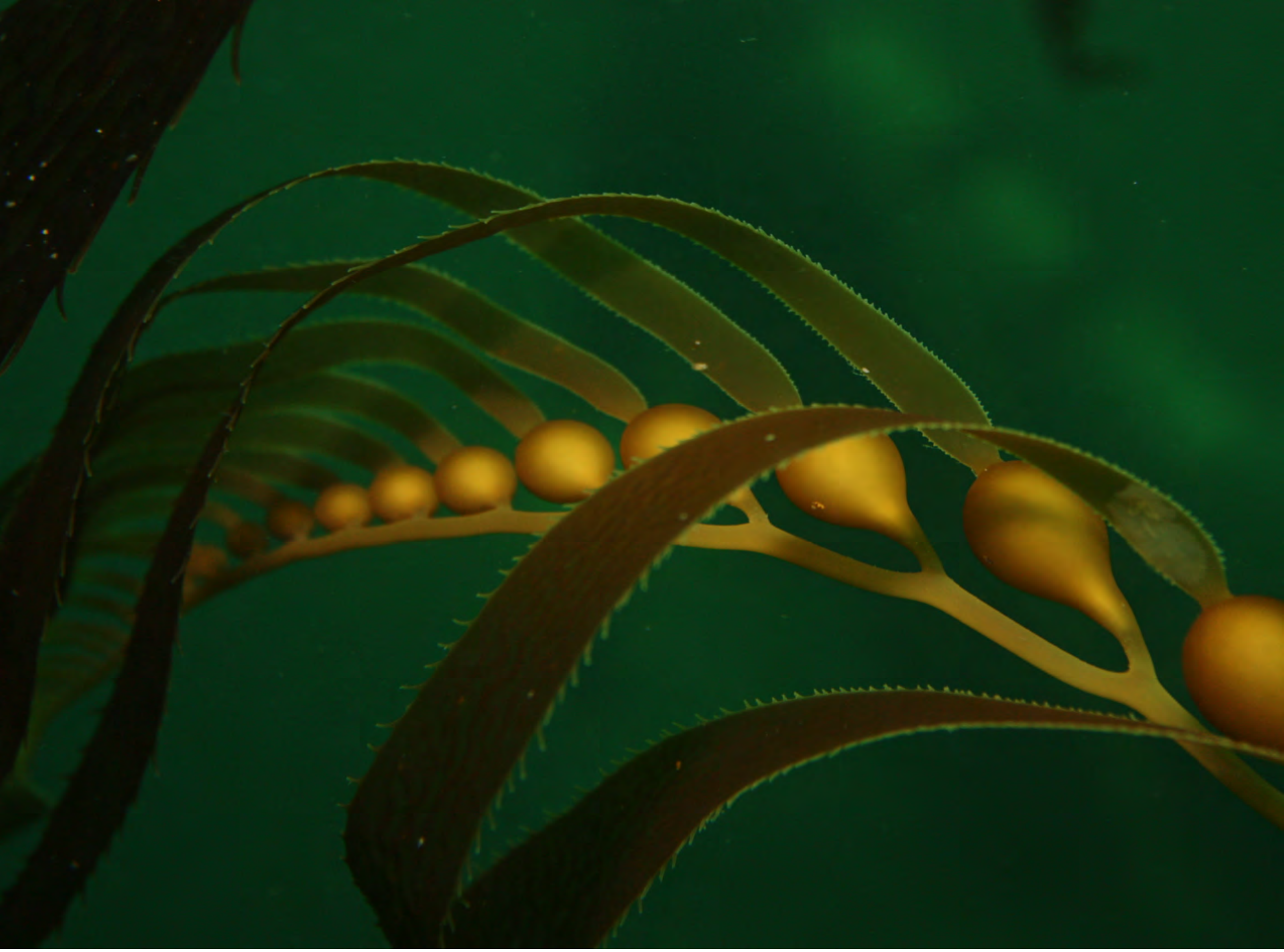

Status of the Kelp Beds in 2015:

Ventura, Los Angeles, Orange, and San Diego Counties

FINAL REPORT

27 July 2016

STATUS OF THE KELP BEDS IN 2015:
Ventura, Los Angeles,
Orange, and San Diego Counties

Prepared for:

Central Region Kelp Survey Consortium and
Region Nine Kelp Survey Consortium

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EXECUTIVE SUMMARY

Giant kelp beds have been mapped quarterly off Ventura, Los Angeles, Orange, and San Diego counties for both the Central Region (CRKSC) and Region Nine Kelp Survey Consortiums (RNKSC). The CRKSC was formed in 2003 as a result of regulations from the Los Angeles Regional Water Quality Control Board (LARWQCB). The program was based on the long-established RNKSC that formed in 1983, a result of regulations promulgated by the San Diego Regional Water Quality Control Board (SDRWQCB). When combined, the two organizations provide continuous and synoptic monitoring for approximately 355 kilometers (km) of the 435-km coastline of the Southern California Bight (SCB), from Ventura Harbor to the Mexican Border.

