HYDROGRAPHIC & GEOPHYSICAL SURVEYS ON A REEF SITE

Planning a Kelp Mitigation Artificial Reef Offshore of San Clemente, California

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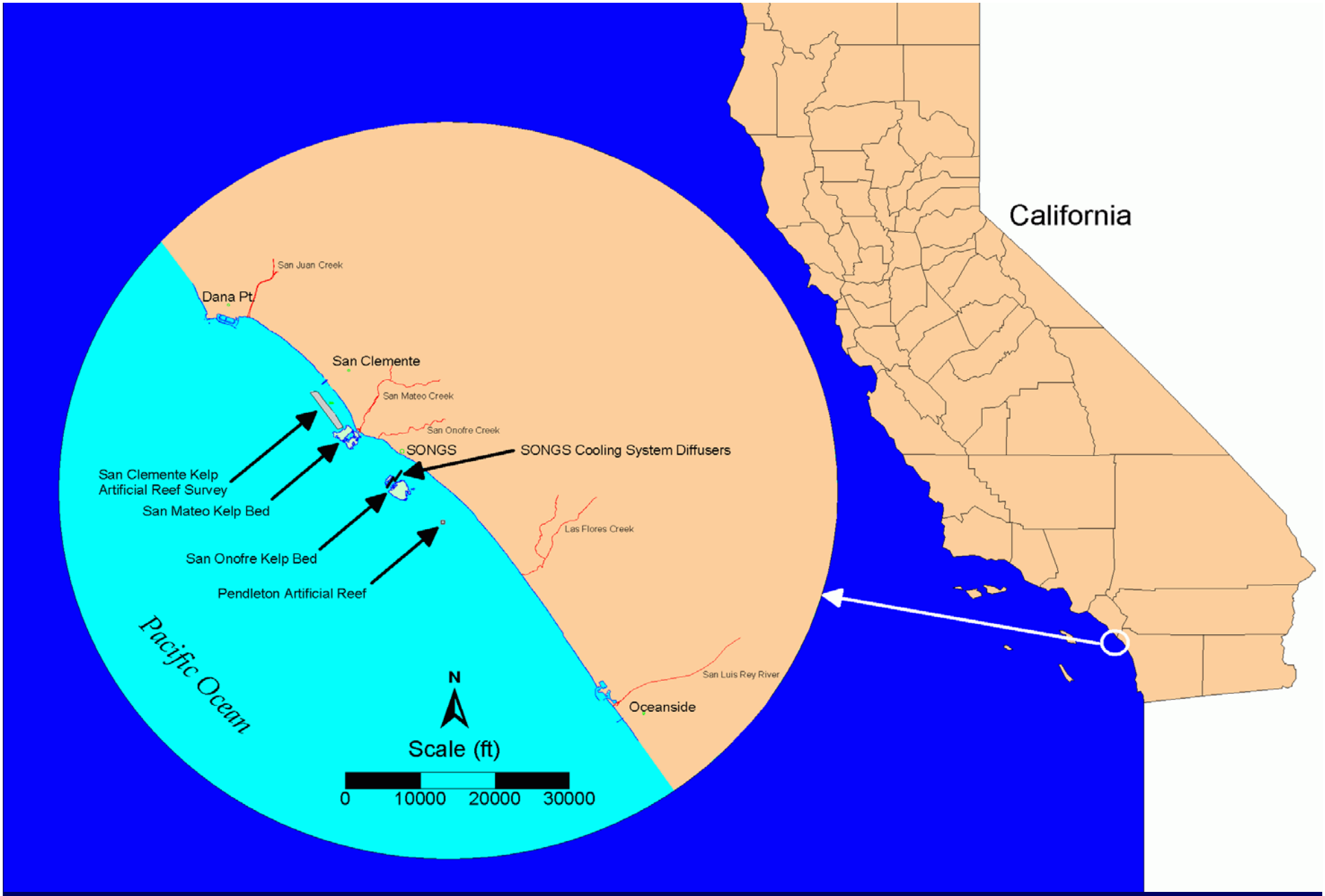
Introduction

Why a kelp artificial reef, and why at San Clemente?

- Compensate for kelp habitat impacts from the San Onofre Nuclear Generating Station
- In-kind, and in-place (nearby) mitigation
- Locate in an area physically suitable for kelp
- Locate in an area that minimizes impacts to existing valuable habitat and substrate

Kelp Habitat – in the San Onofre area



Locations of San Clemente Kelp Mitigation Artificial Reef,
San Onofre Nuclear Generating Station, and Pendleton Artificial Reef.

