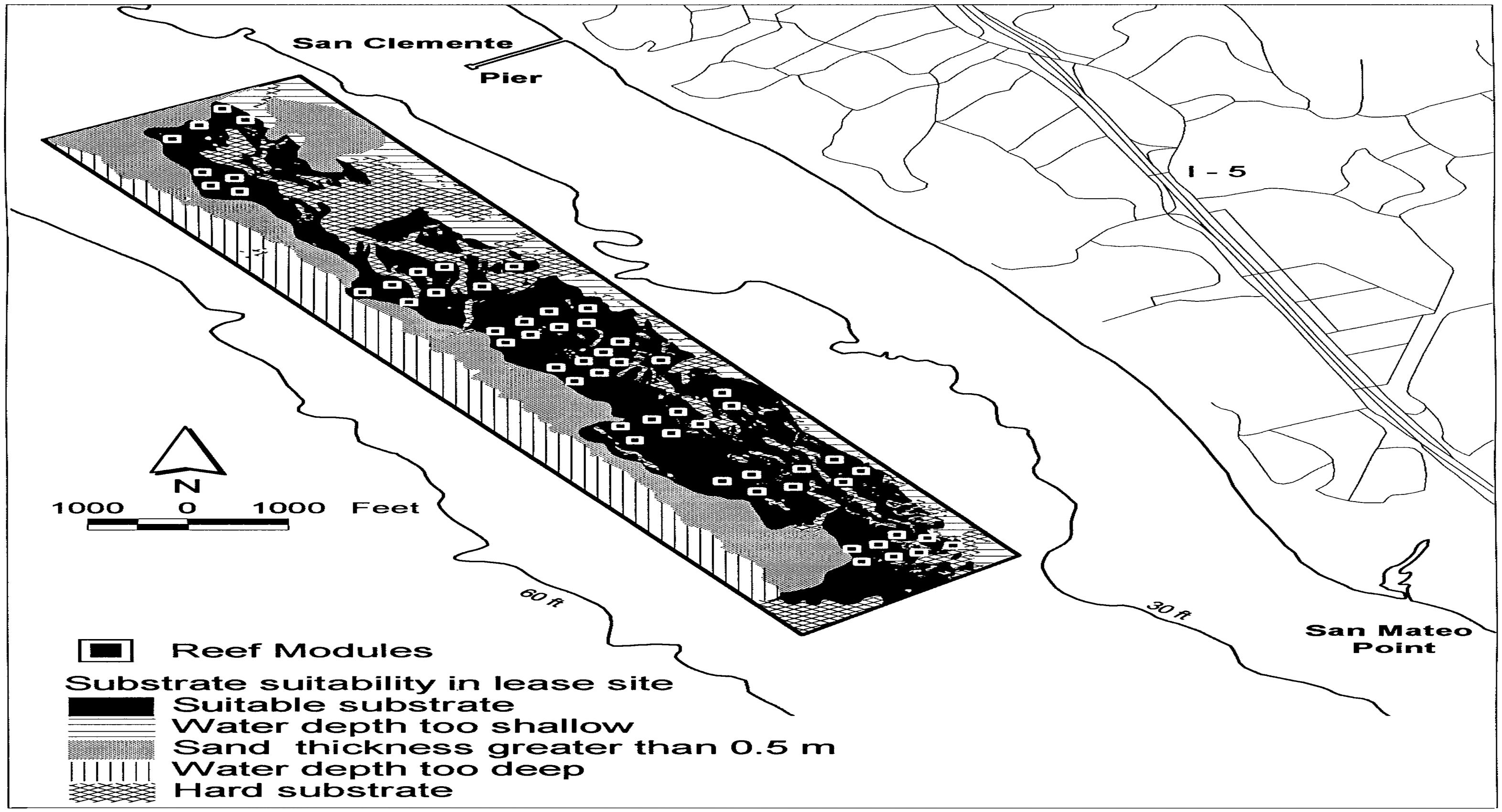
ARTIFICIAL KELP REEF



CE Coastal Environments

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Why Build an Artificial Kelp Reef ?