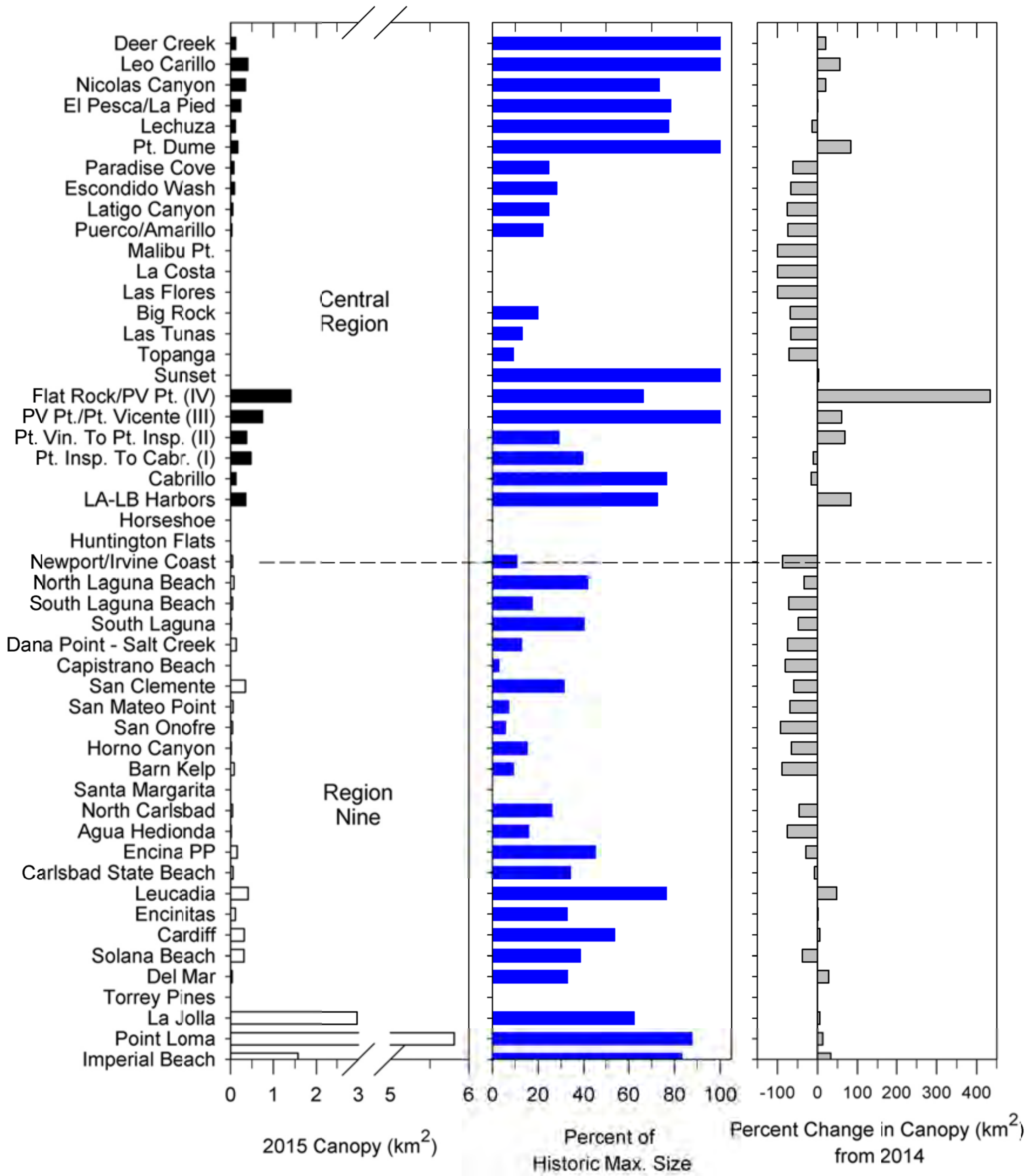
Aerial imaging surveys of the giant kelp beds were conducted by MBC *Applied Environmental Sciences* (MBC) on 9 April, 20 June, 13 September, and 6 December 2015. Digital color and color infrared photos were taken of the entire Central Region and Region Nine coastlines during each survey. These photos were then processed and the kelp depicted on each photo was transferred to base maps to facilitate intra-annual comparisons for ease of analysis (Appendices A, D, and E).

Total canopy size within the 50 kelp beds monitored as part of the CRKSC and RNKSC programs remained above the long-term average in 2015, but decreased 2.3% from the previous year. Most of the kelp beds in the SCB decreased in size since 2014. Total canopy coverage for this survey year was 17.9 km^2, with 5.3 km^2 in the Central Region and 12.7 km^2 in Region Nine. There was no evidence to suggest that any of the two regions' various dischargers had any perceptible influence on the persistence of the giant kelp beds.

Central Region Results. In the Central Region, the maximum total kelp canopy increased from 4.283 km^2 in 2014 to 5.255 km^2 in 2015 (a 22.7% increase) (Figure 19). However, this was skewed by the four-fold increase in canopy coverage at Palos Verdes (PV) IV. Eleven of the 26 beds in the Central Region decreased in size. The number of kelp beds displaying canopy was slightly reduced in the Central Region, with 21 of the 26 historic kelp beds visible in 2015. The total amount of kelp peaked in 2009, with 6.4 km^2 of canopy coverage, and canopy coverage has ranged between 4.3 and 5.7 km^2 since then. The 2009 peak was greater than during any surveys since 1967 (Figure 19 and Appendix B).

Thirteen of the 26 beds in the Central Region lost canopy in 2015. However, five of the six beds between Deer Creek and Point Dume, and three of the four Palos Verdes beds, increased in size since 2014. The four Palos Verdes beds accounted for 57% of Central Region kelp coverage in 2015. Most of the beds in the Central Region reached their maximum extent by the June 2015 overflight.

