# SERNews

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# COLLABORATION WITH TOURISM OPERATORS TO BUILD CAPACITY IN CORAL REEF RESTORATION

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## PROJECT OVERVIEW

Due to the deteriorating health of coral reef ecosystems, restoration projects are being undertaken by various stakeholder groups in coral reefs around the world. Project leads include conservation organizations, environmental consultants, local governments, dive centers, and community groups. Each restoration project differs based on organizational capacity, including budget and personnel. This case study looks at the Nusa Islands reef restoration site in Bali, Indonesia as a model for building capacity with local communities and sustainably financing restoration work.

The Nusa Reef Restoration Project is an attempt to reverse the degradation of reef areas along the northern coastline of the Nusa Islands in Bali – Nusa Lembongan & Nusa Penida. Coral reefs are an important source of income for the local community through tourism and fishing activities, but a variety of impacts from tourism, fishing, and climate change have severely degraded previously biodiverse coral reefs, resulting in a shift to unstable rubble with greatly reduced ecosystem services and biodiversity. The primary goals of this project are to increase ecosystem function, improve habitat complexity, and promote the return of biodiversity.

## SITE DESCRIPTION

Prior to starting the restoration project, reef health monitoring was conducted along the northern coastline of the Nusa islands for 10 years. During this time, a team of biologists from Blue Corner Marine Research were able to identify healthy and degraded areas of reef, as well as track natural recovery trajectories of impacted areas. Through this monitoring, certain degraded areas of reef were prioritized for restoration.

Restoration area with divers. Credit: Blue Corner Marine Research.

These degraded areas consisted of broken and dead coral rubble on the reef flat and reef crest. Similar to many areas of Southeast Asia, reef areas that have turned to rubble are rarely able to naturally recover. During the 10 years of observation prior to project initiation, the rubble areas in this project did not show signs of recovery. Conversely, rubble areas were actually increasing in size due to erosion in currents and smothering of adjacent and down-slope reef area.

Initial causes of coral degradation in the Nusa islands included:

- Anchors dragged from fishing boats, dive and snorkel boats, and tourism pontoons
- Clearing of coral from the reef flat for seaweed farming and building material, which removed the natural structure of the reef and changed onshore energy. Without the natural reef rugosity dissipating wave energy across the reef flat, shoreline erosion has increased.
- Clearing and shading areas of coral reef for tourism pontoons and sea-walking
- Historical dragging of fish traps and nets across reef flats

The resulting rubble areas was highly mobile and began to erode further down the reef slope, increasing the size of the impact footprint. Little recruitment survival was seen in rubble areas. Due to the impact site being 100% rubble, the reef health was reduced compared to adjacent intact reef areas.

## ESTABLISHING A NEED FOR RESTORATION

In order to determine if coral restoration should be conducted in an area, a comprehensive site assessment is needed. Additionally, before beginning any restoration project, it is important to ensure that the causes of degradation are reduced or stopped. If the activities which caused the initial reef damage continue, then any restoration efforts in the area may be futile, as potential gains in ecosystem health will be quickly eliminated by further impacts. The Nusa Islands marine park management has implemented a zoning system within the park defining which activities are permitted within each zone. The restoration site is in a protected area so the previous boat anchoring and fishing impacts are now reduced or eliminated. The area has seen a drastic increase in tourism over the last decade, which has diminished traditional extractive activities such as fishing and seaweed farming that had caused alterations to the reef structure in favor of a tourism-based economy that allows for significantly higher wages and living standards for the local people of the Nusa Islands.

Additional measures to reduce existing threats to the ecosystem have been implemented by conservation and business groups operating in the area. For example, Blue Corner Marine Research has delivered educational programs

Divers survey coral in the restoration site. Credit: Blue Corner Marine Research.

with watersports operators and guides focused on providing environmental briefings for guests. Additionally, waste management initiatives on the island – including the recent establishment of a recycling center – have been launched in an attempt to prevent waste and pollution from entering the ocean.

