Fish Reef Project

Isla San Martín - Tina Reef

Monitoring Update

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Fish Reef Project

Helping Ocean Life Thrive®

Background

Sea Caves® represent a three-fold approach to atmospheric CO_2 reduction by passively removing CO_2 through macroalgae photosynthesis, increasing biomass and biodiversity on a previously depauperate habitat, and dramatically reducing carbon emitting process associated with fishing behavior. Atmospheric carbon reduction directly attributed to ecological processes around Sea Caves® includes sequestration followed by offshore transport and sinking of macroalgae, the carbon holding biomass of living organisms produced by these reefs in locations previously devoid of life, the smaller understory algal communities formed around the reefs, and maintenance and buffer for continued health on nearby natural reefs.

The largest, and primary, reef site of the Fish Reef Project is found in Baja California, Mexico at Isla San Martín 5 miles offshore of the "Volcanoes" region near San Quintin, Baja Norte, Mexico. The reef is found in shallow waters on the east side of the island. The coordinates of corners of the site are:

A. 30 29.838' N 116 6.524'W

B. 30 29.896' N 116 6.389'W

C. 30 29.296' N 116 6.048'W

D. 30 29.277' N 116 6.121'W

In addition to this site, smaller reefs sites are placed in cooperation with local fishing "cooperativas" along the Pacific Baja California coastline, stretching as far south as Punta Abreojos in Baja California Sur. For the purposes of this report, monitoring data will be focused on the Isla San Martín site.

The marine life of the shallow waters adjacent to Isla San Martín, including the algal assemblages, are governed by the same oceanographic and biotic forces that impact the entire California Current Ecosystem, particularly the temperate reefs found south of Point Conception, California. The iconic kelps of this region, those huge, brown, forest forming algae are unique to this area in their growth rates and size, fed by the nutrient rich, upwelled waters of the California Current. The macroalgal assemblage at the island is the same as that found along the mainland and offshore islands throughout Baja Norte.

Pre-site Monitoring

Prior to installation of the Sea Cave® reef the team performed underwater visual surveys and vessel-based sonar surveys. The Fish Reef science team conducted SCUBA surveys in 2022 to assess the site pre-deployment. Stratified random benthic surveys within all sectors of the site were conducted and all transect locations were randomly chosen once on the bottom. The physical characteristics of the site are not expected to vary seasonally.

Uniform point contact (UPC) surveys were conducted along each 30m transect line. The depth at the beginning and end of each transect was noted. The substrate type, any living algae or encrusting

animals, and the relative change in height between that point and the next half meter were noted (to help assess site rugosity).

A total of 10 transects, covering 300 m^2 of area, were surveyed. Over 97% of the substrate was classified as sand, with rugosity not observed greater than 10 cm between any two points. The depths surveyed ranged between 23 and 46 feet. Overall, we found the site to be flat and almost completely sand bottom. A few batches of low relief rock sand boulders were observed at the south end of the study area but were not captured during the random transects.

Benthic surveys at the proposed site were conducted in a random stratified pattern in an attempt to cover as much of the Project area as possible. Once on the bottom, the divers randomly chose survey start locations. Standard benthic swath survey methods were used to survey for algal species. Each transect was 30 m in length, with 1 m on each side of the transect searched and all species encountered recorded. Thus each transect covers a total of 60 m^2. A total of 10 transects were conducted within the project area.

Because the survey area is primarily sand bottom, algal abundance and diversity was low. The southern and most shallow parts of the proposed site did contain seagrass (*Zostera marina*) beds. Averaged across the proposed site, we found a density of about 1 *Z. marina* plant per m^2. In comparison, the eelgrass beds inside nearby Bahia de San Quintin average between 50 – 100 plants per m^2. The reef units are sited outside of these beds. The small chainbladder kelp (*Stephanocystis osmundacea*), which can attach to loose sand substrate, was the other common algal species found. Only a few small, single blade Macrocystis plants were observed, although this supports the likelihood that Macrocystis will recruit and grow on the artificial reef at the site.