Region Nine Results. In Region Nine, the maximum measured kelp canopy decreased from 14.053 km^2 in 2014 to 12.667 km^2 in 2015 (Figure 26). Seven kelp beds increased in size since 2014, and all seven were between Leucadia and Imperial Beach (Appendix A). The much longer history of consecutive monitoring (49 years) in Region Nine (compared to that of the Central Region—13 years) encompasses several very favorable periods for kelp growth. It is also apparent that the La Jolla and Point Loma kelp beds dominate and account for a large percentage of the Region Nine canopy coverage. In 2015, these two beds accounted for 69% of canopy area from Corona del Mar to the U.S./Mexico border (Figure 27).



Central Region (black) and Region Nine (white) kelp canopy coverage in 2015; percent of maximum size at Region Nine since 1983 and Central Region since 2003 (blue); and percent canopy coverage change since 2014 (grey).

Most of the Region Nine kelp beds reached their maximum extent by the June survey. Fifteen of the 24 visible kelp beds decreased in size. La Jolla, Point Loma, and Imperial Beach were the three largest beds in Region Nine during the past survey year. Current canopy areas at the Point Loma and Imperial Beach kelp beds were ranked the second largest since 2008, while canopy area at La Jolla was ranked the third largest since 2003 (Table 2). Among the kelp beds that decreased in size last year, the average loss of canopy was 60%.

Environmental Variables. Similar to 2014, sea surface temperatures (SSTs) during the first four months of 2015 were above average throughout southern California (Figure 7 and 8). Beginning in late March, there were several influxes of cold water between Point Dume and Point Loma. Strong cold-water pulses were evident in both regions from April through August. The upwelling index, calculated for a location 161 km offshore Solana Beach, indicated upwelling in March and April, but monthly upwelling was below average during 9 of 12 months in 2015 (Figure 9). The SSTs throughout the region were mostly above average from August through December. Warmer-than-average SSTs in 2015 coincided with “The Blob,” a large mass of warm water that formed off the Pacific Coast and affected coastal waters from the Bering Sea to Baja California, as well as a strong El Niño event (Figure 12).

The calculated Nutrient Quotient values have been below average throughout southern California for several years (Figures 5 and 6). Nutrient Quotient values are based on monthly mean temperatures, and may not adequately capture multiple, brief periods of cold-water influx. At Scripps Institution of Oceanography Pier (Scripps Pier or SIO Pier), the number of days with low water temperatures (i.e., <14°C) has been below average the last two years, and the number of days >16°C has been above average, suggesting a shift to warmer temperatures (Figure 37). At Point Dume, the number of days <13–14°C has been below average the last four years, and the number of days >16–20°C has been above average the last four years, also indicative of warmer temperatures. At Newport, the number of days with relatively warm temperatures (>16–18°C) has increased the last three years.

The effects of other environmental variables (rainfall/runoff, algal blooms, and large waves) appeared to have had little effect on southern California’s kelp beds in 2015. Rainfall was below average in southern California for the fifth straight year, so effects from runoff were negligible (Figure 17). Nearshore turbidity near the Portuguese Bend landslide area was visible during three of the four surveys, and relatively high during December, coinciding with two- to three-meter wave heights during the preceding day (Figure 38). Nearshore waters were also turbid during the December survey at Point Loma (Figure 39). Persistent turbidity at Palos Verdes could have affected surrounding beds (i.e., PV I and PV II at a minimum). There were no media reports of red tide in the region, so effects due to reduced visibility, if any, were limited. The wave climate in 2015 was considered average, with the largest waves arriving in February, November, and December (Figures 13 and 14). Wave heights exceeded three meters at all stations during February, and exceeded four meters in November and December. Most of the beds decreased in size between the June and September overflights, but the wave climate was mild during that period, and beds often shrink in summer and fall. This was considered a normal seasonal reduction in canopy.

Conclusions. Most kelp canopies decreased in size in 2015, although several beds increased in size. The reduction in canopies coincided with a second year of mostly above-average temperatures throughout the SCB and reduced upwelling. There was no evidence of any adverse effects on the giant kelp resources from any of the region's dischargers. Total coverage in 2015 was still above average for the region, and there were three areas along the coast where kelp canopies expanded: Deer Creek to Point Dume, Palos Verdes, and Leucadia to Imperial Beach. Reasons for variable canopy increases/decreases are unknown, but suggest that while region-wide water temperatures were above average for most of the year, physical and/or biological factors affected the kelp beds on a smaller scale such that adjacent beds performed differently. Predictions by the National Oceanic and Atmospheric Administration’s Climate Prediction Center for La Niña conditions in 2016 could spur kelp growth based on results from past kelp surveys and evidence presented in those reports.

INTRODUCTION

Giant kelp (*Macrocystis pyrifera*) beds along most of the southern California mainland coast have been mapped quarterly by the Central Region Kelp Survey Consortium (CRKSC) since 2003 and by the Region Nine Kelp Survey Consortium (RNKSC) since 1983. The CRKSC covers kelp beds from Ventura Harbor to Newport Beach (Figure 1), and the RNKSC covers Newport Beach to the Baja California border (Figure 2). The upcoast extent of the RNKSC is Abalone Point (Laguna Beach). However, historical surveys have examined the kelp beds from the Newport Harbor entrance to the U.S./Mexico border. It was agreed among the funding participants that the monitoring programs would be methodologically based upon aerial kelp surveys that were conducted since 1967 by the late Dr. Wheeler J. North. With the formation of the two monitoring programs, continuous coverage is provided of the kelp beds along approximately 354 of the 435 km (220 of the 270 miles) of the southern California mainland coast from Ventura Harbor to the U.S./Mexico Border. The geographical ranges and the ocean dischargers located within the CRKSC and RNKSC are shown in Figures 1 and 2, as well as Appendices A and D.

