



These questions and answers followed a webinar presented by the Coral Restoration Consortium on August 8, 2023. The title of the webinar was "[Coping with the 2023 Bleaching Event](#)." A panel presented and discussed strategies for restoration practitioners to prepare, manage, monitor, and recover from the current coral bleaching event. To continue the conversation, join the [facebook group](#) that the CRC has created on the same topic.

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## Predicting Bleaching

### **1. Is it possible to get a NOAA Coral Reef Watch virtual station added?**

We do welcome requests for single-pixel virtual stations, but we have a specific prioritization plan in place, such that we are first focusing on key restoration/nursery sites in US jurisdictions. Once we are able to accommodate our partners/collaborators doing restoration activities in the US jurisdictions, then we will begin considering key international restoration/nursery sites. We don't have a timeline for this because we didn't anticipate this large-scale event happening and it's not clear how long it will take for us to accommodate requests and set up stations. We had originally planned on doing this for US jurisdictions over the next 3 years, but that timeline is being rapidly accelerated and it's not totally clear just how quickly we are going to be able to do this.

### **2. Is there any Coral Reef Pixel Station in the Puerto Rico area?**

Yes! We have a regional virtual station for Puerto Rico. Here is the link to the "alert gauges & outlook."  
[https://coralreefwatch.noaa.gov/product/vs/gauges/puerto\\_rico.php](https://coralreefwatch.noaa.gov/product/vs/gauges/puerto_rico.php)

### **3. On the NOAA site, are you able to go back to look at the archived outlooks and watches? For example, if we wanted to look at how alerts have changed throughout the summer?**

Yes, if you go to the "alert gauges & outlook" link of a regional virtual station, you have the option to look at archived outlook back in time. However, the outlook product is only available from 2017 onward. All the other CRW products are available back to 1985.

#### More Information:

The NOAA Coral Reef Watch 5km satellite products tutorial, it is available at <https://coralreefwatch.noaa.gov/product/5km/tutorial/welcome.php>

For a simple, photographic display of the role of shading UV vs. PAR during a bleaching event in Hawaii, open access and photographs are in the public domain for anyone's use, see <https://www.usgs.gov/media/images/coral-shading-experiment-during-a-bleaching-event>

## Strategies for Field-based Coral Nurseries

### Shallow Nurseries

#### **4. Any concerns about reverse thermoclines within the shallow water nurseries when pulling coral trees down to the bottom?**

The short answer is "no", but yes, it's acknowledged as a possibility....again, it's about what decision we can make now with the information and current conditions we have at the moment and balancing the alternative of not shortening them and maintaining them high in the water column closer to the surface.

### Deep-water Nurseries

#### **5. Trade off of moving nurseries to deep water was mentioned, could you speak about what the possibilities and challenges for depth change are?**

For movement of corals to deeper waters- some of the tradeoffs are maybe more programmatic/logistic-related than ecological. There is the question of coral health- in the Florida Keys the Acroporas aren't found in deep waters (other locations, yes). So, there is a question of how well they will do and for how long can they stay at that depth. Currently, temperatures at depth in the Keys are the same as the shallow, but in theory they will experience less light (irradiance) and cool down quicker.

The other trade offs are more related to logistics and an individual program. Questions like- where would a new nursery be located? and are permits needed to get started? Time to install nursery structures? Time to move corals? Etc... Depending on the nursery structures used, there is not a simple way to simply pick up an entire nursery structure and drop it off deep. So, you need to create an anchor system deep, and move corals/structures bit by bit etc... can that be done quick enough to make an impact? And is that the best use of your resources?

The other consideration is dive safety. It's much different to work at 20m+ than 5m. These are some of the things our team is grappling with at the moment. If you're considering moving deep, my suggestion

would be to map out the process first, including the dive safety element, and use that to help make a decision on how to best move forward.

**6. Did anybody move nurseries to significantly deeper waters or has any experience on it? ie. from 25ft to 70ft.**

Reef Renewal USA in the Florida Keys are moving some nursery stock to 60ft, however, the temperature at 60ft is currently the same as the temperature at 20ft. The effort continues because even though the temperature is the same, the deeper nursery has less intense light conditions and should cool quicker than the shallow nursery.

