

Restoring Caribbean Coastal Protection: The Wave Attenuation Potential of Elkhorn Coral (*Acropora palmata*)

Restaurando la Protección Costera del Caribe: El Potencial de Atenuación de Olas del Coral Cuerno de Alce (*Acropora palmata*)

Restauration de la protection Côtière des Caraïbes : Le Potentiel d'Atténuation des Vagues du Corail Corne d'Elan (*Acropora palmata*)

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EXTENDED ABSTRACT

INTRODUCTION

Caribbean shallow coral reef crests were once dominated by extensive thickets of *Acropora palmata* (elkhorn coral) (Goreau 1959), which formed dense "golden thickets" that significantly reduced wave energy before reaching shorelines, thus providing natural coastal protection against erosion (Osorio-Cano et al. 2018). This natural protection dramatically declined with the demise of acroporid corals across the region in the 1970s, increasing coastal vulnerability to erosion and flooding in small Caribbean islands. In the 2000's and 2010's, there was evidence that *A. palmata* populations were slowly recovering naturally across the region (e.g. Muller et al. 2013), suggesting that biotic and abiotic conditions for the recovery of this species were improving in the region.

Here we present preliminary results of a project aimed at assisting in the restoration of *A. palmata* populations at reef-scape scales to demonstrate their potential to attenuate wave energy, influence sediment accumulation, and improve ecosystem health. The "Wave Attenuation: Natural Solutions with Elkhorn Coral" (WANSEC) project, financed by the Caribbean Biodiversity Fund, uses an interdisciplinary, multi-island, and multi-stakeholder approach with intervention sites in Jamaica, Antigua, and Barbados.

The WANSEC Project has three main objectives. First, it seeks to enhance reef physical structure by restoring *A. palmata* stands in high-energy reef areas to improve the natural wave-break function of reefs (Figure 1). Second, it seeks to reduce coastal vulnerability to erosion, which will entail evaluating how restored *A. palmata* stands influence wave energy reduction and mitigate coastal erosion using coastal risk modeling (Figure 1). Third, it seeks to build local capacity by training scientists, local stakeholders and volunteers in *A. palmata* restoration techniques to ensure long-term sustainability of future interventions (Figure 1). By implementing this project in Barbados, Antigua, and Jamaica, it also seeks to determine the transferability and replicability of the approach used in different socio-ecological contexts.

The project proposes a bespoke design in which small amounts of material from elkhorn colonies that survived the 2023 heatwave (Reimer et al. 2024) are harvested and turned into ~3,000 small (1cm²) nubbins per island to establish coral nurseries. After 100 days, these nubbins are outplanted at selected sites (three 2,500m² sites/island). The project will then