Figure 1. Ocean discharges located within the Central Region kelp survey area.

Figure 2. Ocean discharges located within the Region Nine kelp survey area.

HISTORICAL KELP SURVEYS 2003–2015

Estimated canopy coverages of each kelp bed are presented in Tables 1 and 2. Information on the life history of giant kelp, and the factors affecting kelp growth and distribution, as well as information on the first surveys of giant kelp along the coast of southern California are presented in Appendix B.

Table 1. Canopy coverage of the kelp beds from Deer Creek to Newport/Irvine Coast from 2003 through 2015. Areal estimates were derived from infrared aerial photographs. Red denotes warm-water years, blue denotes cold-water years, and neutral years are in black.

	Canopy Area (km²)												
Kelp Bed	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Deer Creek	0.089	0.107	0.053	0.026	0.046	0.074	0.105	0.062	0.055	0.041	0.104	0.103	0.124
Leo Carillo	0.318	0.399	0.171	0.150	0.145	0.207	0.255	0.232	0.226	0.337	0.366	0.261	0.408
Nicolas Canyon	0.308	0.362	0.195	0.038	0.473	0.268	0.433	0.291	0.130	0.240	0.369	0.288	0.347
El Pesc/La Piedra	0.243	0.314	0.141	0.063	0.255	0.173	0.238	0.164	0.136	0.173	0.236	0.244	0.246
Lechuza	0.105	0.104	0.041	0.022	0.106	0.075	0.105	0.096	0.096	0.066	0.154	0.137	0.119
Total F&W 17	1.063	1.286	0.600	0.298	1.025	0.797	1.136	0.844	0.642	0.857	1.229	1.034	1.244
Pt. Dume	0.012	0.029	0.028	0.053	0.065	0.070	0.104	0.094	0.078	0.154	0.113	0.092	0.169
Paradise Cove	0.162	0.258	0.035	0.036	0.100	0.223	0.244	0.259	0.109	0.346	0.244	0.223	0.086
Escondido Wash	0.214	0.250	0.078	-	0.339	0.278	0.321	0.267	0.104	0.248	0.243	0.281	0.095
Latigo Canyon	0.125	0.161	0.032	0.007	0.186	0.124	0.195	0.142	0.070	0.202	0.133	0.212	0.052
Puerco/Amarillo	0.074	0.051	0.039	0.055	0.095	0.064	0.115	0.126	0.069	0.153	0.105	0.130	0.034
Malibu Pt.	0.011	0.013	0.008	0.008	0.016	0.011	0.012	0.066	0.074	0.084	0.060	0.039	-
Total F&W 16	0.598	0.762	0.220	0.158	0.801	0.769	0.991	0.954	0.504	1.189	0.897	0.976	0.436
La Costa	0.001	0.002	-	-	-	-	0.001	0.001	-	0.003	0.003	0.001	-
Las Flores	0.009	0.023	0.004	-	0.005	0.001	0.005	0.005	0.008	0.025	0.022	0.016	-
Big Rock	0.005	0.014	0.002	0.001	0.004	0.002	0.005	0.006	0.007	0.018	0.017	0.011	0.004
Las Tunas	0.003	0.018	0.004	-	0.008	0.005	0.019	0.015	0.007	0.030	0.029	0.012	0.004
Topanga	0.0002	0.002	0.0001	-	-	0.001	0.002	0.052	0.041	0.048	0.044	0.016	0.005
Sunset	-	-	-	-	-	-	0.004	0.008	0.007	0.008	0.010	0.010	0.010
Total F&W 15	0.017	0.059	0.010	0.001	0.017	0.009	0.035	0.087	0.069	0.131	0.123	0.064	0.022
Malaga Cove-PV Pt. (IV)	0.196	0.245	0.204	0.859	1.151	1.839	2.122	1.136	1.139	1.337	0.974	0.264	1.410
PV Pt-PT. Vic (III)	0.045	0.040	0.056	0.135	0.074	0.300	0.570	0.624	0.452	0.488	0.502	0.468	0.750
Total F&W 14	0.241	0.285	0.260	0.993	1.225	2.140	2.692	1.760	1.591	1.825	1.476	0.732	2.160
Pt Vic to Pt Insp (II)	0.059	0.023	0.034	0.082	0.034	0.108	0.163	0.222	0.238	0.295	0.279	0.224	0.379
Pt Insp to Cabr (I)	1.063	0.211	0.702	0.951	0.703	0.608	0.980	0.389	0.465	0.384	0.672	0.533	0.478
Cabrillo	0.062	0.070	0.102	0.161	0.100	0.060	0.163	0.124	0.103	0.095	0.174	0.158	0.133
Total F&W 13	1.184	0.304	0.838	1.194	0.837	0.776	1.306	0.734	0.805	0.774	1.124	0.915	0.990
Total PV	1.425	0.589	1.098	2.187	2.062	2.916	3.998	2.494	2.396	2.599	2.600	1.647	3.149
POLA-POLB Harbor	ND	ND	0.147	0.494	0.118	0.213	0.151	0.277	0.397	0.495	0.337	0.196	0.359
Horseshoe	-	-	-	-	-	-	-	-	-	-	-	-	-
Huntington Flats	-	-	-	-	-	-	-	-	-	-	-	-	-
Newport-Irvine Coast	0.002	0.002	0.000	0.023	0.054	0.089	0.095	0.161	0.419	0.395	0.428	0.366	0.045
Total F&W 10	0.002	0.002	0.147	0.517	0.172	0.302	0.246	0.438	0.816	0.890	0.765	0.561	0.404
TOTAL	3.105	2.698	2.075	3.161	4.076	4.793	6.406	4.817	4.427	5.665	5.614	4.283	5.255

ND = No Data; "-" = 0

Sources: Veisze et al. (2004); MBC (2004a-2012a, 2013, 2015).

