Additional questions from attendees answered by the panelists from the *New Guidance on Coral Reef Restoration Webinars* held August 5th and August 11, 2025

These webinars are brought to you by the Reef Resilience Network and Coral Restoration Consortium, in collaboration with the International Coral Reef Initiative as part of their #ForCoral webinar series.

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1. Can you share any difficulties you face during outplanting?

Seychelles:

Two of the major challenges that we face are weather conditions and *Sargassum* (and other minor macroalgae) expansion. Swell is often very strong in our location which makes operations slower and less efficient (e.g., higher detachment) but also dives are less safe (e.g., divers are constantly moved several meters from the outplating point), sometimes hitting the bottom is the main problem, if the diver is not experienced enough, or ears problem due to the shallow operational area and sudden and strong change of pressure

due to the swell. Therefore, planning and good diving skills are fundamental to avoid to lose corals and eardrums 😊

Sargassum is a recent (last couple of years) problem that we are trying to face. In the outplanting operation, the difficulty is due to the space competition, the removal effort/time needed and the lower success due to the negative interaction. In this case, dedicated actions needs to be adopted before outplating (yearly removal, understanding of the cause, recovery of sea urchin population).

2. Any recommended distance between individual corals from one another during explanation on bare reefs?

In Chapter 7 of the Guide – Restoration Design and Techniques – we offer some guidance on spacing of corals during outplanting. As with most things, there is no one-size-fits-all answer as research has shown that some species do better in higher density designs while others seem to need more space. The advice we offer in the Guide is to mimic the spacing observed in the wild populations or that has been documented historically for that species and habitat. Also, broadcast spawners need to be within a certain distance in order to increase the likelihood of successful cross-fertilization; there are some more specific guidelines for specific species offered in the Guide on page 107-108.

3. How did you decide on the best outplanting method that is suitable for the environment and cost effective?

Seychelles: We have a very high exposure to current and swell, therefore we need a method that quickly gives a strong attachment to the colony. Due to this exposure, operation itself needs to be easy (e.g., hammering nails while spinning because of the swell will affects a lot of fingers :D). Additionally, time, cost and availability are strong limitations, we need a method that is quick to prepare, cost-effective and characterized by easy available materials. Therefore, the cementing technique has been selected has the most successful in our project.

4. How do you protect the coral nurseries during high SSTs before they experience bleaching?

Mexican Caribbean: Moving them into deeper and fresher waters.

Seychelles: The nurseries in the RR project are anchored at around 18m, corals are normally at 5 to max 12m. Due to the flexibility of the rope system, we can lower down the nurseries. Unfortunately, sometime heat waves hit even below 18m, making any of our effort unsuccessful.

Saudi Arabia: Similarly, we lower our structures to approx. 10-12m. Due to our seasonality extremes in the Red Sea, we halt coral manipulation i.e. propagation and outplanting during our hottest summer months. Furthermore, we have applied shade clothes to our floating line structures with new propagations to reduce further stress post fragmentation.

5. It seems that the species used most predominantly across all the programs are highly susceptible to thermal stress. Given that we are on the tail end of the fourth global bleaching event (with more to come), are programs considering a shift to more thermally tolerant species? What goes into that decision-making?

Seychelles: Yes, there is planning to explore thermally tolerant species and genotypes to be prioritized into the restoration operation (without completely excluding non-tolerant species/genotype). We are integrating CBASS in our operations at the RR coupled with the land-based nursery and the sexual reproduction will give a wider range of species/genotypes.

Saudi Arabia: In our region, we lack historical data of coral bleaching and as such we are finding out which species are most thermally tolerant through monitoring bleaching occurrence on both the reefs and our nurseries. The “winning” gentotypes or simply corals with the highest survival and growth will be repropagated for subsequent cycles in the nursery.

6. How do you take into account repeated coral bleaching on your restoration efforts? Do you select resilient corals, aim to keep diversity high or any other specific approach to increase resilience of your outplanted corals?

Seychelles: In this case monitoring both donor and restoration sites can give an overview of which species/genotype is more resilient in the area. Selecting these species/genotypes that are more resilient (especially after multiple bleaching events) can increase success. In

addition, systems like CBASS can help in quickly screening large numbers of species/genotypes. Lately, conditioning is attracting attention, in order to understand whether prolonged exposure to high temperature can increase short- and/or long-term resilience. In this topic, microbiome is also particularly important, a topic that has still gaps in our knowledge.

