Nature Funding Projects: Coral Restoration on Bonaire and St. Eustatius

The large fields of elkhorn *(Acropora palmata)* and staghorn coral *(Acropora cervicornis)* that once dominated our shallow reef communities are now mostly dead coral rubble zones with a few isolated populations of Acropora. Staghorn and elkhorn coral are two of the most important reef-building corals in Caribbean reefs, and their branches offer an important 3-dimensional habitat for many species of reef fish. The once abundant and healthy populations of these corals suffered mass mortality (>95%) in the late 1970s and early 1980s due to the rapid spread of white-band disease throughout the Wider Caribbean Region. The intensification of local stressors such as pollution, coastal development and hurricanes in the 1990s and onwards has meant that many Acropora populations never got a chance to recover. Both species are extremely sensitive to high sea temperatures (Steneck et al. 2005) and therefore suffer mass mortality during severe bleaching events, most recently in 2005 and 2010. Elkhorn and staghorn coral are currently listed as Critically Endangered under the IUCN Red List of Threatened Species.

Several projects are running on our islands to restore degraded reef flat areas along the coastlines. On St. Eustatius, coral reef restoration efforts have been ongoing since July 2016. The RESQ project, which is funded by the European Union Best 2.0 Program and co-funded by the Dutch Ministry of Economic Affairs, made possible the creation of elkhorn and staghorn nurseries with the aim of restoring degraded branching reefs zones around the island. St. Eustatius National Parks (STENAPA) constructed 8 ladders that housed a total of 200 elk and staghorn fragments, which were then deployed in two nurseries (Crooks Castle and Jenkins Bay). STENAPA reported seeing and measuring extensive coral growth and recovery following these initial restoration efforts.

Thanks to the generous funding from the Netherlands' Ministry of Economic Affairs through the Nature Fund, coral reef restoration on St. Eustatius has accelerated. The Government of St. Eustatius, STENAPA and the Caribbean Netherlands Science Institute (CNSI) have come together to combine the RESCQ and CNSI's Nature funding coral restoration projects and re-establish a healthy branching community on the island's reefs. The Jenkins Bay nursery has been expanded with an additional 6 bigger ladders, increasing the number of elk and staghorn fragments to 450 in total. Outplanting of the first coral fragments has already taken place, with so far 15 fragments put back to the reef through the use of bamboo frames and epoxy glue. However, the devastation caused by Hurricane Irma this September has been a severe setback. It wiped away the Jenkins Bay nursery, including all 10 ladders and all fragments. The 4 ladders and 100 fragments in the Crooks Castle nursery have been damaged, but STENAPA has already fixed the ladders and hopefully the fragments will recover from Irma's impact.

On Bonaire for the past five years, Coral Restoration Foundation Bonaire (CRFB) has been working to restore degraded reef flat areas along the coastlines of Bonaire and Klein Bonaire by transplanting nursery-raised elkhorn and staghorn coral fragments to these sites. To date, the foundation has transplanted corals to seven restoration sites, and in May 2017 celebrated the transplant of its 10,000th coral! And now, thanks to same Nature funding as on St. Eustatius from the Netherlands' Ministry of Economic Affairs, CRFB will transplant an additional 5000 nursery-reared staghorn corals to Bonaire's reefs over the next 2 years.

Coral Restoration Foundation Bonaire was established in 2012 with a mission to "develop affordable, effective strategies for protecting and restoring shallow water population of staghorn and elkhorn corals along the coastlines of Bonaire and Klein Bonaire". With support from the government and the Bonaire National Marine Park (BNMP), CRFB's restoration program has been a huge success. The funding received through the Nature Funding for the BES islands is now helping the foundation take a further step in the restoration of Bonaire's shallow reefs: over the next 2 years, 1250 nursery-reared coral colonies from 12 different genotypes will be transplanted at four different sites totaling an area of 600 m2, for a total project amount of 5000 corals.

The first restoration site was chosen at Playa Lechi, close to the recreational swimming area and easily accessible by snorkelers. In early December 2016, volunteers, interns, and team members transplanted the first 150 corals to the area. Now 1,250 corals have been transplanted there from CRFB's Klein Bonaire nursery, completing the restoration work planned for the site. CRFB is currently conducting surveys around the island and gathering information in order to select, with the support of the BNMP, the project's next three restoration sites. CRFB uses the following criteria to select coral restoration sites: existing wild populations, depth, water quality, bottom type, size of the area, space competitors, predator abundance, wave exposure, origin of parent colonies, current/historical presence of Acropora, human activities/impacts and number of out planting sites. Restoration activities at the next chosen site are set to begin at the end of this year's 2nd quarter.