Table 2. Canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 2003 through 2015. Areal estimates were derived from infrared aerial photographs. Red denotes warm-water years, blue denotes cold-water years, and neutral years are in black.

	Canopy Area (km^2)												
Kelp Bed	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
N Laguna Beach	0.0004	-	-	-	-	0.002	0.005	0.093	0.147	0.192	0.142	0.120	0.080
S Laguna Beach	0.0002	0.008	-	-	0.001	0.025	0.058	0.098	0.221	0.214	0.273	0.165	0.048
South Laguna	0.004	0.009	0.003	-	0.004	0.023	0.017	0.023	0.018	0.017	0.038	0.031	0.016
Dana Pt/Salt Crk	0.303	0.278	0.123	-	0.302	1.068	0.892	0.839	0.442	0.607	0.835	0.528	0.137
Capistrano Beach	0.069	0.008	-	0.011	0.002	0.071	0.071	0.124	0.010	0.056	0.099	0.034	0.007
Total F&W 9	0.376	0.303	0.126	0.011	0.309	1.189	1.043	1.178	0.838	1.086	1.385	0.879	0.287
San Clemente	0.352	0.182	0.178	0.014	0.016	0.203	0.210	0.710	0.795	0.874	1.097	0.843	0.343
San Mateo Point	0.242	0.123	0.258	0.016	0.201	0.487	0.545	0.583	0.203	0.216	0.219	0.199	0.062
San Onofre	0.162	0.109	0.065	-	0.320	0.476	0.419	0.458	0.127	0.191	0.767	0.584	0.043
Total F&W 8	0.755	0.414	0.501	0.030	0.536	1.166	1.174	1.750	1.124	1.281	2.083	1.627	0.449
Horno Canyon	0.001	-	-	-	0.015	0.083	0.018	0.081	-	0.008	0.125	0.055	0.019
Barn Kelp	0.492	0.075	0.064	-	0.466	0.858	0.926	0.500	0.095	0.442	0.868	0.741	0.085
Santa Margarita	-	-	-	-	-	-	-	-	-	-	0.080	-	-
Total F&W 7	0.494	0.075	0.064	-	0.481	0.941	0.944	0.581	0.095	0.450	1.073	0.795	0.104
North Carlsbad	0.017	0.003	0.013	-	0.026	0.108	0.135	0.078	0.017	0.052	0.125	0.086	0.047
Agua Hedionda	0.002	0.001	0.008	-	0.016	0.080	0.092	0.031	0.022	0.046	0.102	0.065	0.016
Encina Power Plant	0.178	0.067	0.001	-	0.081	0.306	0.215	0.176	0.084	0.216	0.352	0.221	0.159
Carlsbad St. Bch	0.002	0.0001	-	-	0.064	0.121	0.127	0.069	0.024	0.058	0.178	0.065	0.061
Total F&W 6	0.199	0.070	0.023	-	0.187	0.615	0.569	0.354	0.147	0.372	0.757	0.437	0.282
Leucadia	0.185	0.048	0.001	0.016	0.233	0.421	0.429	0.215	0.119	0.232	0.541	0.279	0.414
Encinitas	0.050	0.016	-	0.002	0.205	0.346	0.205	0.128	0.124	0.260	0.231	0.112	0.113
Cardiff	0.202	0.045	-	0.004	0.286	0.484	0.520	0.213	0.395	0.459	0.590	0.299	0.318
Solana Beach	0.245	0.022	0.093	0.0003	0.457	0.823	0.505	0.328	0.504	0.442	0.606	0.504	0.316
Del Mar	0.030	-	-	-	0.037	0.057	0.044	0.038	0.074	0.024	0.056	0.027	0.034
Torrey Pines	-	-	-	0.010	-	0.001	0.0004	0.003	0.031	0.034	0.081	-	-
Total F&W 5	0.712	0.131	0.094	0.032	1.218	2.133	1.703	0.925	1.247	1.452	2.106	1.221	1.195
La Jolla F&W 4	3.444	1.029	0.873	0.117	2.750	4.145	2.274	2.776	2.565	1.569	4.006	2.790	2.968
Point Loma F&W 3&2	4.509	1.924	2.152	1.767	3.616	6.623	4.909	3.977	4.212	5.340	5.127	5.121	5.806
Imperial Beach F&W 1	0.083	0.191	0.400	0.400	1.493	1.895	0.861	0.004	0.152	0.333	0.526	1.183	1.576
TOTAL	10.572	4.136	4.233	2.358	10.591	18.706	13.476	11.545	10.379	11.882	17.064	14.053	12.667

"-" = 0; Tr = Trace <100 m^2

Sources: MBC 1994-2003; 2004b-2012b, 2013, 2015.