- To mitigate kelp and associated biota losses from operation of the San Onofre Nuclear Generating Station, a 150-acre Artificial Kelp Reef will be constructed.

How Do You Build an Artificial Kelp Reef?

- Design the Reef
- Permit the Reef
- Select a Contractor
- Set the Schedule (e.g., before lobster season)
- Select the Materials
- Develop the Methodology and Equipment Needs
- Build an Experimental Reef
- Evaluate the Constructed Reef
- Build the Mitigation Reef using Experimental Data

Why Build an Experimental Kelp Reef ?

- To experiment with varying densities of hard substrate coverage and with reef materials.
- Information gathered from construction and monitoring of the Experimental Kelp Reef will be utilized to build the remaining acres of the 150-acre Mitigation Kelp Reef.

What Conditions are Required for the Experimental Reef Site?

- Sandy bottom, <0.5 m thickness
- Depth of water between 35 and 55 feet (MSL)
- Light (0.1 Einsteins/m^2)
- Nutrients

- Conditions offshore of San Clemente, California meet the requirements.

Experimental Reef Design Specifications

- The reef consists of seven blocks. Each block contains 8 modules (40 m by 40 m).

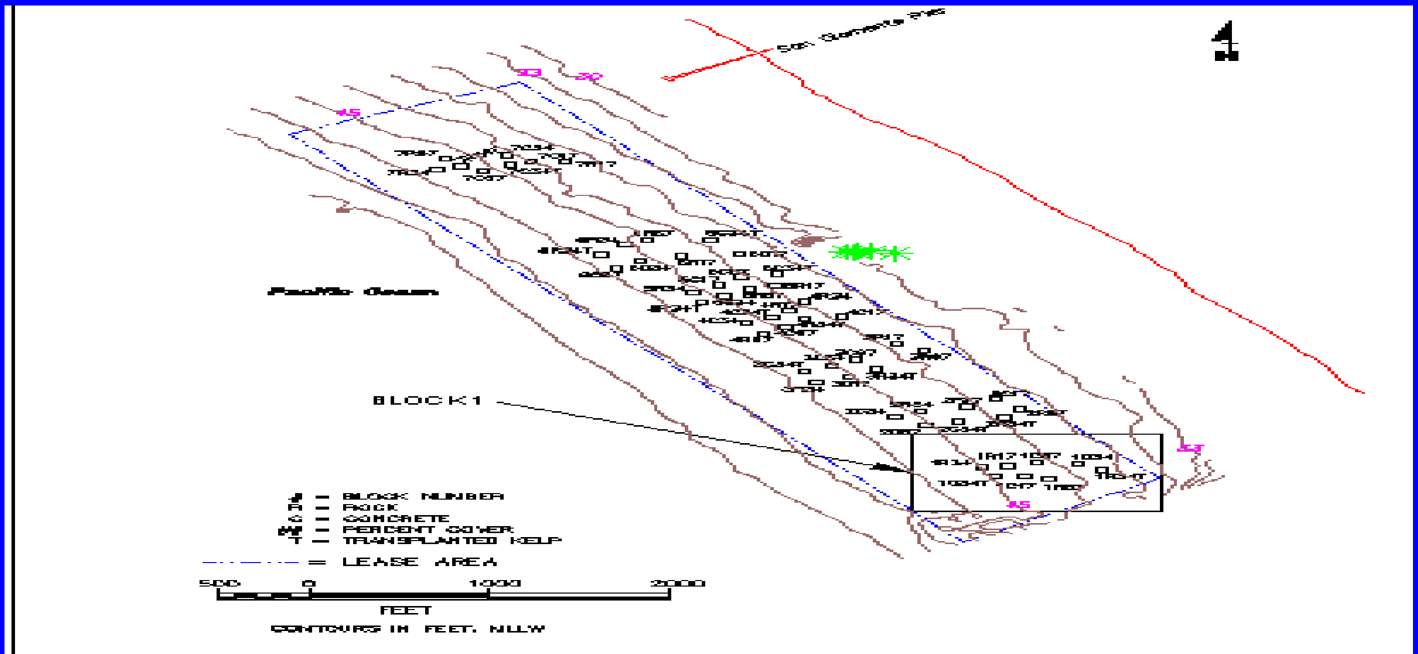
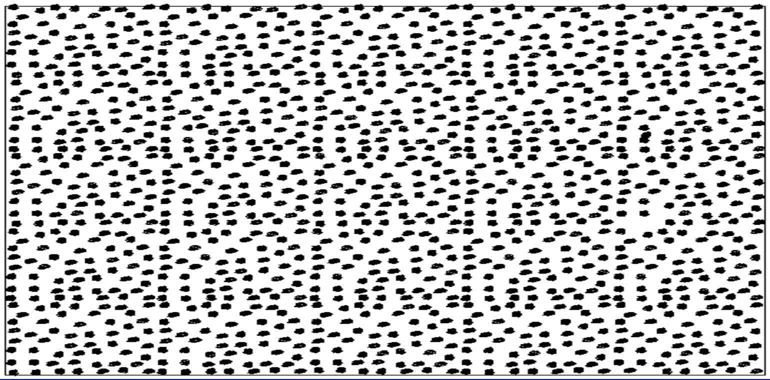