Project in the Maldives during the 2016 bleaching event where the Pocillopora that were moved to deeper waters did not fare as well as the corals of the same species that were left in the shallower, hotter water. Conversely, the Acroporids on that same project that were also moved to deeper locations definitely benefited from the deeper, cooler water. If you are considering moving corals to deeper water, there could be differences between species so consider leaving some stock in the shallower water and monitoring both the shallow and deeper locations to see how each species does.

**7. For what scale would you recommend moving deeper? And if a large well-attached native coral, have you tried this? By scale, I mean the size of a coral head, or are you speaking only about fragments?**

This is in reference to moving fragments in a field-based nursery to a deeper, temporary nursery location.

The answer/recommendation here would probably vary by location and program. Practitioners should think a few steps ahead and to what they want to accomplish *after* the event subsides, what's the priority? And based on your "next steps" put energy into moving what you need to achieve that next step in the future. A general recommendation would be to move larger colonies over smaller ones. Larger are more likely to handle stress of the move and provide a greater amount of material to frag-out at a later date and re-build stock. Also you're probably able to move fewer large colonies quicker than multiple small colonies. Would recommend protecting/prioritizing genetic diversity in your decision making.

**8. In the mid 2000's there was a cold water bleaching event, I think in a non el nino year, if we take corals from the hotter lagoon/near shore areas, won't cold water bleaching also be a problem?**

While sudden changes in temperature in either direction can detrimentally affect corals, in this scenario of moving coral to deeper nurseries, the intention is to move the coral to water that is only a couple of degrees cooler. Similarly, when coral is removed from the field-based nursery during these extreme heating conditions for temporary holding in a land-based nursery, the water temperature is gradually decreased to reacclimate the corals to the more suitable temperature of the aquarium. When returning corals from deeper nurseries to the shallower nurseries, care must be taken to make the return gradual as the coral must reacclimate to increased light conditions.

## Resilience and Resistance

**9. If perhaps there is a catastrophic wipe out this year , how do you think the corals you have saved will be strong enough to handle future high temp events? Based on this year's bleaching results how will your future transplant and nursery areas change (in scales from inter site to inter region)?**

Over the years one of the big things we've come to understand is that corals behave differently depending on site, season, event etc. Which is why we promote diversity in our restoration efforts. How things will change- we're not sure yet and will depend on what ultimately happens. Like Austin was saying (and is mentioned in the CRCs monitoring guide as well), often those corals that survive an event have/retain their resilience to future events. So their performance through the event will help inform our decisions moving forward as well. Some additional things to remember/consider are:

- Post-bleaching nursery and reef surveying and monitoring is now more important than ever to understand where and what there is in terms of resilience. Contrasting that information with previous data will help to guide future efforts and decision making.
- There is no guarantee that saved corals will be strong enough to handle future high temperatures. However, there is a better chance to be able to restore coral populations if we have a genetically diverse stock to start with in a way that is informed by the observation obtained by the previous point.

**10. I just got back from diving in the Red Sea. Are any studies going on looking at these variables?  
Coral was in great shape.**

There are studies looking at temperature and coral health in the Red Sea, KAUST is one of the institutions looking at these variables. There is some expectation that the corals of the Red Sea are adapted to higher temperatures, however, temperatures that are being observed are higher than seasonal norms so this year will be a test of this theory.

**11. Coral color card is one method to find out the health of corals. Is any specific software with artificial intelligence technology available for coral distribution and identification?**

Not that we're aware of for large-scale use. [Reef Support](#) is working on such a tool.

**12. Is it possible for people to heal bleached coral and if yes, how would it be possible?**

Depending on the extent of the heat and how long elevated temperatures last, bleached corals can recover. This is often seen in short periods of high temps. The challenge with this event is that temperatures are extremely high (record breaking), arriving early, and persisting longer. What we're seeing is corals basically blanch and fry quickly because it is so hot. Those that are only paling or beached, will become a question of how long can they stay like that.

Intervention strategies like shading, probiotics, etc are some strategies that may have an impact in helping corals ameliorate the impact of high temps.