Kelp Reef - Siting Guidelines

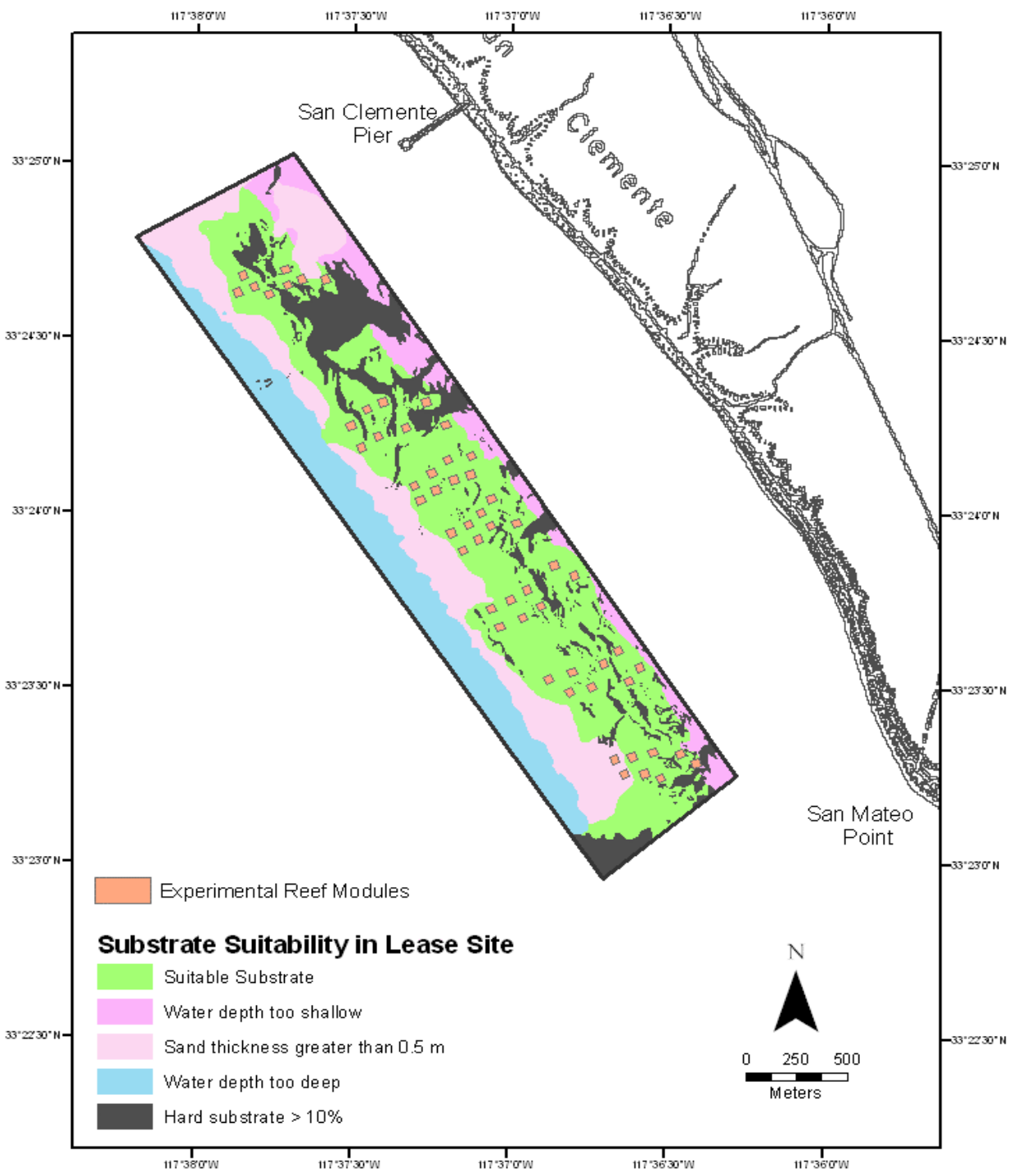
As governed by physical conditions and regulatory agency constraint:

- Suitable kelp growth depths: ~ 11 to 16 m.
- A thin (< 0.5 m) layer of sediment on top of bedrock or existing natural hard substrate.
- Near-persistent natural kelp forests.
- Not directly on existing natural hard-bottom substrate.
- At a distance from areas with major sediment deposition.
- At a distance from areas near wastewater discharge or other human perturbations.
- At a distance from areas of historical or cultural resources.
- As near as practical to the SONGS-impacted natural kelp reef.

Mitigation Kelp Reef – Project Schedule

- **Phase 1** – General Siting and Design Studies: 1991 to 1997.
- Phase 1 – San Clemente Site Sonar Study: 1997-1999.
- Phase 1 – Construction, **22.4 acres**: Sept. 1999.

- **Phase 2** – Sonar and Ground-Truth Studies: Sept. 2005 to Feb. 2006.
- Phase 2 – Construction, **127.6 acres**: 2007 - 2008.



Phase 1 Reef:

Constructed in Sept. 1999

864-Acre Lease Area

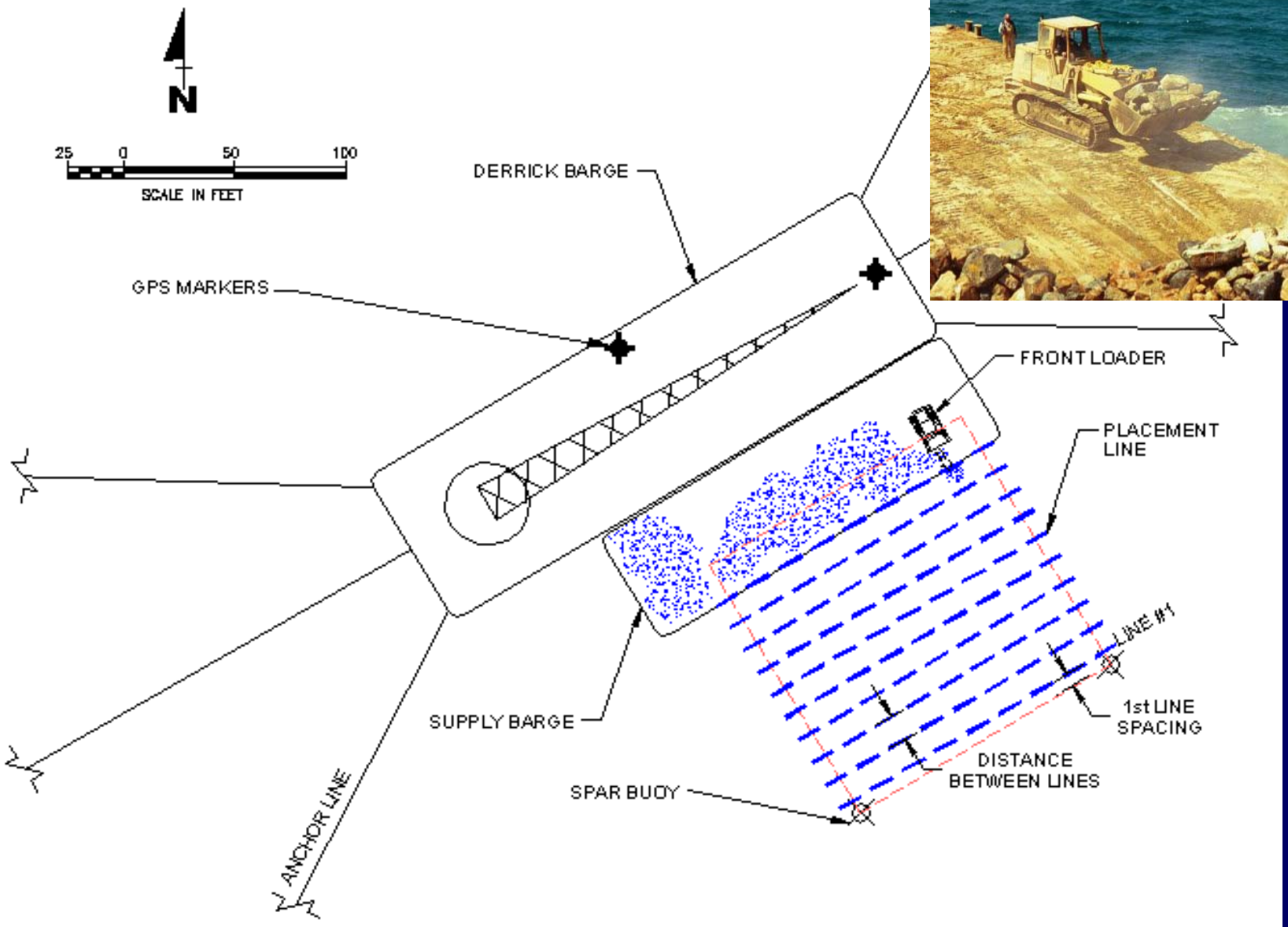
356 Acres Suitable Substrate

56 Modules - Each 40 m x 40 m

22.4 Acres Total

Phase 1 Construction – Derrick Barge and Supply Barge

September 1999, 22.4 Acres of Reef Area Created



Phase 1 – Construction Method - Derrick and Supply Barges

Aerial View, 2002, Phase 1 Reef Modules with Kelp Canopies

Kelp Habitat – Phase 1 Reef Modules

Phase 2: 127.6-acre Build-out Mitigation Reef Siting Methods and Project Objectives

2005-2006:

- Multibeam sonar surveys – bathymetry and bottom type (sand or hard-substrate)
- Sub-bottom sonar surveys – sand thickness
- Diver ground-truth surveys – verify bottom type and sand thickness, assess biological communities
- Reef siting and design planning

2007- and beyond:

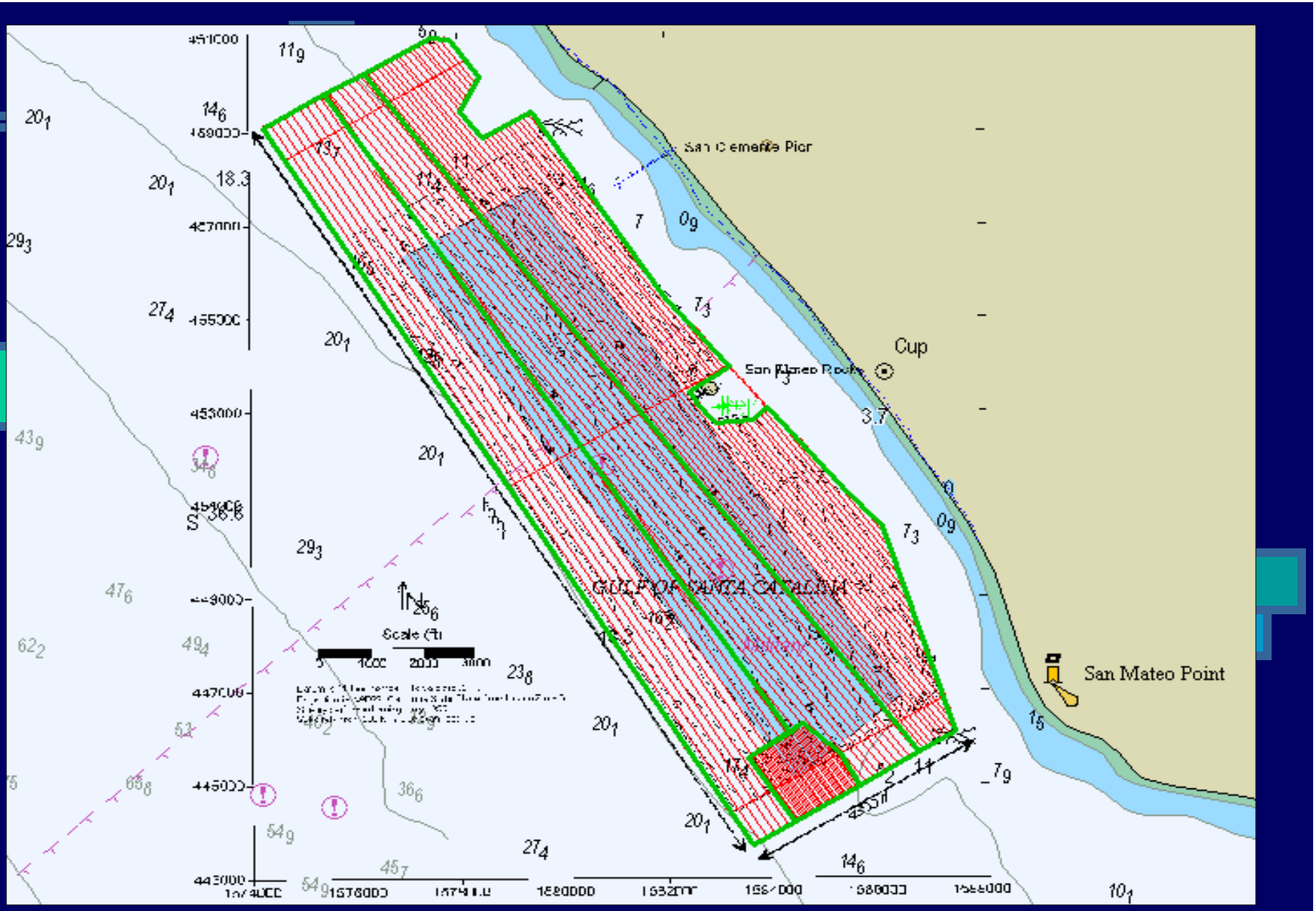
- Kelp Mitigation Reef Construction
- 40-year biological and physical performance study
- Adaptive management process

Survey Vessel: 2005 Multibeam Sonar Surveys at the San Clemente Kelp Mitigation Reef