DESCRIPTION OF THE CENTRAL REGION KELP BEDS

The CRKSC program area extends from Ventura Harbor (also referred to as Ventura Marina) to Abalone Point in northern Laguna Beach in Orange County, and recognizes 26 existing or historic kelp beds, including three (Sunset kelp, Horseshoe kelp and Huntington Flats kelp) that have been missing or greatly reduced since the first half of the 20th century (MBC 2004a–2012a). The kelp surrounding the breakwaters of the Ports of Los Angeles and Long Beach (POLA-POLB) was included in the CRKSC surveys upon realization in 2005 that there was considerable giant kelp in the Ports. One kelp bed, Sunset kelp (near Santa Monica), has not been observed since the initiation of surveys by the CRKSC in 2003, but it was reported as a very small bed during a 1989 survey (Ecoscan 1990). During the CRKSC surveys, despite the apparent presence of hard substrate offshore Will Rogers State Beach Park, kelp at Sunset has only been observed at the submerged breakwater off the Santa Monica Pier. The disappearance of these three kelp beds was likely the result of turbidity and sedimentation from increased industrialization (and population growth) throughout southern California from the 1940s to the late 1960s. One other historic kelp bed (Newport/Irvine Coast, previously Corona del Mar) reappeared following restoration efforts after absences of one to several decades resulting from a series of El Niño events in the 1980s and 1990s.

The continued absence of three of these 26 beds may be the result of the loss of suitable substrate. Horseshoe kelp likely was buried during excavations of the POLA-POLB from the 1920s to the 1950s and dumping of the sediment at that location (Schott 1976), and the apparent burial of suitable substrate by natural sedimentation processes at Sunset kelp (which occurred at several other kelp beds removed from population centers). The loss of the Huntington Flats kelp bed was probably the result of increased turbidity due to the extension of the Long Beach breakwater, and the dredging of Alamitos Bay and Sunset-Huntington Harbors. All three missing beds had substantial canopies prior to 1950. Large declines and subsequent recoveries are common occurrences in the historical record (especially if all of the quarterly surveys are compared). Drastic reductions may simply be short-term fluctuations that are of little importance to the long-term welfare of a kelp bed. If, however, the decline is persistent, more evaluation may be needed to clarify the cause(s).

Most kelp beds recognized by the RNKSC and CRKSC are within California Department of Fish and Wildlife's (CDFW's) administrative kelp bed lease areas that may include more than one giant kelp bed. The CRKSC and RNKSC programs identify these individual beds either using local names or geographical references for the name

Administrative kelp bed areas in California waters are numbered, defined by compass bearings from known landmarks, and have associated commercial harvesting regulations in the California Fish and Game Code. The California Fish and Game Commission designated 87 geographical kelp beds along the California coast and Channel Islands. Each of the 87 kelp beds falls within specific designations that were designed for optimal harvest while ensuring sustainable management of the resource and the species that depend upon kelp (Figures 3 and 4). The administrative kelp beds are designated as closed, leasable, leased (from the state), or open. Closed beds may not be harvested. Leased beds provide the exclusive privilege of harvesting to the lessee, and open beds may be harvested by anyone with a kelp harvesting license. No kelp harvesting is allowed in Marine Protected Areas. In 2015, only one administrative kelp bed was leased in the CRKSC and RNKSC areas: Bed Number 3 at Point Loma. However, mechanical kelp harvesting has been proposed in Beds 17 (between Mugu Lagoon and Point Dume) and 18 (off Oxnard) (Mastrup 2015).

Giant kelp has been harvested commercially along the California coast since the early 1900s. Since 1917, kelp harvesting has been managed by the CDFW under regulations adopted by the California Fish and Game Commission. Regulations currently allow kelp to be cut no deeper than four feet beneath the surface, although the surface canopy can be harvested several times each year without damaging the kelp beds. Kelp harvesting licenses are required to take kelp for commercial use. Kelp beds can be leased for up to 20 years; however, no more than 25 square miles or 50% of the total kelp bed area (whichever is greater) can be exclusively leased by any one harvester.

Many of the kelp studies between 1911 and 1989 consolidated all local kelp beds into the CDFW Kelp Bed designations, making it difficult to discern patterns of specific sub-areas within the much larger CDFW lease areas. For example, CDFW Kelp Bed (lease area) No. 17 encompasses over 10 kilometers of coastline. Therefore, natural breaks in the beds were determined (as noted by either Crandall's 1911 survey or Ecoscan's 1989 survey) and assigned names that describe the location based on nearby canyon names, prominent features, or other local names in use. Descriptions of each CDFW kelp bed are provided in previous CRKSC reports (e.g., MBC 2014).