The proposed site, because it is found on primarily soft sand habitat (see above), is devoid of most of these species. Instead, we observed very low densities of common soft bottom species of the Pacific coast: anemonies, marine snails, and hermit crabs. These animals were found in low abundances, and this Project is not located in any kind of refuge, recruitment, or nursery type habitats for these species. In fact, the addition of the reef units, and the resulting increase in marine algae biomass, will likely increase the abundance of these sand bottom species as well.

Ten 30 x 2 m swath surveys were conducted in a random stratified pattern across the Project area. The most common macroinvertebrates encountered were small Cnidarians (anemones) and Kellett's whelk, a large gastropod. The faunal biomass and densities were extremely low, as expected in this habitat type.

The fish assemblage at the Project site was also surveyed by the dive team. Fish surveys were stratified random in design. Along the transect, the diver swam 2 m above the transect line, and scanned a survey area within a 2 m x 2 m square in front of them, while continually moving forward. This gives a total survey area of 120 m^3 per transect, and a total of 1,200 m^3 area surveyed within in the site.

As expected, fish densities were extremely low. This is a product of the sandy bottom of the site. We did observe small numbers of the common temperate reef fish common to the region. Fish sizes were not estimated on the surveys, but years of experience along the Baja coastline allowed

qualitative assessment. Overall, we observed smaller sized individuals (of the common reef fish) than we would have on the nearby hard bottom reef sites.

Implementation

In August 2023, 430 individual Sea Cave® units were placed within the project boundaries at San Martin Island, marking the beginning of the reef complex. Caves were placed in clusters of 4 using a specialized crane aboard a large barge (Fig 1). Due to wind, waves, and current, some of the 4-cave blocks are oriented at variable angles. See Figure 2 for side scan sonar image of the reef once full sited.

Figure 1. Deployment of Sea Cave® units in groups of 4 at Isla San Martín, August 2023.

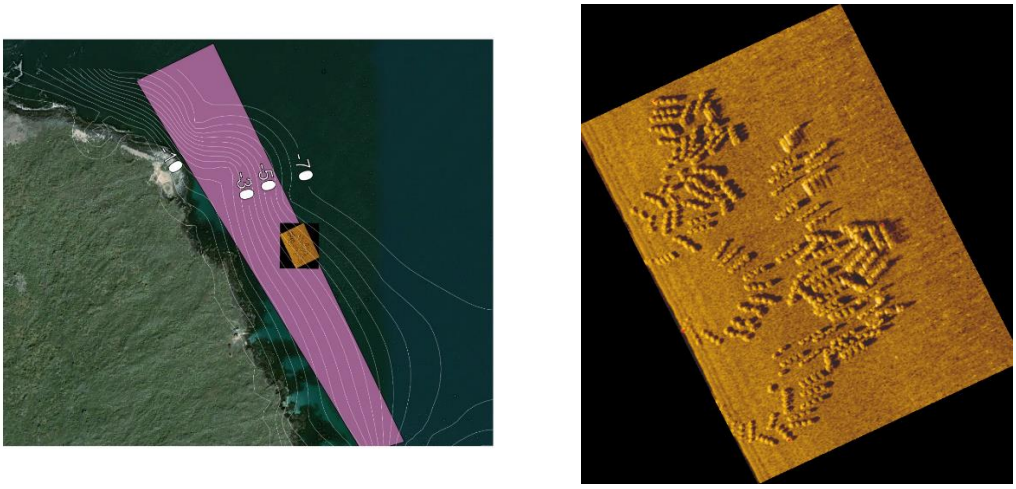

Fig 2. Side-scan imagery of "Tina Reef" at Isla San Martín. First image shows current reef location within the total project area boundary. Second is a closer look at the orientation of the individual Sea Caves® .

Preliminary Monitoring

The preliminary monitoring of Tina Reef occurred in November 2023. All monitoring methods used in the pre-deployment surveys (described above) were repeated at two locations within the current reef complex:

A) 30 29.364' N 116 5.448'W

B) 30 29.352' N 116 5.464'W

At each location, monitoring transects were conducted in randomly chosen directions across the reef complex. In total, four complete transects were run during this initial monitoring period. Monitoring was conducted by Dr. Ryan Jenkinson, Fish Reef Lead Scientist and research assistant Douglas Simpson.