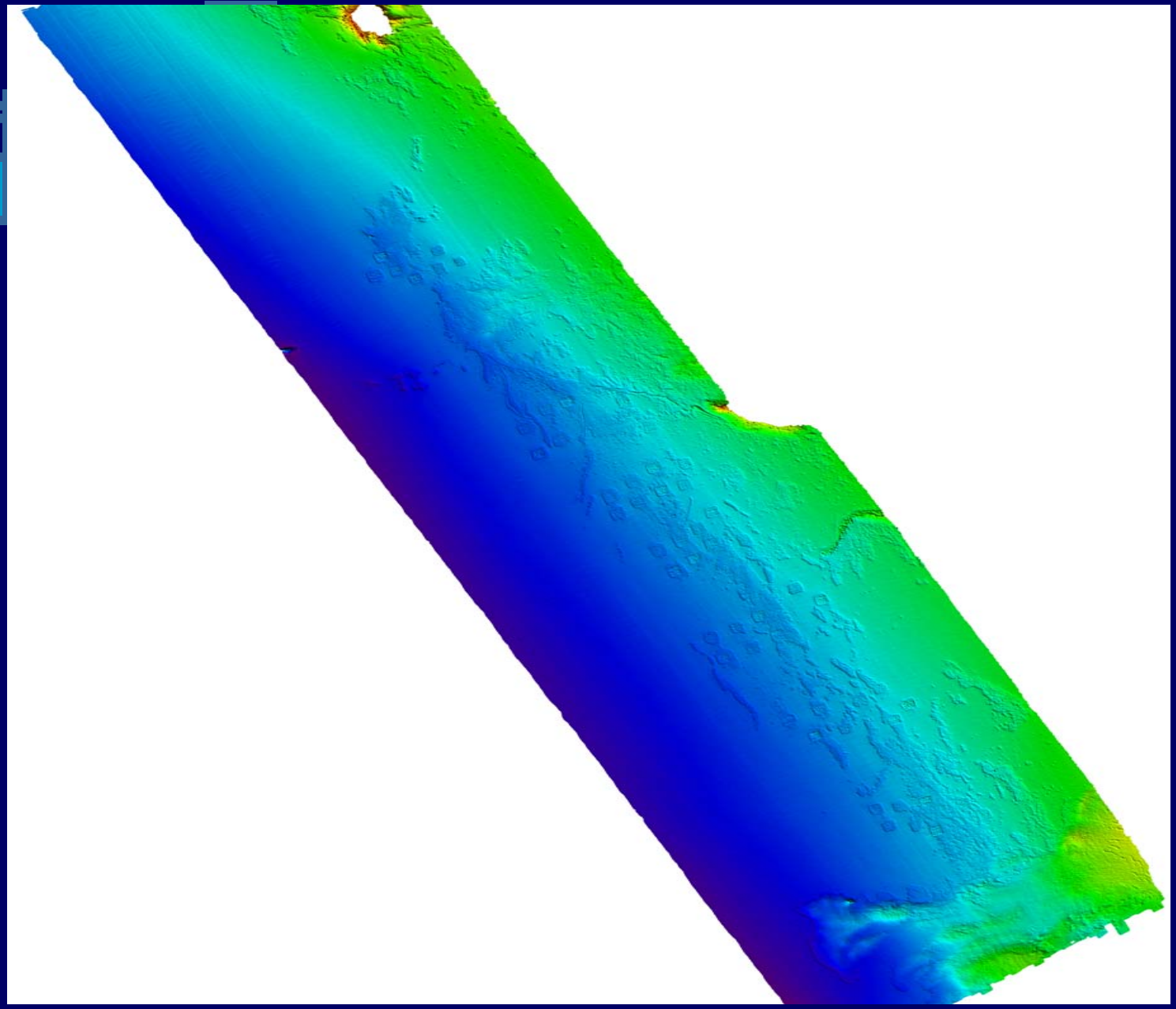
Methods – Field Equipment for the 2005 Hydrographic and Geophysical Survey at the San Clemente Kelp Reef

The *M/V Locator*, a 25 foot long Parker boat, was used as survey vessel for the project. The vessel was equipped with the following primary equipment for execution of the survey:

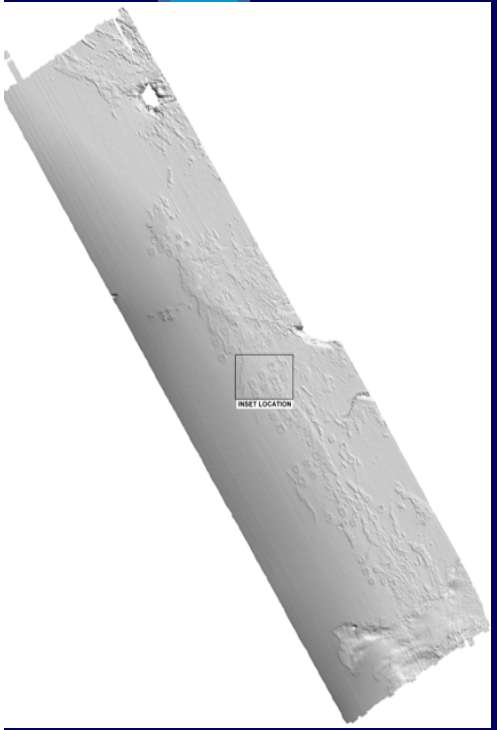
- **Reson SeaBat 8101 Multibeam Echosounder (MBES), over-the-side mounted**
- **POS/MV 320 positioning, heading, and motion reference sensor**
- **CSI DGPS-MAX USCG Differential correction radio-beacon**
- **GeoAcoustics Model 5110 Sub-bottom Profiler (SBP), over-the-side mounted**
- **Applied Microsystems Limited (AML) SmartProbe, for Sound Velocity Profiles (SVP)**
- **FPI's WinFrog navigation software**
- **Triton Elics International (TEI) Isis Sonar, DelphMap, BathyPro, & DelphSeismic Software Suite**
- **CARIS HIPS**