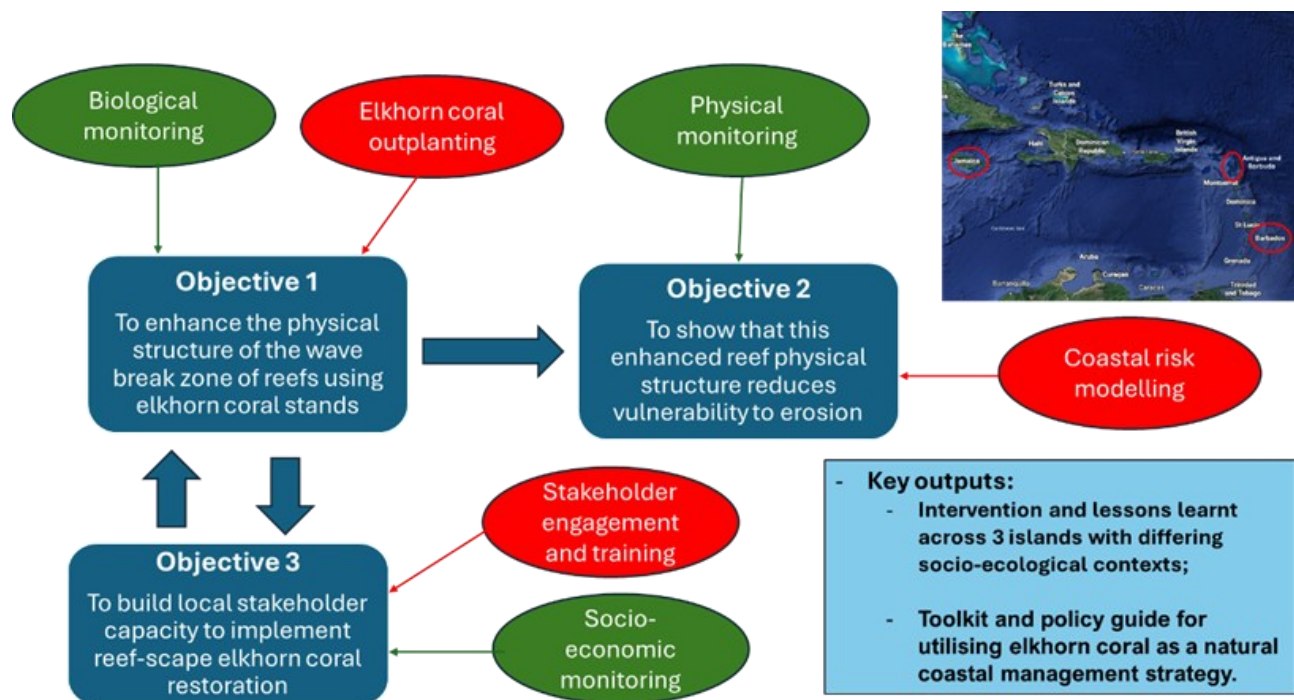


Figure 1. Objectives (dark blue), key activities (red) and associated monitoring components (green) of the “Wave Attenuation: Natural Solutions with Elkhorn Coral” (WANSEC) project conducted in Barbados, Jamaica and Antigua.

monitor outplanted and control sites to assess future changes in wave attenuation using permanently deployed loggers. It will also assess changes in reef organisms at individual, population, and community levels using diverse methods, including photogrammetry and visual fish and benthic surveys. The project emphasizes local stakeholder engagement, input and training whilst adopting an active adaptive management approach to optimize success and impact. The WANSEC project will provide a foundation for sustainable, nature-based coastal defense solutions whilst empowering local stakeholders for long-term resilience.

The case of Barbados

The loss of reef structure has exacerbated coastal erosion in many Caribbean nations. In Barbados, the average annual coastal erosion rate is 0.3–0.4 m per year and so the Government of Barbados has spent USD 20 million between 2002 and 2010 to deploy gray infrastructure (e.g., sea walls, breakwaters, etc) to mitigate coastal erosion effects (Brathwaite et al. 2022).

In Barbados, three fringing reef sites were initially selected on the west coast of the island after stakeholder consultations in April 2024. Two sites were designated to serve as outplanting sites and the third one to serve as control (with the same design also being implemented in Jamaica and Antigua). The sites had to be large enough to accommodate the outplanting area, easily accessible, shallow, flat, depauperate of benthic organisms, and seasonally subject to high wave action. In May 2024, a 50 m x 50 m section of the back reef of each site was marked, divided into 10 m x 10 m cells and subsequently

mapped using photogrammetry. Atlantic Gulf Rapid Reef Assessment (AGRRA) type surveys were also conducted for fish and benthic organisms. Subsequent consultations in September 2024 with local communities and more stakeholders, notably fishers and surfer groups, led to changes in the site selection, underscoring the importance of engaging all relevant stakeholders into the decision-making process surrounding restoration efforts.

In May 2024, five donor colonies of *A. palmata*, believed to belong to different genetic lineages based on morphology, were identified in two reefs. The five selected donor colonies had survived the 2023 heatwave and fully recovered, with no signs of past partial mortality. Fragments were collected from these colonies (<10% of total donor colony) and placed in the nursery. In June 2024, these fragments were subsequently cut into hundreds of small coral nubbins (~10 mm x 10 mm), yielding a total of 3,500+ nubbins. This fragmentation was conducted with the assistance of a wide range of local volunteers, who were trained in the handling of the nubbins and on the techniques used by the project.

These nubbins were then secured to the nursery using specially designed and color-coded cable ties to allow keeping track of the different lineages. The growth, survivorship and health status of the nubbins was then monitored weekly up to October 2024 and beyond.

This regular monitoring revealed that nubbins growth rates differed among lineages, with some lineages growing 4× their original size in 100 days, underscoring the importance of lineage in the recovery of the nubbins after

Table 1. Areal growth of nubbins over a 100-day period after transplantation to the WANSEC project nursery in Barbados during the summer of 2024. Individual nubbin size was estimated in mm by multiplying the longest dimension of a nubbin by its largest perpendicular width. Colors correspond to five different lineages (based on donor color morphology). Estimates for each lineage include 100s of measured nubbins.

Colony lineage	Nubbin growth
Black	3.1-fold
Blue	4.0-fold
Green	2.6-fold
Red	3.3-fold
White	4.0-fold

fragmentation (Table 1).

In July 1st 2024, Barbados's coastline was severely impacted by the passage of Hurricane Beryl. The passage of Beryl led to the total extirpation of one of the donor *A. palmata* populations (located on the south coast) and to the loss of 45% of the other donor *A. palmata* population (on the west coast). Moreover, extraordinary high sea surface temperatures over the summer led to the onset of coral bleaching in September 2024, which affected all the nubbins in the nursery as well as all the colonies of the donor population that had survived Beryl. These conditions made it impossible for the project to proceed with the outplanting of the nubbins.

This unfortunate outcome underscores the urgent need to identify heat-resistant donor colonies for restoration efforts, which requires ongoing monitoring of donor populations. Until conditions improve, the project will continue to monitor the fate of the nubbins and donor coral populations, with the hope of identifying heat-resistant lineages, while continuing to engage with local stakeholders.

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