The bottom substrate, as expected, was a mix of sand (60%) and Sea Cave® (40%). No seagrass or other benthic structure was observed in the reef area (Fig 3). The benthic surveys, as previously observed, found little life within the sand substrate of the reef area. Our expectation is that as the reef "settles in" and begins to attract larval recruits, it will begin to show signs of new life in these habitats over the next year.

In addition to the primary Sea Cave® reef, we surveyed a nearby "natural" kelp forest system as part of the monitoring protocol. This hard-bottom nearshore benthic system has all components of a classic kelp forest community, and we expect Tina Reef will soon appear similarly. We will continue to monitor this *in-situ* kelp forest system over the life of the project.

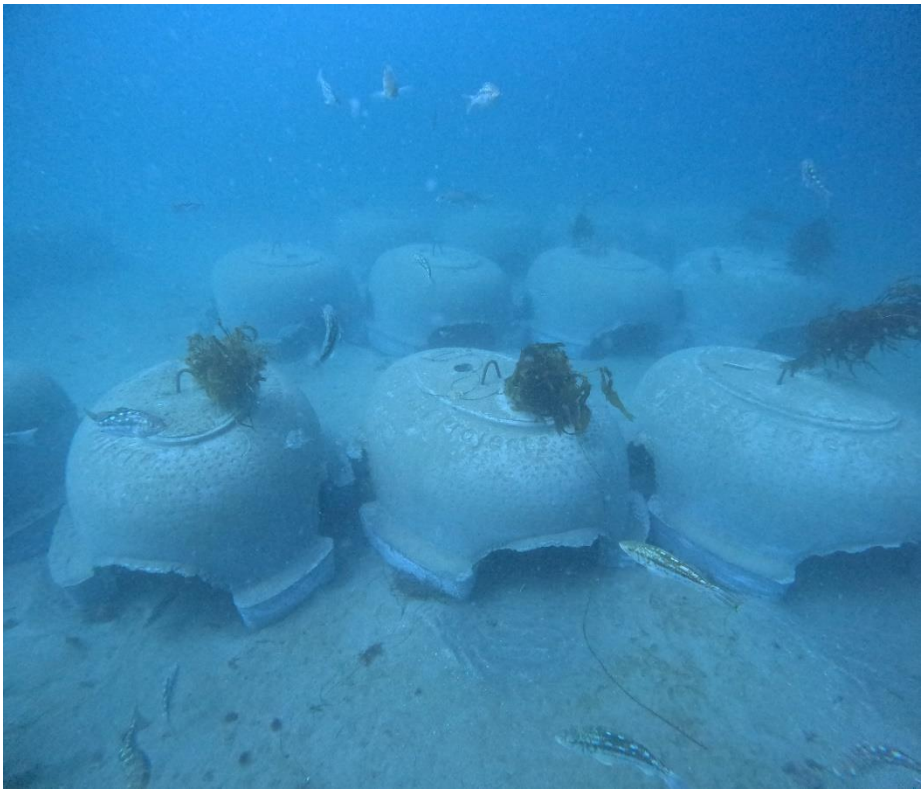

Figure 3. Sandy, flat bottom substrate and newly placed Sea Caves® at Tina Reef.

Twenty-five Macrocystis plants were recorded on the Sea Cave® units on transect. Many of these were transplanted onto the caves immediately post deployment. While most had no more than 2-3 stipes, they appeared to be growing successfully, with 3-4 reaching about halfway to the surface. No other large algal species were observed at this time. However, qualitative observation of the entire reef revealed early recruits of various algal species, too small to identify at this point, but likely to be observable by the next monitoring period.