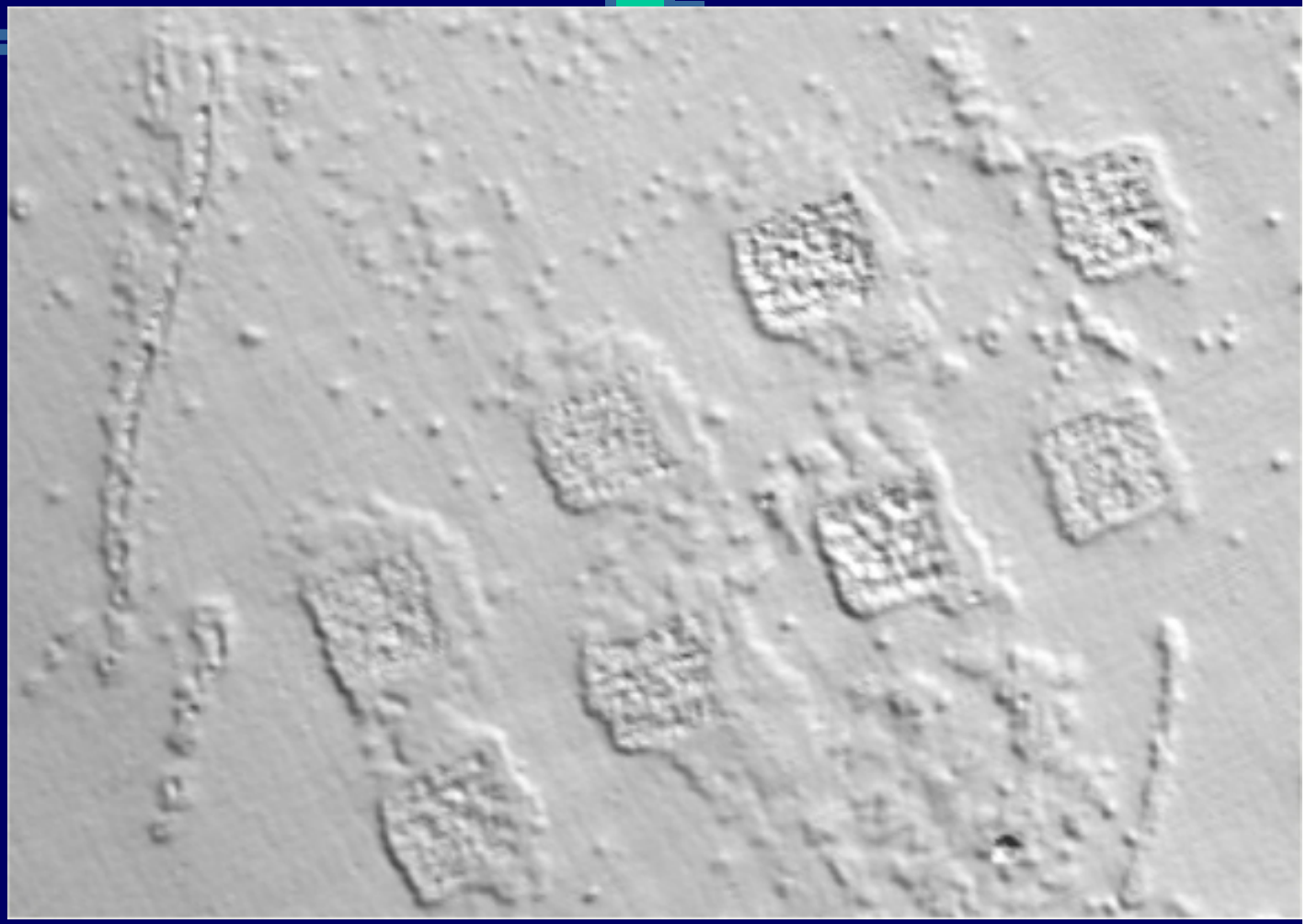


Phase 2 Multibeam Survey, October 2005.
Study area: 7.5 sq km, 52 tracks, 295 km total line length.



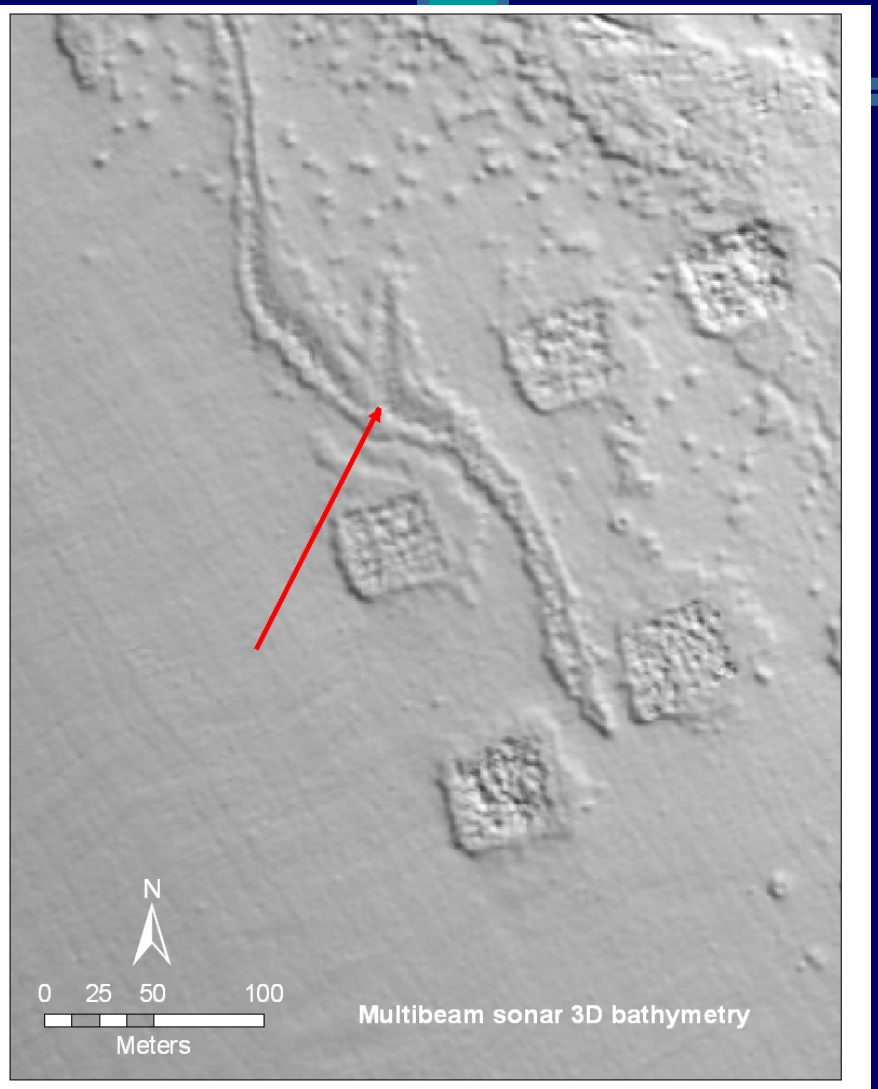
Phase 2 Multibeam Coverage: Bathymetry, Oct. 2005