## Shading

### Nursery/Reef Shading

**13. When using the horizontal rope nurseries as the coral grows it rotates i.e. changes its orientation , and because of this the nursery grown corals polyps do not have a unidirectional growth, have you had any problems after outplanting such corals?**

No, the colony forms a roughly circular form over time, and at one year we replant the gene bank line and outplant everything else as 15-20 cm fragments affixed to A-frames, all during the cool season.

**14. Re: surface level shading, such as sargassum mats, have there been any trials or studies involving surface level shading, besides fogging? (More along the lines of a "floating" shade device or mat versus the underwater shading). This could potentially cover a larger area and allow easier access for cleaning and removal. What would be some of the obstacles with implementing this type of shading method?**

Obstacles include: permitting/regulatory agencies. Creation of navigational hazards. Logistics of how to deploy and manage, etc. Would need to understand when (how far in advance of an event) and for how long to deploy to make a difference.

**15. Normally the endosymbionts of scleractinian corals required sunlight for photosynthesis with simultaneous production of CaCO<sub>3</sub> structures. If shading nursery, how is the growth of corals and their productivity?**

When shading in the context of preventing or alleviating stress as a result of direct sunlight, the idea is that shading of the corals would only be done for a certain period of time to prevent complete loss of the coral and that without the shading, the coral would likely experience bleaching and potential mortality.

**16. What materials are the shading structures made from?**

Shade cloth is a material that can be purchased in most hardware stores. It is often used to protect greenhouse plants from too much direct sun. Some shading structures are custom built to attach to nursery structures that are made out of PVC or rebar and make use of buoys to float above corals. Other shades have rebar sewn in to stretch over a nursery structure to help position them.

**17. What is the maximum percent shading that can be used without negatively affecting the corals and zooxanthellae? Would applying UV and blue light-blocking yellow filters have a beneficial effect or negatively impact photosynthesis?**

The effects of shading decrease when you block out more than 30% of incident light. However, one of the presenters used 50% shading for a limited amount of time and the corals survived. Coral growth and zooxanthellae production will be negatively affected by shading; that is the tradeoff when the alternative is coral bleaching or death.

## Atmospheric Shading

### **19. How long does fog last before it dissipates? Is constant fogging necessary to somewhat lower temperature/light over a period of time?**

Conclusions from fogging tests are that fogging needs to be run during the most intense light parts of the day and that the fogger/s must be run constantly during that time. There are limits to the benefits of the fogging as it's not cooling the water, only reducing the intensity of the sunlight so starting the process before water temperatures critically rise

### **21. What about cloud shading as a method of shading?**

Cloud brightening is being tested - reduce the size of the vapor droplets in clouds resulting in more droplets and reflection of sunlight. This does not have the same effect as shading and maybe will change the level of light coming through the clouds by a maximum of 5-10%. This method requires specific aerosol counts and has to be done over a long period of time beginning before water temperatures rise and would have to be done over a large area to account for the boundary effects of water movement.

### **22. Use of cloud seeding?**

Cloud seeding is increasing the size of vapor droplets in order to induce rain/clouds. This system also requires very specific atmospheric conditions and high investment. The group is not aware of anyone studying this in conjunction with coral reefs, but a benefit to coral reefs could potentially be that rain falling on the surface of the water could have a cooling effect.

### **23. Is there a group we can put together to facilitate multiple cooling innovations that are in the beginning stages of proof of concept?**

Yes. Please reach out to the [CRC's Engineering and Innovations Working Group](#).

### **24. Are there any experiences for moving coral to natural shade areas, for example, caves?**

Because of the algae that live inside their bodies, corals depend on natural light in order to live. Corals would not survive in caves. However, shading corals temporarily during hot water events - is recommended. And cool water refuges are an excellent place to grow corals until the oceans cool or during a marine heatwave.

## Sampling for Genetic Preservation

**25. If you are preserving a sample in RNAlater for microbial analysis, do you freeze, unthaw, then change out the RNAlater 24 hours later? Or am I misunderstanding a piece of the protocol?**

RNAlater should soak into the sample for 24 hrs in the fridge before placing it into a freezer. Changing preservative is particularly useful when using Ethanol. Don't do this with RNA/DNA shield because some of the DNA is found in the liquid.