In well-managed reef areas, natural unassisted recovery may be possible if there is suitable stable substrate remaining on the reef and ample larval input of new young corals settling in the area. If natural recruitment is already high at a site, then a restoration program may not be necessary; however, our restoration site in the Nusa Islands is comprised of unstable rubble and has not shown signs of successful natural recruitment, as any young corals attempting to settle in the area become smothered by rubble and die. Since many of the initial impacts and activities causing degradation at the site have been reduced and little self-recovery was taking place, we determined that coral restoration was a suitable option for this site.

## DEVELOPING THE RESTORATION PLAN

The first step in developing the restoration plan was to map the impact area. Next, we conducted a pilot project within an impacted reef area deemed as high priority for restoration. Once we established which techniques were appropriate for the local conditions through the pilot project, we expanded restoration activities out to three adjacent areas. By 2022, the total restoration site covered an area of about 5000 square meters ($m^2$).

When developing a restoration plan, it is important to use adjacent or relevant reference sites in order to define an appropriate restoration target. To do this, a description of the reference environment – including species, structure, and features – is created so that a recovery trajectory can be made to determine what the reef is being restored to. For this project, our reference was developed by looking at historical reef health monitoring data and photos of the area; analyzing the contents of the rubble in terms of dead coral skeleton species; and surveying adjacent healthy areas of reef along the same shoreline and depth for reef substrate and diversity of marine species.

The goal of the Nusa Reef restoration project is to take the site from its current degraded state – almost completely denuded of living coral and structure – and bring it into a healthy state of high coral cover and biodiversity. We've approached this through a two-step process:

1. Recreate the physical structure of the reef in order to provide habitat and stabilize the rubble from erosion
2. Re-establish the primary habitat-forming organisms in an attempt to attract key marine species and reinstate ecosystem functioning

## STRUCTURAL RESTORATION

The Nusa Islands reef restoration site consisted of unconsolidated rubble substrate which was prone to erosion in ocean currents. Therefore, structural restoration was needed prior to other restoration activities. Structural restoration of the site involved a variety of measures, including the installation of coated metal frames and mesh rubble fencing to provide a stable substrate and habitat for marine life to utilize. The frames provide topographical structure to the reef and are used as building blocks for habitat formation. They also provide a stable substrate for coral transplantation.

We deployed structures onto the restoration site in a formation along the natural reef crest and clustered in other high erosion areas within the reef flat and slope. The purpose of this formation was to trap rubble from shifting down the reef slope and eroding into healthy reef areas. Biological rationale to the design was to provide patch-reefs, in which reef organisms such as fish and invertebrates could easily colonize by immigrating from adjacent reef areas. In addition to the frames, we rolled out wire mesh across areas of rubble in an attempt to stabilize rubble movement. The mesh is able to hold the rubble for a long enough period of time for pioneering species – such as sponges and soft corals – to settle and begin to naturally stabilize the area.

## BIOLOGICAL RESTORATION

By transplanting corals to the installed structures, we increased habitat for fish and invertebrates and stimulated the recovery of biological aspects of

Restoration structures trapping rubble. Credit: Blue Corner Marine Research.

Transplanting corals at the restoration site. Credit: Blue Corner Marine Research.

the reef. We determined suitable coral species for transplantation during restoration plan development by surveying species composition in adjacent healthy areas of reef and developed a list of target species that should be transplanted in appropriate proportions according to water depth and reef zone. Additionally, studies in naturally recovering areas helped us determine the initial habitat forming foundation species so that these could be used in restoration efforts.

We transplanted coral fragments into the area after structural restoration was started, using transplants sourced from nearby reefs with similar environmental conditions so as to not introduce new genetic stock or species. We started the transplanting with several different species, including four species of *Acropora* corals. *Acropora* are habitat-forming species that are known to grow quickly, aid in substrate stabilization, and provide refuge for natural settlement of other coral larvae. Additional transplants included slow-growing *Galaxea* and *Porites* corals, as well as foliose-shaped *Echinophylia* coral and branching *Montipora* coral. In order to reduce pressure on donor colonies from healthy areas of reef, we established a site-specific coral

nursery. The nursery allows coral fragments to grow under optimal conditions with good water movement and away from benthic predators. Coral fragments are grown for several months in the nursery until they are large enough to transplant onto the restoration frames.