7. Considering ecological sustainability, cost-effectiveness, and varying site conditions such as currents, salinity, and other environmental parameters, which method of coral restoration is generally regarded as the most environmentally responsible and what best practices would you recommend to minimize ecological impacts when sourcing coral materials, especially in cases where live coral fragments are used?

Indonesia: For each restoration project we develop a site-specific restoration plan. When a particular restoration method is successful in one area or ecosystem, we naturally want to apply it in other restoration efforts. However, there are so many variables on a reef that there is no one solution which will suit every site. This is known as the "myth of the cookbook" in restoration ecology – where a recipe for restoration is attempted to be applied across every site. When we are conducting a site assessment in the planning stage we use the following decision-making approach:

1. Factors inhibiting recovery
    a. Evaluate the need for restoration
    b. Determine causes of impacts at site
    c. Create project goals
2. Scale of project
    a. Determine size of impact area / outplant site
    b. Map and conduct baseline study
3. Determine Physical components to be used in restoration treatment. Methods chosen will be a function of the following:
    a. Function
        i. Is substrate stable or needs stabilization?
        ii. Do we need a base for transplanting corals?
        iii. What habitat needs to be created?
        iv. Is there secondary functions – fisheries, tourism, biodiversity?
    b. Environmental Conditions

        i. What type of reef – exposed, sheltered, lagoon, outer?
        ii. Hydrodynamics of area – swell, currents, storms?
        iii. Potential navigational hazards?
        iv. Water quality, sedimentation
    c. Spatial Scale
    d. Materials
        i. What is available at the site?
        ii. Import or locally sourced?
        iii. Is there benefits or impacts from introduced materials?
    e. Budget
    f. Logistics
        i. Is the work done by volunteers or professional divers?
        ii. Size of structures for moving underwater?
4. Determine Marine species & habitat to be restored
    a. Select suitable species for area
    b. Find reference & donor sites
    c. Determine if there is a need for nursery to increase coral stock
    d. Select outplanting methods based on species and physical components mentioned above.
5. Develop an adaptive monitoring & maintenance strategy

After working through a decision-making tree for planning a restoration site, then we determine what structures, species, methods will be suitable for that particular site – and the approach may differ from a site further down the coastline!

8. What are the ratios of major funding sources for your restoration work between partners, grants, internal for-profit programs, etc.?

Indonesia: Our restoration work is funded 95% by internal education programs, with about 5% from donations and grants. We run experience programs and training workshops which the course fees participants pay then go to pay all our expenses (staffing, materials, boats & fuel, utilities, etc). Because we use simple, locally-sourced methods (rather than research programs testing flashy new high-tech) it has been very hard for us to obtain grants. Therefore, we have structured a financially sustainable model to not rely on external funding. That way, if we do receive grants and donations we are already extremely well positioned to make sure that funding goes directly to the restoration work - as daily overhead expenses are already covered by our existing programs.

9. I just wondered if any/all of you would be happy to comment on how you engage with the social and cultural dimensions of coral reef restoration work: how do you consider social and cultural dimensions of site selection, species selection, outreach etc.

Indonesia: 100% yes. We believe that the best restoration efforts come from people working on the reef in their local area. Indeed, the only way we will tackle the coral reef crisis is if each local community focuses on efforts to improve ecosystem health in their area.

At each of our restoration sites our staffing is almost entirely local. It is local decision making at all stages. Local instructors and guides, local restoration practitioners, local support staff, local suppliers – the entire budget stays within the local economy. We also work with the local snorkel boat and dive operators to provide training in their own language so that they can show the benefits of a restored reef to their guests. Students and interns from all over the world come to join our programs and the money they pay goes directly back into the local village. After 15 years of operating on the island we work, Our organization is now one of the main employers supporting the livelihoods of over 30 families providing them with healthcare, living wages, educational support. Many other members of the community and surrounding communities now approach our team to help them also initiate coral restoration efforts.

10. Which (nursery and/or outplanting) method had optimal survival or produced high success rate and the least? Do you have any insights on why this method is successful or not?

Mexican Caribbean:
For us in the Mexican Caribbean, tree nurseries and reef stars have worked very well for Acropora cervicornis, as it grows faster than in the grid type nursery. However it hasn't worked as well for Acropora palmata as the grid type and the reef stars.