Figure 1. Southern California Edison Experimental Artificial Reef.

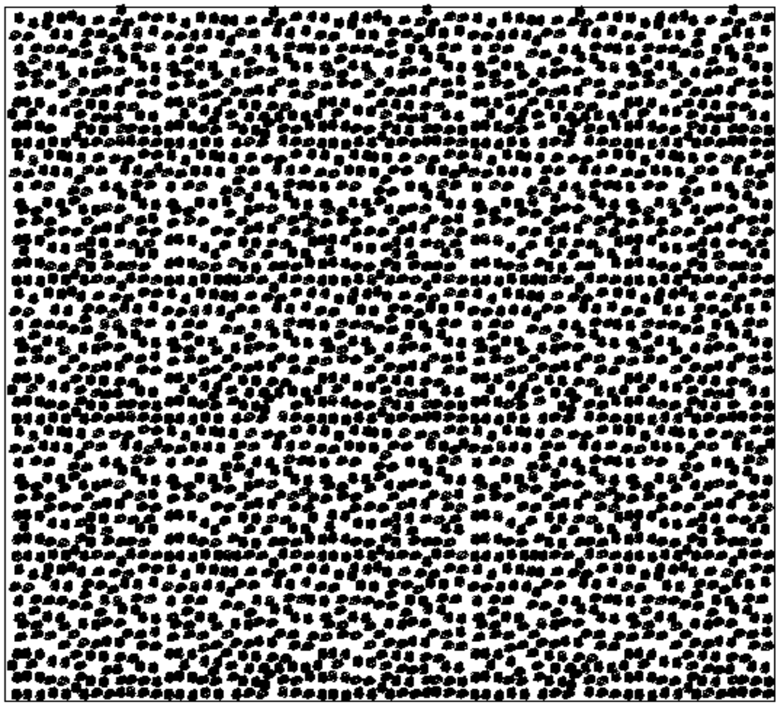
Experimental Reef Design Specifications

- Varying densities of hard substrate material are utilized, denoted low, medium, and high.
- Hard Substrate Coverage: Low (17%)