## ENGAGEMENT WITH TOURISM

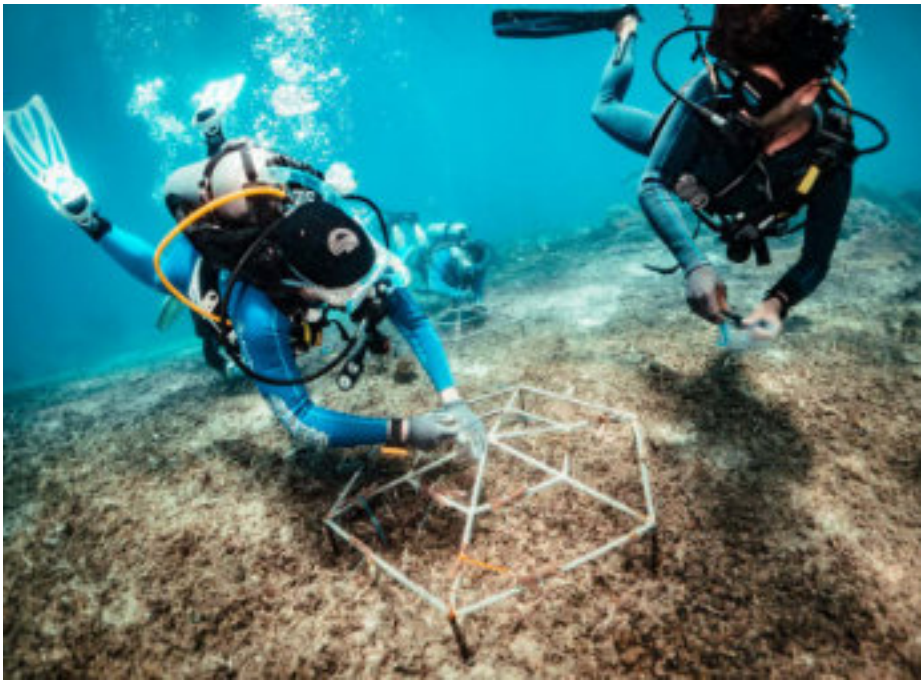
The project is run through a conservation organization – Blue Corner Marine Research. Sustainable long-term financing for the restoration work includes the delivery of educational and tourist experience programs. Additionally, partnerships with local marine tourism operators support the restoration project with financial and staffing assistance. Through these partnerships, we have trained dive guides from tour operators to lead underwater experience programs at the restoration site. Program fees go towards maintenance and expansion of the restoration project, as well as towards providing additional employment opportunities within the local community.

Tourists are also able to take part in the ongoing coral restoration project alongside professional biologists by signing up for training programs ranging from single-day coral transplantation experiences to multiple-week internship programs. The programs focus on delivering scientific knowledge to the public as well as providing hands-on experience for early career marine scientists and students. We've found that engaging with dive and snorkel tourism operators provides added benefits by creating opportunities for the local community to get involved in projects, as well as producing financial incentives to value healthy reefs – since local communities receive direct financial benefits from tourism activities. The focus is now shifting in the community from destructive mass tourism activities (such as sea-walking) to guided ecotourism activities promoting ecosystem restoration.

## CONCLUSION

Blue Corner Marine Research has been operating for over a decade and running the Nusa Islands restoration project for the last five years using this sustainable financing model. We continue to expand restoration efforts with uptake by local businesses and stakeholders. This restoration project has become a training site in which other conservation organizations in the region can send employees and managers to learn how to start their own projects on other coral reefs, helping to develop a network of coral restoration projects across the Indonesian archipelago.

The Nusa Islands restoration site has expanded to an area measuring 350 meters long by 20 meters wide (around 7000 $m^2$) of fringing reef along the Nusa Penida island shoreline. Our substrate stabilization methods have allowed settlement of sponge and coral recruits to bind the rubble, and coverage of hard coral has significantly increased from both the initial and ongoing outplantings. The site is continuously monitored to track changes in fish and invertebrate diversity, as well as 3D-mapped to show coral coverage increasing over time.



Participants in a coral restoration workshop led by Blue Corner Marine Research. Credit: Blue Corner Marine Research.