Photo by: Rudy van Gelderen

The number of corals needed for each of the four restoration site has been determined according to the abundance restoration criteria listed by NOAA in the 2015 Recovery Plan for staghorn corals, which requires the establishment of approximately 25% of live staghorn coral cover in the restored areas (National Marine Fisheries Service 2015). The restoration technique used by CRFB is known as coral gardening, whereby fragments from a healthy, robust wild population are fragmented and grown in nurseries on Christmas tree-like trees. These trees are structures with a PVC trunk and fiberglass branches on which coral fragments are suspended. When the fragments have reached maturity, they are then transplanted to degraded reef areas. Transplantation requires the use of supporting horizontal bamboo structures elevated 10-20 cm from the bottom. Corals are tied on the structures which allows transplantation on unstable bottoms (rubble or sandy areas) and keeps the corals, initially small, relatively far from the bottom and less affected by predators. Transplanted corals are expected to reach the bottom in few years when they are strong enough to withstand predation.

The four restoration sites will be carefully monitored over time to record coral cover and mortality rate for the different genotypes transplanted (all transplanted corals are carefully tagged so that CRFB can easily track their genetic information). The foundation is developing an online database to help project members keep track of nursery and transplanted coral fragments and organize fieldwork according to it. CRFB also partners with Project Baseline: *(http://www.projectbaseline.org/)*, a global initiative that enables stakeholders to record and monitor changes to their local aquatic environment. CRFB's recent purchase of a boat - purchased thanks to the Nature Funding and aptly named Coral Lover - will allow the foundation to implement a comprehensive and effective coral monitoring program over time.

Partnership with local dive shops has been key to the success of CRFB's programs. The foundation was established thanks to the support of Dive Buddy Dive Resort and is now also sponsored by Eden Beach Resort, Harbour Village Beach Club, Gooodive and Tropical Divers. These dive shops act as educational centers of the foundation and train CRFB volunteers through the PADI Coral Restoration Diver Distinctive Specialty Course. Thanks to the Nature Funding for the BES islands, this partnership is expanding. The funding has made possible the installation of a nursery that will be maintained by the dive shop Gooodive, which became a CRFB diveshop member in October 2016. The dive shop's five-tree nursery has been set up at the Something Special dive site and can hold up to 500 corals. Trained staff members are responsible for nursery maintenance and related coral transplanting activities in the area.

Nature Funding projects

As part of the 2013-2017 Nature Policy Plan for the Caribbean Netherlands, 22 projects that promote coral reef conservation, sustainable use of nature or the synergy of sustainable use of nature in combination with agriculture and tourism were approved to receive funding through the Nature Fund allocated by the Ministry of Economic Affairs for the BES islands. Ten projects received funding on Bonaire, 7 on Saba and 5 on St. Eustatius including coral reef restoration projects on Bonaire and St. Eustatius.

Project	Lead scientist(s)	Goal	Activities
Coral Restoration Bonaire	**CRF Bonaire:** Francesca Virdis **DRO:** Frank van Slobbe	Restore the shallow populations of elkhorn and staghorn corals along the coasts of Bonaire and Klein Bonaire.	Replant degraded reefs with nursery grown corals, support efforts to improve water quality, developing multi-clonal thickets of each species of coral that will be able to successfully reproduce, outreach and communication, involve local dive community in project.
Coral restoration St. Eustatius	**Government of St Eustatius** **STENAPA:** Jessica Berkel **CNSI:** Johan Stapel	Re-establish a healthy branching coral community.	Creating a coral nursery which would supply second and third generation planting out sized coral colonies

Photo by: Mark Vermeij

Coral nursery on St. Eustatius. Photo credit: RESCQ

Restoration Site Playa Lechi. Photo taken on: 29 March 2017. Photo credit: CRF Bonaire

Coral Reef Restoration Initiatives in the rest of the Dutch Caribbean

Coral Restoration Foundation initiatives

On Curaçao, the Curaçao Reef Restoration Program was launched in 2015 by Ocean Encounter Curaçao and with the support of Coral Restoration Foundation International and Coral Restoration Foundation Bonaire. The goal of this project is to restore Curaçao's shallow water reefs. Similar to the work carried out by CRF Bonaire, elkhorn and staghorn coral fragments are grown in nurseries and transplanted to degraded reefs areas. A similar coral reef nursery project - but on smaller-scale - was launched on Saba in October 2015 in partnership with the Coral Restoration Foundation, Samford University, Saba Conservation Foundation (SCF), Youth Environmental Leadership Program (YELP) and Sea Saba Dive Center.