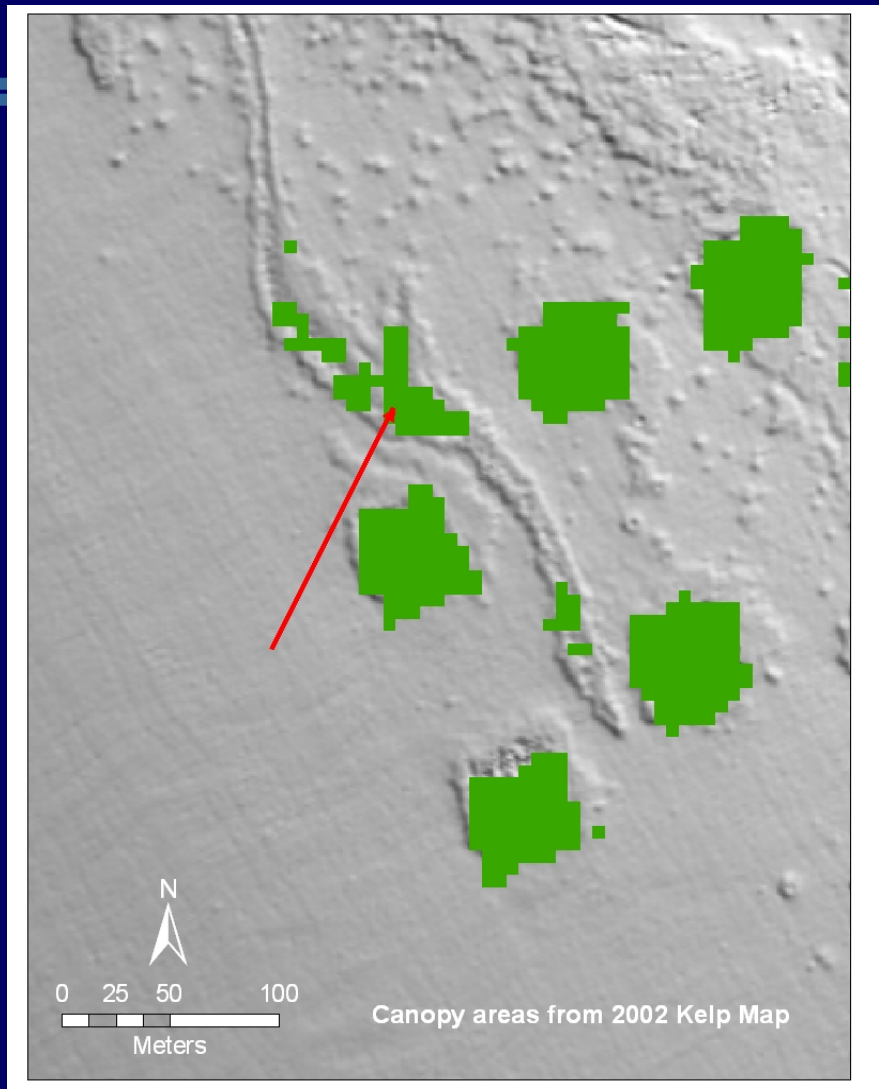




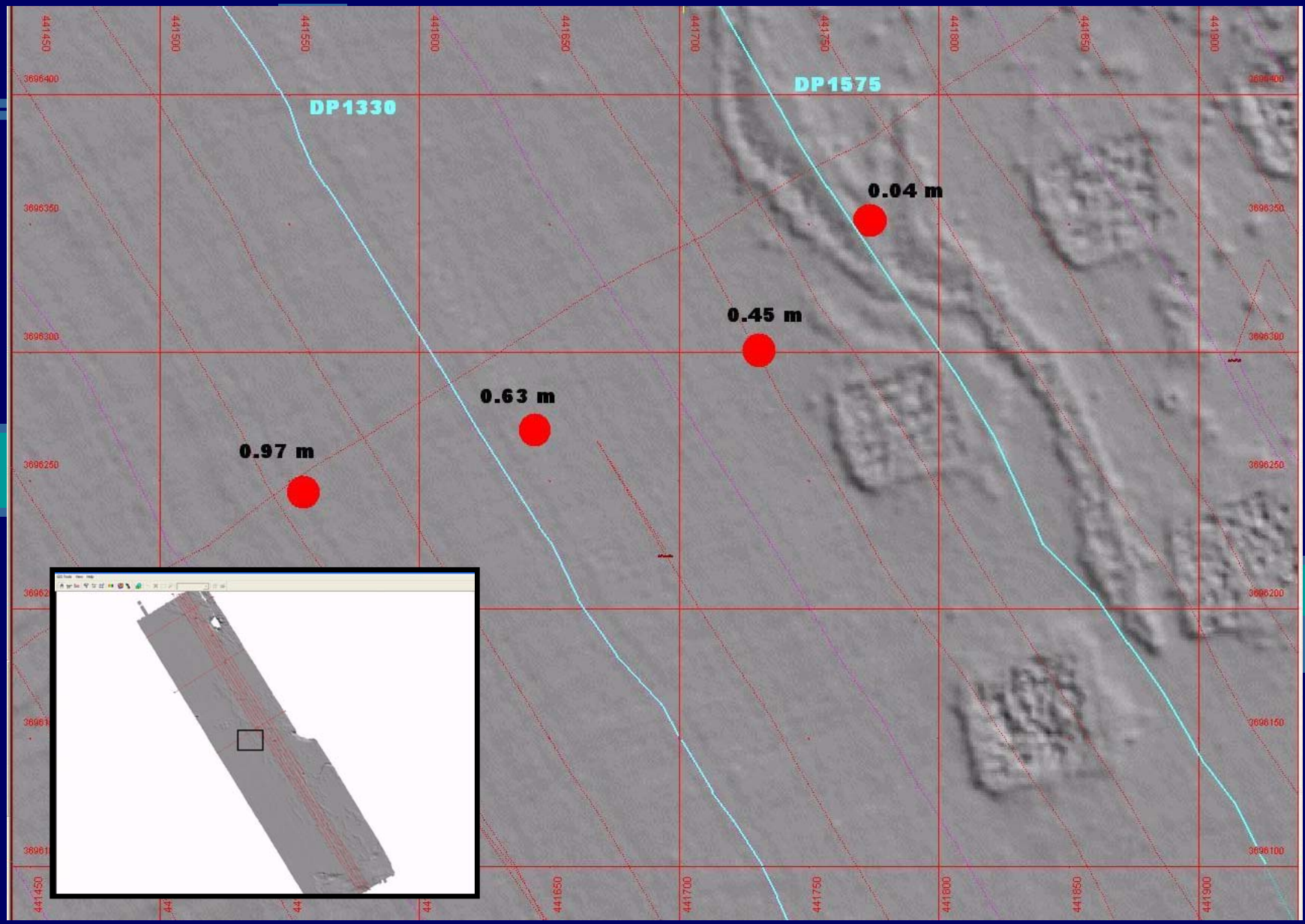
Left: Image and Inset Location in the San Clemente Reef Study Area.

Right: Sun-Illuminated Multibeam Bathymetry Image of Kelp Modules.