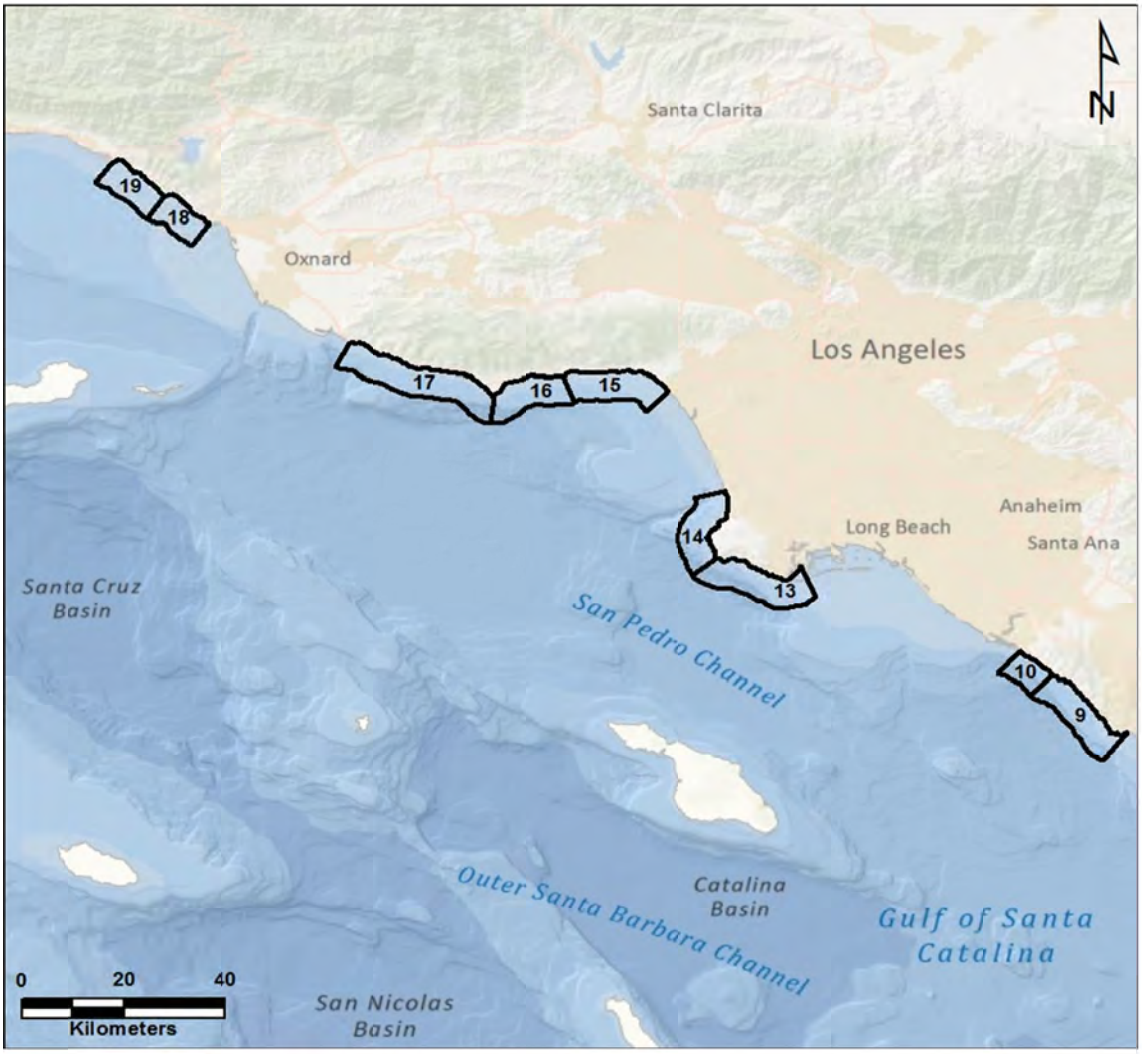


Figure 3. Administrative kelp bed leases in the Central Region study area. Beds 18 and 19 are upcoast from the CRKSC study area, and therefore not addressed in this report

DESCRIPTION OF THE REGION NINE KELP BEDS

In the Region Nine kelp survey area, between Abalone Point in Laguna Beach (Orange County) and the U.S./Mexico Border, the CDFW recognizes just 10 administrative kelp bed lease areas (Figure 4). In this same area, MBC has identified 24 kelp beds: 22 that are persistent and two other beds that appear ephemerally (Santa Margarita and Torrey Pines), as well as four other areas of interest (marinas and small boat harbors) (MBC 1994–2003, 2004b–2012b, 2013-2015). The Consortium's monitoring began following a strong El Niño in 1982–1984, and this was followed by a very strong La Niña cold-water event in 1989–1990. Due in part to the impetus provided by this La Niña, all 24 of the kelp beds that have supported kelp in the last half of the 20th century were displaying canopy in 1991. Descriptions of each CDFW kelp bed are provided in previous RNKSC reports.