The most striking change in biomass associated with the newly implemented reef occurred in the fish densities observed. This is to be expected, as these mobile species are attracted to and find shelter around this new structure almost immediately. However, the difference in fish abundance was striking. No species was observed with more than 5 individuals per transect in our initial surveys. Post-implementation, we observed over 118 individual calico bass (*Paralabrax clathratus*) on average per transect (Fig 4). Overall, fish density and abundance increased more than 10-fold following the deployment of the Sea Cave® reef (Fig 5). In addition to the species described on transect, larger pelagic species such as yellowtail (*Seriola lalandi*) were observed while working the area, and were not seen during the pre-site visit.

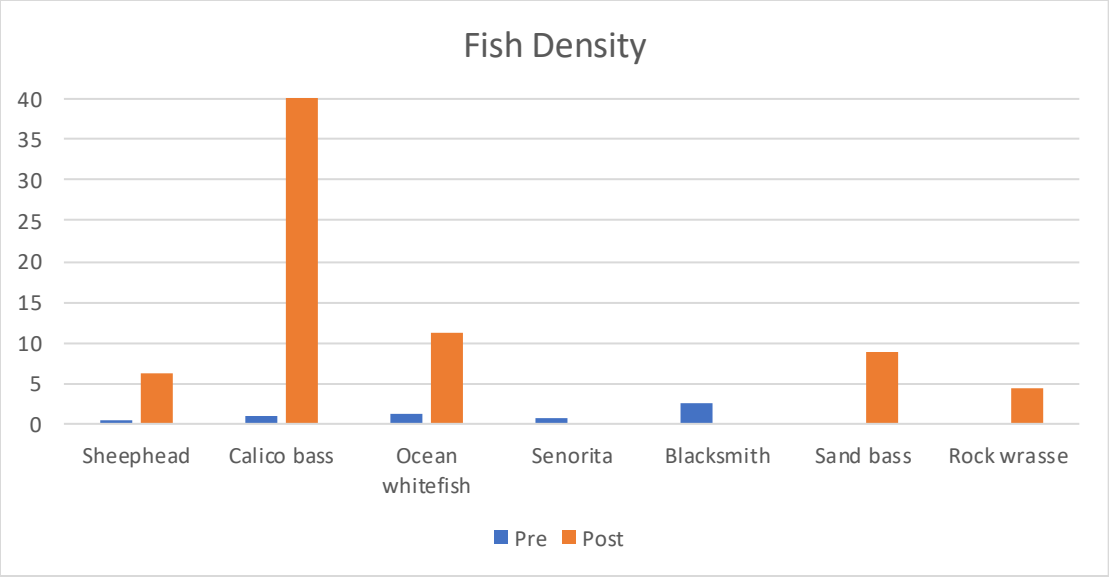

Figure 4. Mean counts of fish species per transect at Tina Reef during initial site survey ("pre") and post implementation of Sea Caves® ("post"). Total transects Pre (n = 10) and Post (n = 4). Scale was adjusted to make figure more readable- actual density of calico bass post implementation was 118.5 / transect.

Figure 5. The striking density of *Paralabrax clathratus* and out planted Macrocystis growing successfully on the Sea Cave® units at Tina Reef.

Summary

The initial monitoring efforts at Tina Reef at Isla San Martín clearly demonstrate the efficacy and impact of the Sea Caves® on soft bottom, low diversity, and low biomass habitats of nearshore waters. The deployment operation was successful in placing the individual caves in place within the project boundaries with no loss of equipment or any additional debris. The addition of hard structure to this area clearly attracts a variety of fish species in large numbers, and the expectation is the average size and abundance of these species will continue to increase as the reef matures.

While these initial monitoring surveys occur in too short a time frame to capture discernable larval settlement on the reefs, the reefs' capacity on average sustains conditions sufficient to allow verification of initial blue carbon credits on par with the methodology. The expectation is to find initial larval settlement of invertebrates on the caves and adjacent sand habitats, and initial algal recruitment and growth within the next monitoring period in the Spring of 2024. As demonstrated by the Macrocystis plants already growing on the reef (Fig 6), Sea Caves® provide usable and viable habitat and structure for the growth of a full-scale kelp forest within the first few years of the project.

Figure 6. Juvenile Macrocystis holdfast on a Sea Caves® unit at Tina Reef.