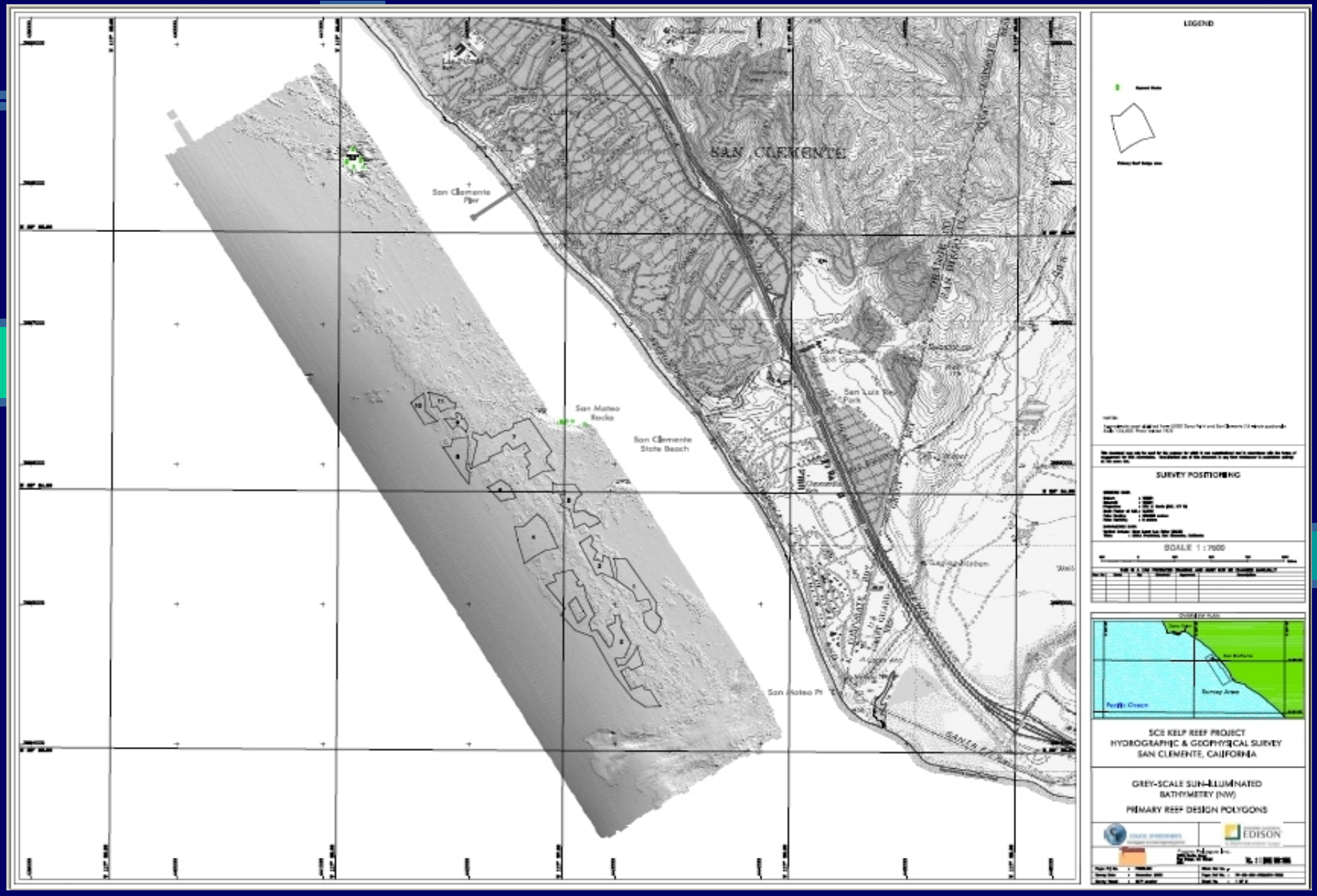




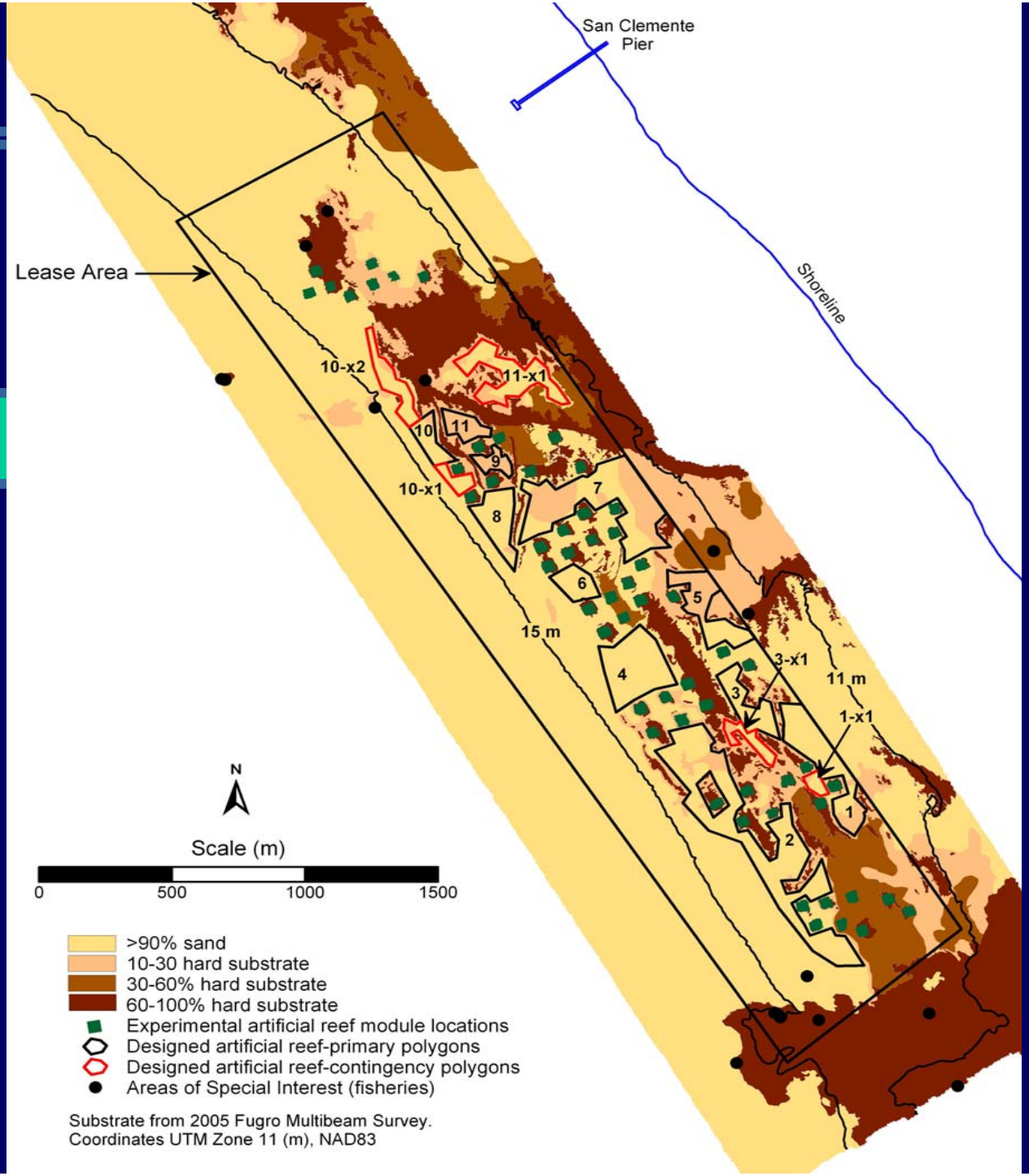
Comparison of kelp canopy areas - 2002 kelp aerial map (right); with substrate features from the 2005 multibeam sonar bathymetry map.