For outplanting, ibulbs (or concrete bases) have worked better, as they allow the coral to grow without competition at the begining, from which the coral grow and survive better, can be always identify and also connectors and bases could be re-used in case needed.

Seychelles:

In our experience at RR, net nurseries and large rope nurseries were trial. These methods were selected due to their flexibility in an exposed area (e.g., strong current and swell). Net nursery were successful but the amount of effort in cleaning was higher and not worth it compared to the rope nursery. In addition, rope nurseries of 20x6m were previously used, however recently we found out that 10x6m allow for better management of materials, rope itself (e.g. transportation), cleaning, budget (e.g., rotational stocking), and more importantly less collapsing due to coral weight and or long exposure to no maintenance due to weather constraints.

Regarding outplanting, nailing ropes directly to the substratum was previously used, however friction and consequent damage to colonies made this technique not efficient. Whereas, the cementing technique had the highest survival due to the rapid attachment and stability given to colony.

Saudi Arabia:
Nursery - Initially, we trialed various nursery methods to observe what works best in our local conditions, we found the twisted line nurseries which yield high survival in other regions of the world such as Maldives and French Polynesia is not as successful at Shushah. For the past 1.5 years, we have used 4 nursery methods including floating lines, floating tables, trees and rack trees. Across species, we found higher survival rates for corals hanging by monofilament on floating lines and trees and as such have begun phasing out propagating corals on cement plugs. Naturally, tables and rack tree methods are still most appropriate designs for massive (boulder type) species.

Outplanting - As our restoration site comprises 100 hectares, we outplant across diverse habitat including reef flat, walls, and pinnacles. Our methods are tailed to the environmental conditions at each site, for example coral clips are more ideal to secure fragments on vertical walls however they are not appropriate when outplanting on unstable substrate or using large colonies. Cement is cost and time effective to deploy for large scale operations, although it requires an hour or so to harden and therefore outplants are vulnerable to detachment if there is high wave action or fish predation. As restoration practitioners, we have an idea of the potential threats to outplanted corals however in a new environment, we do not know the scale of the problem. Through monitoring the survival of the outplants, we are able to grasp what are the most prominent threats and can we adapt our outplanting strategy to improve survival rates. For example, outplanting in shaded, protected microhabitats to reduce stress from fish predation and high light exposure.

11. Besides fragmentation and sexual propagation, are there other complementary strategies to improve coral growth, or overall reef health? Maybe the mixture of different coral species in the same area, or usually "monoculture" is better?

Seychelles: Monoculture might be a good idea if this pattern or this species shows similar patchy development in your area or it was present as monoculture previously. Otherwise, monoculture could not be the best idea (e.g., high exposure to disease and predation). The use of other species can potentially help coral survival and growth, example can be coral associated organisms such as crabs, brittle stars and shrimps, or non-farmer damselfish, and sea urchins. Adding these components to the restoration can increase chance of survival due to the ecological interactions among the corals (usually the only focus in restoration operations) and the other components of and healthy reef (a bit forgotten sometimes but equally important).

Saudi Arabia: Although outplanting corals of the same genotype can induce fusion and enhance growth, monocultures are not ideal as they are vulnerable to disease outbreaks and genetic bottlenecking. High diversity of corals similar to the natural composition is preferred. It is good to do an environmental assessment and identify what stressors are impacting reef health, e.g. pollution sources and fishing pressure. Healthy fish and invertebrate population also contribute to good reef health, especially herbivorous fishes and urchins that reduce algal growth.

12. In Saudi Arabia, is there any methodology they follow for building their artificial structures/pinnacles?

Saudi Arabia: We have a partnership with Reef Design Labs and use their specially designed modular units to construct pinnacles up to 3m tall. The structures can be purpose built for the environmental conditions as RDL has various designs of different shapes and sizes.

13. Do you monitor parent colonies (both branching and massive) to determine the impact of harvesting on the reef?

Seychelles: We do monitor a subsample of parent colonies. We also monitor all our donor sites similarly to the restoration/healthy/degraded sites. This is important to keep track of the effect of collection (removal of coral biomass).

14. Just want to ask the best depth to install a tree nursery, considering tides.

This will depend significantly on the local conditions and species used, but we do generally recommend that any buoys attached to the tree remain at least 2-3m below the surface of the water in areas with boat traffic to avoid navigational issues. In areas with high tide ranges, this distance should remain at low tide. Some species can withstand a larger range of depths than others, so it is important to consider this when choosing a nursery site, and to monitor corals after being placed in a nursery to make sure they are healthy at the new site and depth. This is one reason we highly recommend a pilot nursery to better understand the conditions at the site and how the corals respond.