Studying the effectiveness and of coral reef restoration methods

Researchers of SECORE International, the CARMABI Foundation and the University of Amsterdam have been investigating since 2010 the effectiveness of another coral restoration method, larval seeding, in restoring Curaçao's degraded reefs. To date, thousands of brain coral offsprings have been successfully reared and outplanted in reefs under a variety of conditions. Chamberland et al (Chamberland et al. 2015; 2016) have also looked into the potential of larval seeding to rehabilitate threatened elkhorn coral populations on Curaçao, and researchers from CARMABI, the University of California, the University of Amsterdam and Pennsylvania State University are assessing the potential of larval seeding for pillar coral *(Dendrogyra cylindrus)* (Marhaver et al. 2015).

Project RESCQ (Restoration of Ecosystem Services and Coral Reef Quality)

The RESCQ project aims to restore degraded elkhorn and staghorn coral reef zones on St. Maarten, St. Eustatius, Saba and the Turks and Caicos by creating coral nurseries and transplanting healthy grown coral fragments to select restoration sites. The project, which is running over the next three years, is funded by the European Union Best 2.0 Program and co-funded by the Dutch Ministry of Economic Affairs. On St. Maarten, and in collaboration with IMARES Wageningen UR, SCF and STENEPA, St. Maarten Nature Foundation has installed the first nursery site at the dive site "the Bridge" (close to Simpson Bay) and is populating the nursery with staghorn and elkhorn fragments. Nursery sites have also been installed on St. Eustatius and on Saba.

Project AROSSTA

On Saba and St. Eustatius, different types of artificial reefs are compared in the AROSSTA (Artificial Reefs On Saba and Statia) project *(https://www.hvhl.nl/arossta)*. University of Applied Sciences Van Hall Larenstein (VHL), St. Eustatius National Parks (STENAPA), Saba Conservation Foundation, Caribbean Netherlands Science Institute (CNSI), Wageningen Marine Research and dive school Golden Rock have been working on this two-year project since March 2017. In AROSSTA, three different artificial reefs are deployed: natural rock reefs, reef ball reefs and layered cake reefs. Researchers and students from VHL will study the functioning of these reefs in the years to come. Building with Nature is one of the key concepts used in AROSSTA; the artificial reefs increase three-dimensional structure and provide shelter for fish and other organisms. Coral recruits can settle on the reefs naturally and will further increase three-dimensional structure. The aim of AROSSTA is to determine which type of reef provides the best habitat for (juvenile) fish, coral and lobster. The results of the study can be used by nature management organizations when they wish to implement artificial reefs on a larger scale. AROSSTA is partly financed by a SIA RAAK publiek subsidy. Researchers of VHL recently put together a video that shows the deployment and first inhabitants of the different reefs on Saba *(https://www.youtube.com/watch?v=qOpA11QyEHo)*.

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Other Coral Restoration Projects in the Dutch Caribbean

Subject	Island	Organisation(s): lead scientists
Environmental factors driving recruitment success in Caribbean corals	CUR	**UvA:** Valerie Chamberland (PhD candidate) **CARMABI , SECORE International**
Development of restoration methods for threatened Caribbean coral species	BON CUR	**CRF Bonaire:** Augusto Montbrun, Francesca Virdis **SECORE Project, CARMABI:** Mark Vermeij **UvA:** Valerie Chamberland **SCF, Sea Saba, Samford University:** Jennifer Rahn
Restoration Ecosystem Services and Coral Reef Quality (Project RESCQ)	SAB	**WUR:** Erik Meesters, **SCF, STENAPA** **NFSXM, Turks & Caicos Reef Fund** **Students:** Niels Wagenaar, Silvan Allard, Pam Engelberts, Roxanne Francisca, Lotte Staat, Carmen Carpendale, Daniela Simal, Emma Louise Pratt, Renate Olie, Amber Mulder
Artificial Reefs On Saba and Statia (AROSSTA)	SAB	**VHL:** Alwin Hylkema, Marlous Heemstra **WUR:** Dolfi Debrot, **STENAPA:** Jessica Berkel, Erik Houtepen **SCF:** Kai Wulf, Jens Odinga, Aymi Izioka **CNSI:** Johan Stapel **Students:** Callum Reid, Esmee vd Griend, Daniel Heesink Golden Rock Dive Center, St. Eustatius

Staghorn transplanting. Photo credit: CRF Bonaire

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