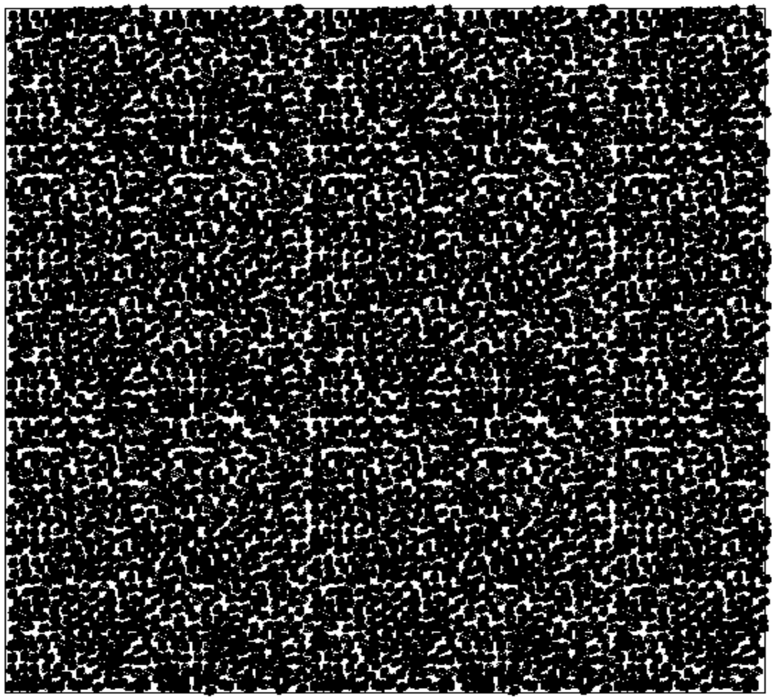
Experimental Reef
Design Specifications

- Hard Substrate Coverage: Medium (34%)



Experimental Reef Design Specifications

- Hard Substrate Coverage: High (68%)



Reef Materials

- Two materials are utilized to build the experimental reef. One half of the modules in each block are built from quarry rock and the remaining half from recycled concrete.

Reef Materials

- Quarry Rock: from Pebbly Beach Quarry, Catalina Island

Reef Materials

- Recycled Concrete: from buildings, curbs

Reef Materials

- Material is sorted prior to use at the reef to meet the size specifications for reef design.

Reef Materials

- Material is inspected prior to use at the reef. Rebar, asphalt, and paint are removed or trimmed from materials.

Material Specifications

- Quality and size specifications for rock and concrete were developed from biological criteria:
- Rock: <12” (0 to 5%)

  12 to 24” (75 to 90%)

  24 to 36” (5 to 10%)
- Concrete: <6” (0 to 5%)

  6 to 12” (85 to 100%)

  12 to 24” (0 to 15%)

Equipment

- A derrick barge, supply barge, tugboat, crane, and front loader are used along with computer programming and GPS system to place the modules in the desired locations.

Methodology

- The derrick barge has six anchors connected to 10-ton blocks for stabilization. Barge winches allow manipulation and movement.