Kenya: The intertidal tree structures are placed at a minimum depth of around 0.5M during low tide and are sometimes completely exposed during spring tides. The structures are usually attached to heavy concrete anchors putting into consideration the strong surf and extreme conditions of the intertidal area. The structures are also placed at a distance from each other to prevent them from bumping into each other. The species propagated in these nurseries are collected as corals of opportunity in the intertidal zone.

15. Which physical factors need to be in which range to select the suitable site?

In Chapter 1 – Restoration Planning – and Chapter 2 – Nursery Setup – we offer a list of criteria for selecting both restoration sites and nursery sites. Again, the actual ranges will be highly variable depending on where you are working, but we offer guidance on how to think through the different variables that will affect success in your area. A Manager's Guide to Coral Reef Restoration Planning and Design also offers some guidance in Step 2 on prioritizing outplant sites.

16. How have you selected the Acropora species?

Acroporids were the focus of restoration for many years in Florida and the Caribbean because of the significant population decline over the last 30 years. They are also relatively easy to work with because of their fast growth rates and ease in fragmenting, allowing for all work to occur in the water. However, many programs are now incorporating a wider range of species due to declines in other reef-building species and advances in techniques

to propagate them. The branching corals tend to be highly susceptible to bleaching compared with other species, so we may see a shift towards propagation of hardier species following the 2023/2024 bleaching event.

17. How resistant are these nurseries and outplanting structures/methods to storms? Has there been some cases where they've been destroyed during stormy events? What are your recommendations?

In Chapter 4 – Nursery Maintenance – we offer some guidance on preparing for storm season. We also discuss redundant anchors in Chapter 2 – Nursery Setup. Following Hurricanes Irma and Maria, we hosted a RRN-CRC webinar called Building Restoration Programs to Withstand Hurricanes: Lessons Learned from Irma and Maria. The main takeaway, and our main recommendation, is that a nursery should always be prepared for a storm by staying current on maintenance tasks like checking and replacing frayed lines, maintaining good buoyancy, and keeping corals to a manageable size. Many programs also try to schedule large outplanting events early in storm season so that the stock in the nursery is relatively low, which helps minimize the amount of coral that could be lost if structures go missing or are buried, and preventing corals from swinging into each other and causing abrasion.

18. In selecting site for the nurseries can you suggest online maps that can help us figure out where to put those nurseries.

I think this will vary based on location, but we do provide the criteria you would want to consider. If no maps are available, those criteria could be used to conduct site visits and decide from there. In places where there isn't much data or local knowledge to help guide site selection, piloting a nursery will be extra valuable because it will give you some quick data on whether the site performs well.

19. How do you measure success beyond # of recruits outplanted (e.g., other indicators, such as ha restored)?

We suggest you evaluate the Coral reef restoration monitoring guide: Methods to evaluate restoration success from local to ecosystem scales, published in 2020 by the CRC Monitoring Working Group. There are suggested universal metrics for all projects and

metrics that are focused specific to the goals of your program. In addition, we hosted a webinar on this guide called Evaluating Success in Restoration.

20. What are all the monitoring techniques your team use for the Post outplant monitoring?

There are numerous methods that are used across the field of restoration, a number of speakers indicated that they use photogrammetry to evaluate the success of their outplanting. To learn more about methods applied in the field we suggest you evaluate the Coral reef restoration monitoring guide: Methods to evaluate restoration success from local to ecosystem scales, published in 2020 by the CRC Monitoring Working Group. There are suggested universal metrics for all projects and metrics that are focused specific to the goals of your program.

There are also a few webinars that may be of interest to you as well:
Using Photogrammetry as a Tool to Improve Restoration Monitoring
Evaluating Success in Restoration

21. If you have tried an online restoration training, was it efficient compared to face-to-face training? Any suggestions for online restoration practice courses?

We generally suggest that newer practitioners take the online RRN-CRC course that we will be offering this fall to get an idea of the breadth of options available, and then following up with an in-person training opportunity once you have a better idea of what types of methods you will likely use. The course gives you the opportunity to interact with experts on each of the lesson topics which include restoration, planning, in-water nurseries, land-based nurseries, larval propagation, rubble stabilization and structures, emergency restoration, and monitoring.