funded by the FKNMS conducted by UNCW/Nova Southeastern University (S. Miller lead). However, these efforts were both under episodic funding, and ARIT is not aware of any supported efforts for the needed 5 year review process, evaluation of effects of the 2017 hurricane season, nor evaluation of the potential wide-scale benefits of other recovery actions. While benthic monitoring of coral reefs under various programs (e.g., National Coral Reef Monitoring Program (NCRMP), Florida Reef Resilience Program (FRRP), USVI Territorial Coral Reef Monitoring Program (TCRMP)) provides some information about *Acropora*, these efforts are not designed to specifically target listed *Acropora* species and thus often fail to provide robust results (i.e., too few colonies are captured in these regional sampling efforts to draw meaningful conclusions regarding *Acropora* status). However, strategic incremental investment in these existing monitoring programs could fulfill this need at moderate cost.

#### **Action 6d: Develop ex situ conservation of corals and related organisms**

This action was rated by ARIT as a medium priority over an intermediate timeframe. The realization of worsening environmental conditions, including severe thermal bleaching in 2014 and 2015 and severe hurricanes in 2017, emphasizes the original context of need for this action, as 'insurance' against catastrophic losses in local populations. Although considerable technical advances have been made in both laboratory rearing and cryo-preservation of elkhorn and staghorn coral colonies, tissues, and gametes, there has been little action or progress in terms of coordinating and prioritizing either live or cryo-preserved archives for either species. The potential for cryo-archiving both coral tissue explants and/or coral sperm represent different potential applications and opportunities in future recovery strategies. Specifically, the availability of cryo-archived coral gametes (at this time primarily sperm) from different locations throughout the species' range may provide opportunities for transfer of genetic resilience among

populations (by implementing cross-fertilization during local spawning events) when or if this is deemed an appropriate strategy.

To maintain as much future opportunity as possible, coordinated planning and prioritization is needed to focus effort on both live archiving and cryo-archiving collections. Determinations need to be made regarding what sort of tissues (live/aquarium banking, cryo-preserved tissues, cryo-preserved gametes), from where, and how many from each location are needed to maximize future opportunities for enhancing resilience and restoration. Also, a strategy needs to be identified to maintain these collections over the long term (e.g., public access facility and long-term support). A working group is likely needed to address these difficult questions.

### **Action 5aiii: Evaluate robust reference populations**

ARIT ranked evaluating robust reference populations (Action 5aiii) as a medium priority in the intermediate timeframe. Evaluating robust populations is important for informing recovery criteria development and restoration efforts by characterizing contemporary functional thickets and the environmental and ecological properties that support their persistence. Some of the known thickets have declined or disappeared in the last few years, indicating time may be a factor in the ability to collect needed information. Linking this action to Demographic Monitoring Action 5ai would facilitate data gathering.

## **Obstacles**

Sustainable support for long-term efforts such as monitoring, databases, and biological archiving are always substantial hurdles, but is crucial to the advance of many diverse recovery actions. The need to sustain monitoring efforts has been dramatically illustrated in the past few years. Devastating bleaching and hurricane impacts over all of the US range as well as a substantial portion of the entire range of the species suggests substantive, negative change in status have occurred rapidly. Prior studies have documented severe hurricane impacts and continuing follow-on declines from disease and predation after severe hurricane impacts. These disruptive events add to urgency of need for current information to feed assessment for the five-year status review due in 2019.

The severe hurricane disturbances also likely represent substantial setbacks for many of the other recovery actions and accomplishments including population enhancement and some threat-reduction actions, though the scope of these setbacks remains to be fully understood.

## **Conclusions**

ARIT was created, in part, to characterize the progress of research and management actions outlined within the *Acropora* Recovery Plan. So far, the group has compiled the current efforts associated with each of the action items within the plan and identified gaps that exist within these efforts. The created document has been shared with the coral reef community, as well as the public, and will act as a 'living document' to be updated as further research and management actions take place. ARIT also created a list of 16 priorities that identify pertinent

areas of research or management for near-future investment, and provide guidance for implementing actions related to these priority areas. Obstacles, such as chronic disease outbreaks, back-to-back coral bleaching events, and strong hurricanes continue to limit progress towards the actions identified within the Recovery Plan. Future efforts for ARIT include continuous updating of the progress towards Recovery Plan actions, providing guidance for future funding initiatives, and the participation within current working groups and the formation of ARIT-led working groups to address priority actions identified.