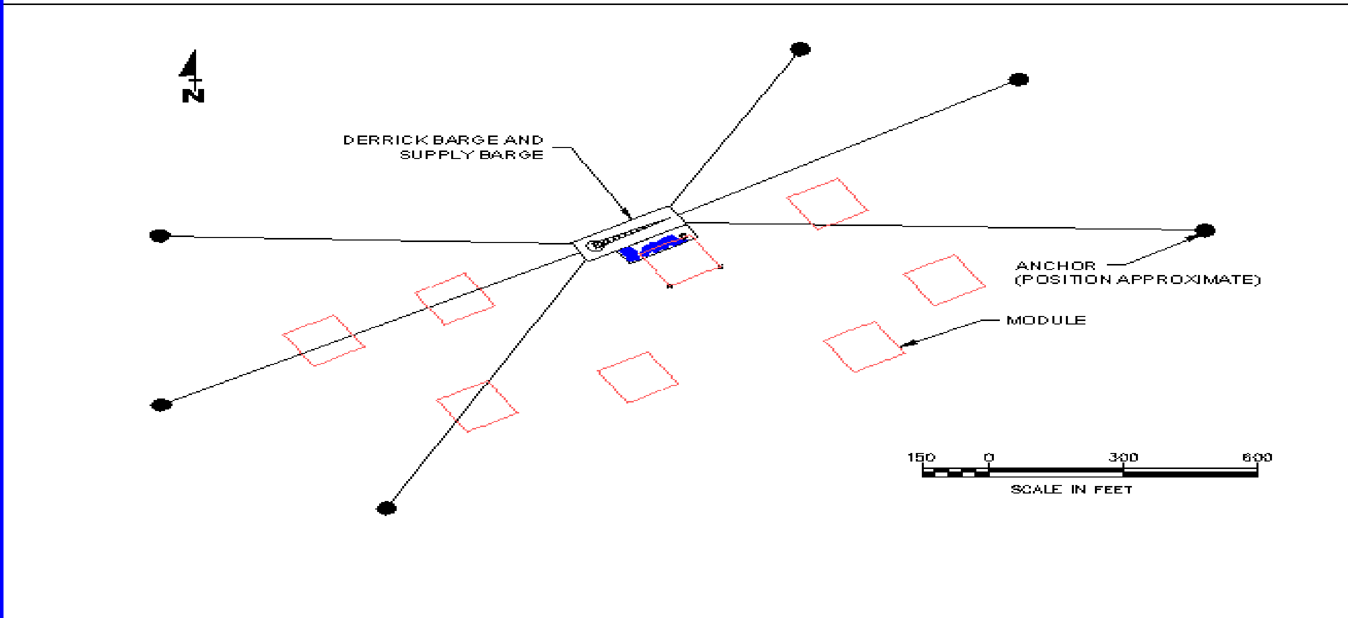


Figure 7. Derrick barge and supply barge anchored at Block 2.

Methodology

- Spar buoys are used to locate the edge of the module. GPS is used to place the spar buoys (California State Plane Coordinates (NAD 83)).

Methodology

- The control room on the derrick barge. The computer program allows real-time positioning by use of the six winches.

Methodology

- The tugboat brings the supply barge and materials out to the anchored derrick barge each morning.

Methodology

- The supply barge contains materials to build one 17% module (right) and one 68% module (left), or two 34% modules.

Methodology

- The derrick crane transports the front loader to the supply barge.

Methodology

- Rock/concrete placement parameters for a 34% rock module. Number of lines, spacing, and weight vary between densities.

Module Number	*Module Name*	*Lines*	*Spacing (feet)*	*Dist. (feet)*	*Weight (tons)*
18	2R34	11	10	12	568

Methodology

- The number of lines and loads per module are determined by the hard substrate percent coverage.