## Evacuation to Land-based Nurseries

**26. How can less-resourced places preserve genetic diversity from their own nurseries in land-based settings in case of emergency? What are the minimum resources necessary?**

Suggestions from an aquarist:

Temperature control within 1C max. Coolers rather than “bins”

Appropriate saltwater and saltwater exchange. Maintaining uniform water chemistry, this is essential.

Appropriate light (and UV) exposure

Flow is essential (DBL)

Use appropriate materials (Drinking water safe/aquarium safe)

**27. Any comments on a land nursery for use at all times to provide field nurseries when needed after bleaching times, not just as a gene bank holding system?**

Yes, there is a lot of potential of a combined land/field based approach in restoration efforts. We've seen this with aquariums who raise larvae ex situ then provide them to in situ programs to grow, propagate, and fold into restoration efforts. Other examples- **Mote (Summerland Key), KAUST - Shushah plans, etc.**



## Broad Questions

**28. Are countries in the Caribbean ready to attend this crisis, are there enough adaptation and mitigation plans on this?**

Caribbean nations have been stepping up their reef management plans, but there is always more work to be done. Extreme weather events are now the norm. Nations and regions will be best suited to prepare in advance for the inevitable; to help with this CRC and the International Coral Reef Initiative will be developing guidelines for regulations on coral reef restoration this year. Interested parties should contact [info@crc.world](mailto:info@crc.world) to get involved.

**29. Also wondering what can we do from the legal standpoint to press governments to take quick action. You are lucky in Florida to have the resources but not the case for the rest of the countries... sadly**

Show your elected officials photos of what is happening. Monitor what you are losing. If you need help with advocacy, please reach out to [info@crc.world](mailto:info@crc.world).

**30. How do we relay solutions we've developed?**

The CRC has developed a new facebook groups where solutions can be shared. Please visit <https://www.facebook.com/groups/1046344139615412>

**31. How do you all balance communicating restoration's scopes, promises, and limitations so that volunteers/non-scientists who see their outplants die remain motivated to continue trying?**

A huge element to the restoration process is the communication/outreach and public messaging. It's very important to not over promise or create false expectations. For example, restoration takes place in a challenging and changing environment, why would restored corals behave differently then native ones? We are very upfront about the conditions of coral reefs, in the Florida Keys and around the world and the decline they are facing. We're very upfront that restoration is **a part** of the solution, not **the** solution. And we're very upfront about sharing wins and losses and the importance of continuing these efforts.

**32. If Global warming continues at current rates, Can You foresee a time where all Coral reefs will be GMO,s that have increased heat tolerance?**

Possibly! If there are corals on reefs, so that generations from now reefs can be rebuilt, that will be better than no corals at all.

**33. What do we know about external variables and the likelihood of coral survival post-bleaching? How might this inform restoration and co-location of efforts (whether pollution reduction or restoration of other habitats)?**

We know that if we can limit and remove other pressures, that gives coral a greater chance of making it through bleaching events. For example if you can curb agricultural runoff and an influx of nutrients at a local level, that helps a system be more resilient to another stressor that is harder to manage for (like climate change). There is also climate modeling work and protected area planning tools that help people understand locations around the world that are predicted to change the slowest, or the least, essentially becoming climate refugia.

**34. What is the effect of mass mortality of sea urchins on coral bleaching with rising seawater temperatures?**

Beyond coral bleaching, coral reefs face a multitude of threats - overfishing, sedimentation from development or agricultural runoff, and coral diseases to name a few. Mass mortality of sea urchins is another threat – one that led to the demise of reefs in the Caribbean decades ago and [is now being witnessed in the Red Sea](#). Urchins play a key role in scraping the reef clean, preparing a surface on which coral planulae can settle. Urchin mass mortality certainly does not help the issue of coral bleaching. We must investigate the proximal causes of urchin die-off. Where and when possible, [seeding reefs with juvenile corals AND juvenile urchins](#) as is being investigated in Puerto Rico by Stacey Williams.

**35. Is there any research currently being done in Northern Myanmar region on non-reefal coral communities in turbid waters? If so, could you share the contacts?**

I don't know of that research but would be interested to learn more if you find out!