Sub-Bottom Lines (2) with Historic Core Samples (sand depths in m): Overlaid on Bathymetry



Layout of the Phase 2 Mitigation Reef Proposed Build-out Areas on the 2005 Multibeam Bathymetry Sonar Data.

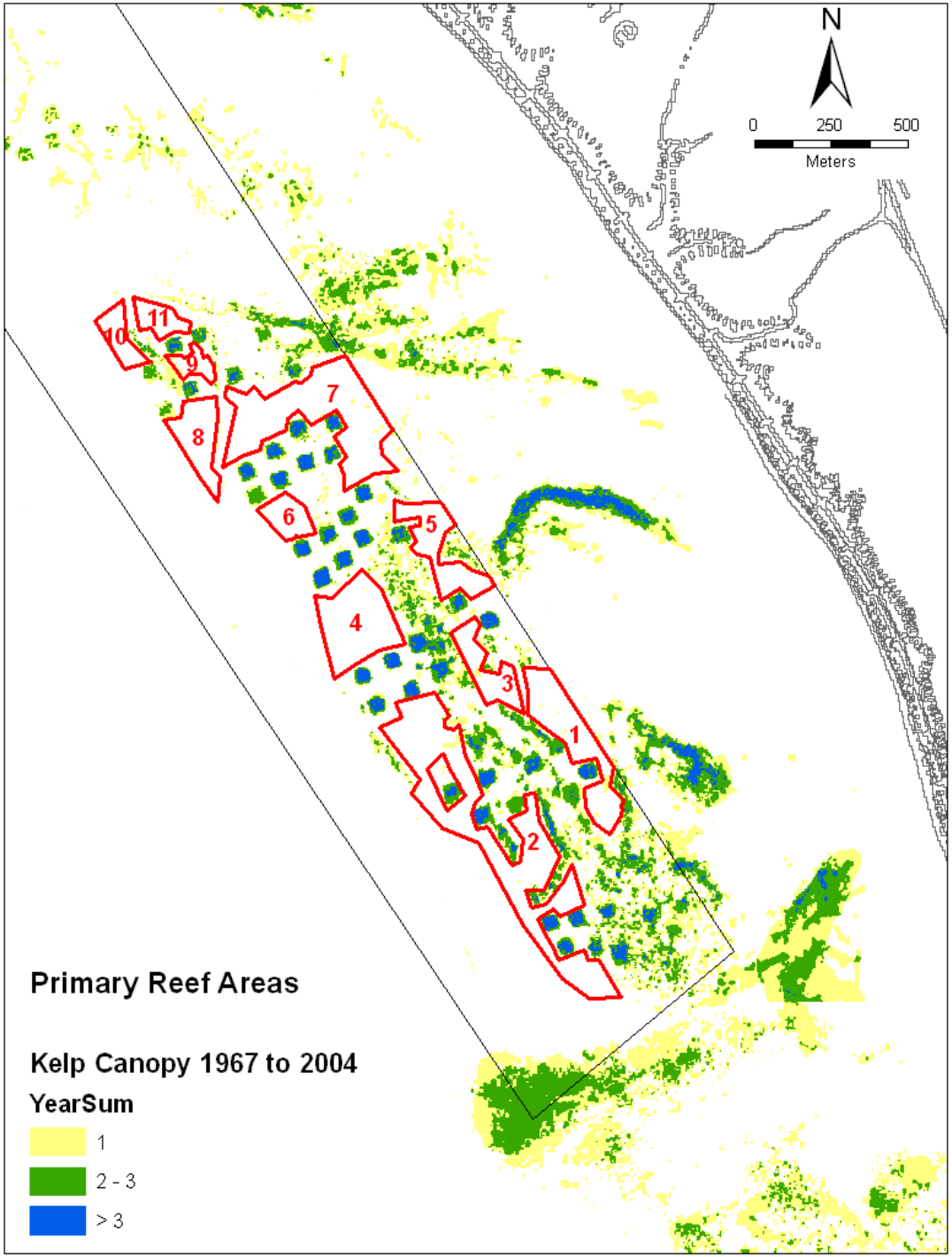


Phase 2 Reef Study

2005 Multibeam sonar results:

Build-out reef (127.6 acres) and contingency areas (22.4 acres)

overlaid on seafloor characterization map.



Phase 2 Mitigation Reef – Proposed Site (127.6 acres)

Overlaid on historical kelp canopy in the lease area - 1967 to 2004.

Kelp canopy areas have been geo-referenced to the substrate features of in the 2005 multibeam sonar data.

Year-Sum is the cumulative number of years that kelp has occurred at a location.

Conclusions

The five-year 1999-2004 study of the 22.4-acre Experimental Reef demonstrated that:

- Sustained kelp growth on a low-profile artificial reef is viable
- Well-placed reef substrate will not disappear into the sediment
- Minimum bottom density of reef substrate meets performance-mandated kelp coverage

2005-2006 Hydrographic & Geophysical Study provides:

- Time-series data (1997-2006) demonstrating that the natural seafloor elevations, seafloor types, and biological communities have not change significantly in the San Clemente area
- Assurance that artificial reef materials in the planned polygons will avoid the potential of burial into the sand seafloor
- Assurance that viable existing hard-substrate biological communities will not be adversely impacted by new reef material placement
- An accurate map for siting the 127.6-acre build-out Kelp Mitigation Reef

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