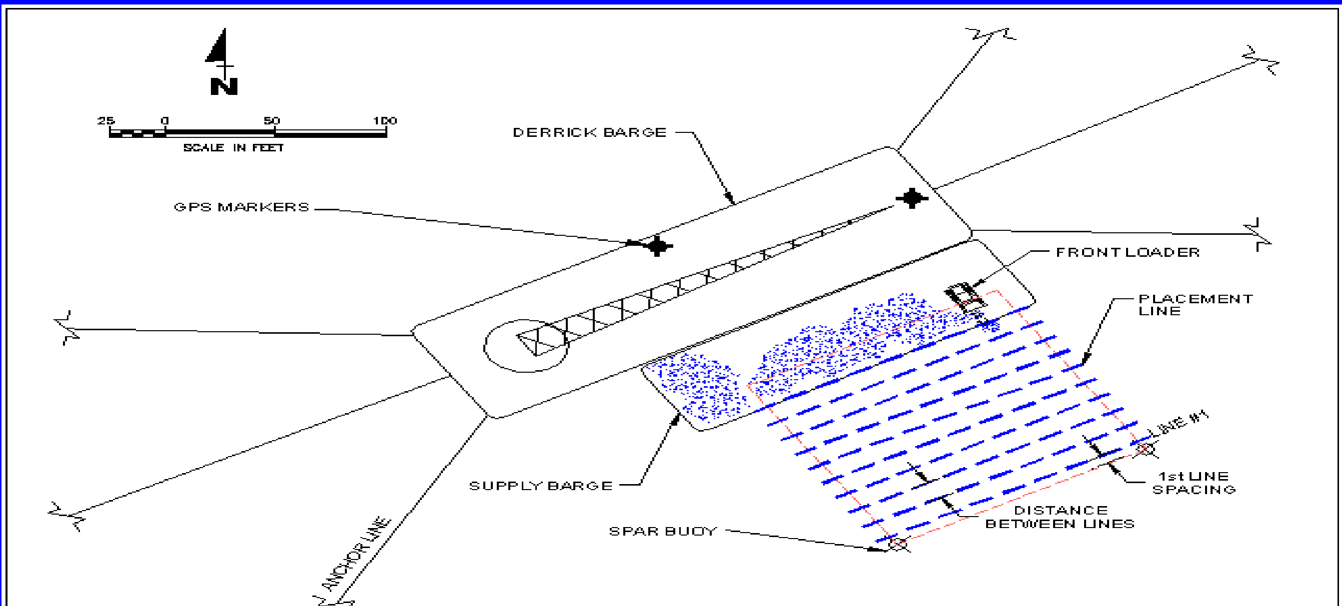


Figure 9. Construction method.

Methodology

- The front loader is used to place calculated amounts of substrate (rock or concrete).

Compliance with Permits

- Water is sprayed onto materials to control dust prior to placement.

Compliance with Permits

- Material, placed by front loader into the ocean, causes minimal turbidity.

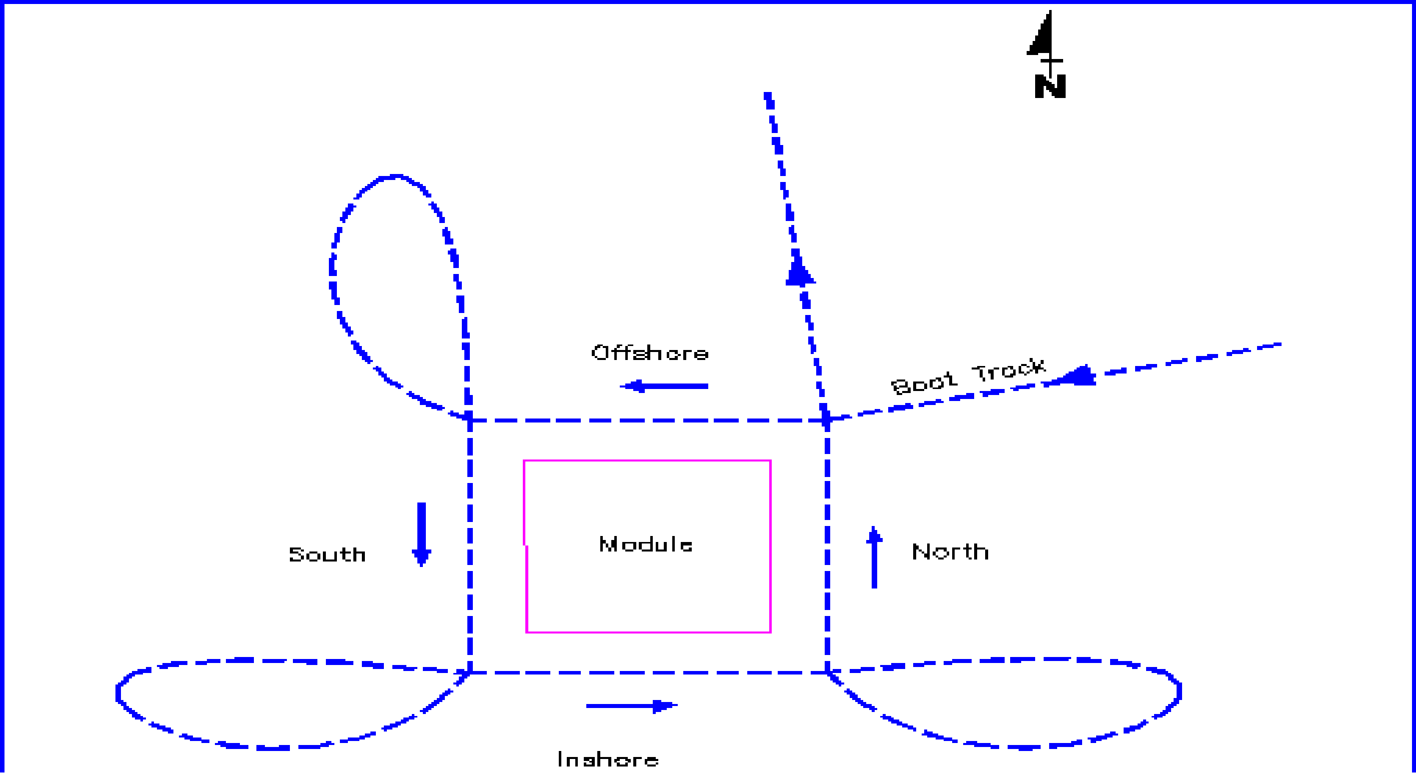
A Successfully Constructed Reef

- The Reef is monitored and verified by:

- Side-Scan Sonar Verification
- Diver Survey Verification
- Comparison of Designed Versus As-built
- Observation of Future Kelp Growth

A Successfully Constructed Reef

- The sonar boat track shows the four routes by which information is collected.



A Successfully Constructed Reef

- Side-scan sonar is utilized to verify construction per design.

Module Number	*Name*	*Design %*	*Off-Shore %*	*South %*	*In-Shore %*	*North %*	*Ave. %*
18	**3R34**	**34%**	**33.1**	**34.1**	**33.9**	**37.4**	**34.6**

A Successfully Constructed Reef

- Divers are deployed to verify sand to substrate ratios, height, and overlap.

A Successfully Constructed Reef

- The diver survey results are:

- Sand to substrate ratios between the modules are easily differentiated;
- Modules of maximum height of 3 to 5 feet;
- Average height of 2 feet; and
- Material was placed in mono layers (overlap of materials is minimal).

A Successfully Constructed Reef

- Location of the as-built reef approximates that of the design reef.

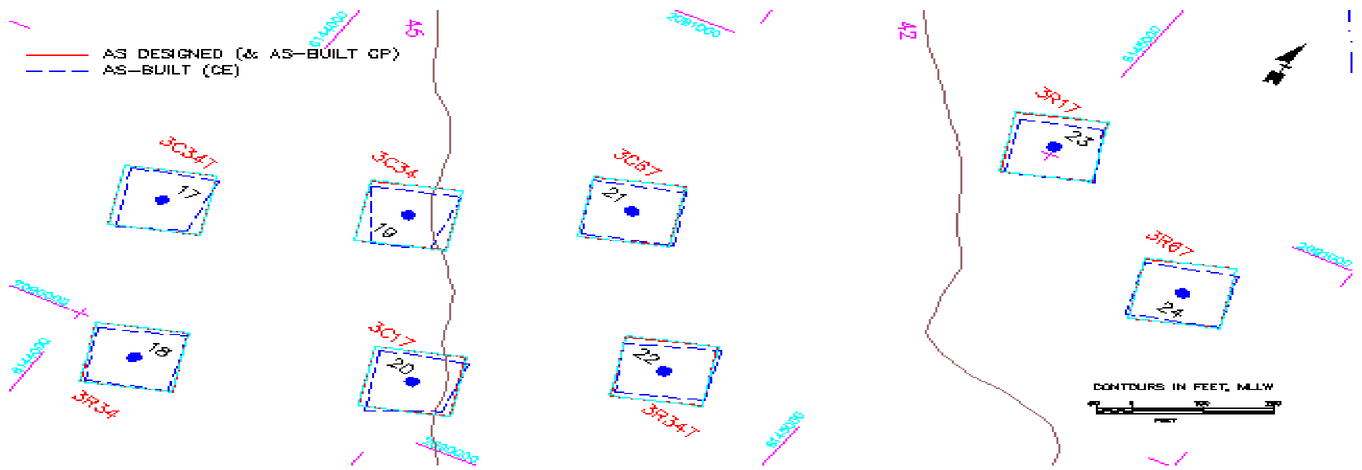


Figure 4. Designed versus as-built modules, Block 3 modules.

A Job Well Done

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The Credits

- Funded and Managed by **Southern California Edison, Rosemead, California**
- Engineering and Construction Support by **Coastal Environments, La Jolla, California**
- Construction by **Connolly-Pacific** and **Manson Construction, Long Beach, California**

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