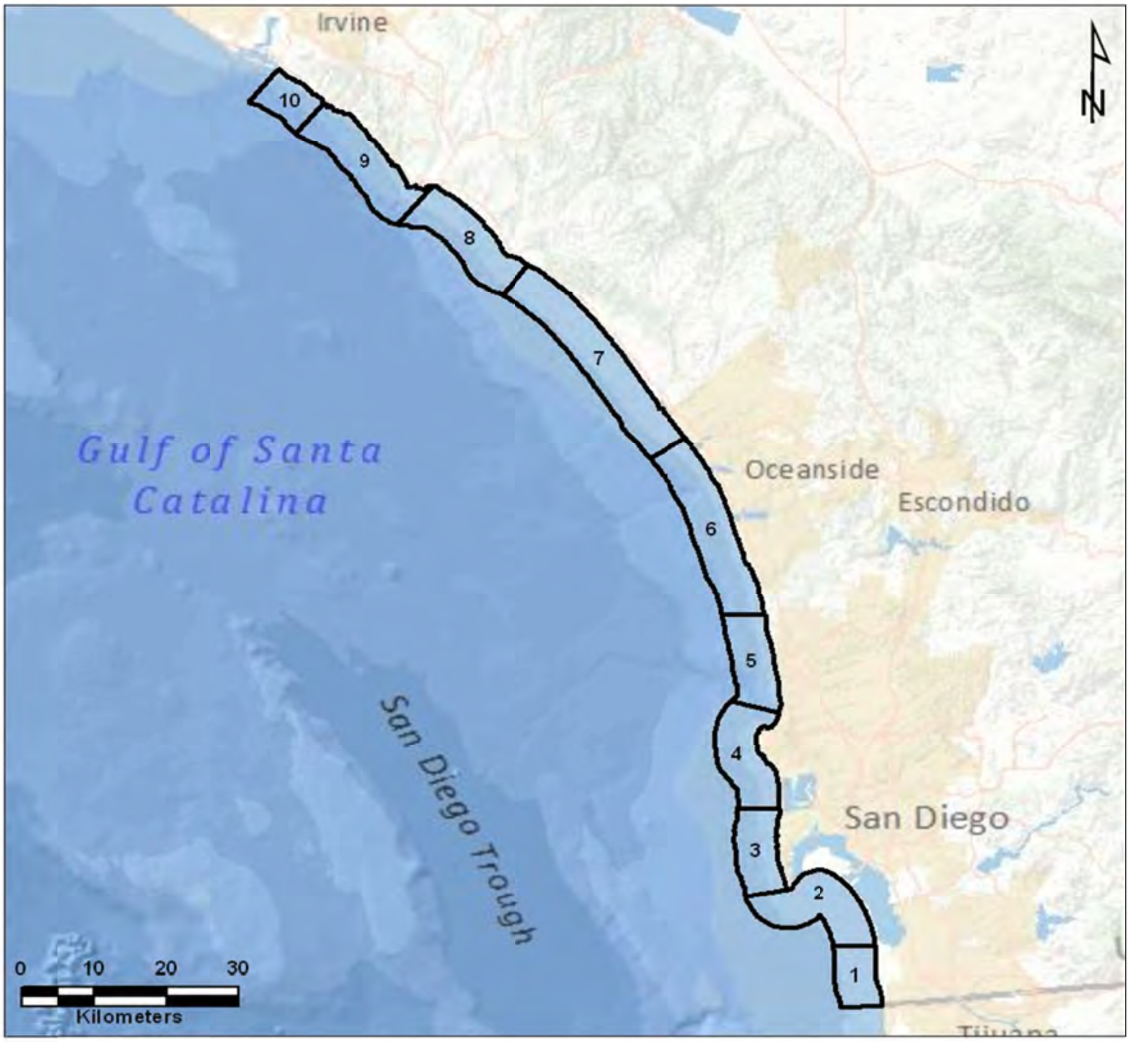


Figure 4. Administrative kelp bed lease areas in the Region Nine study area.

Region Nine supports the largest kelp beds in southern California: from north to south, the La Jolla, Point Loma, and Imperial Beach kelp beds. Rocky substrate is prevalent offshore of La Jolla, and it supports giant kelp beds to a depth of at least 27 m. Sand predominates from Pacific Beach downcoast past Mission Bay, and there is very little hard substrate. Downcoast of Mission Bay, rocky substrate emerges and giant kelp can be found out to at least 30 m during favorable years. The Point Loma kelp bed extends along the length of the peninsula. About two kilometers downcoast from the entrance to San Diego Bay, sand is the dominant substrate, and this habitat continues to about the Imperial Beach Pier. There is a group of low-lying, mostly cobble reefs, from just upcoast and offshore of the Imperial Beach Pier to the international border, and out to a depth of 20 m. According to Crandall's 1912 survey map, a medium-density kelp bed at Imperial Beach extended past the border and several nautical miles into Baja California.

MATERIALS AND METHODS

Environmental Data. Oceanographic data from shore stations, data buoys, and thermistor strings were used to determine potential effects on kelp bed extent during the study year. These data sources included:

- Water temperature data from automated stations at Santa Monica Pier, Newport Pier, and Scripps Pier. At these locations, automated samplers measure conductivity, temperature, and fluorometry every one to four minutes. Samplers are mounted at a depth of 2 m Mean Lower Low Water (MLLW) at Santa Monica and Newport Piers, and at 5 m MLLW at Scripps Pier. These data are made available in real time via the Southern California Coastal Ocean Observation System (SCCOOS) website (www.sccoos.org).

- Water temperature data were provided by Los Angeles County Sanitation Districts from monitoring stations offshore Palos Verdes Peninsula (Stations PVS and PVN). Both stations are located at a depth of 23 m, with sensors at the surface and a depth of 11 m MLLW.

- Water temperature data were also provided by City of San Diego from a thermistor string approximately 3.8 km west-northwest of Point Loma in 60 m of water. Sensors were placed at four-meter intervals from near the sea surface to a depth of 54 m MLLW.

- Water temperature data from the National Data Buoy Center (NDBC) Point Loma South, Dana Point, and Point Dume data buoys that record water temperature, wave height, period, and direction every 30 minutes from approximately one meter below the waterline, and are available in real time via the NDBC website (www.ndbc.noaa.gov).

- Sea and swell height data from Coastal Data Information Program (CDIP) data buoys located off Ventura (Anacapa Passage), San Pedro, Oceanside, and Point Loma. Wave direction, height, and period are available in real time via the CDIP website (cdip.ucsd.edu).

- Harmful Algal Bloom (HAB) data are made available in real time at several locations via the SCCOOS website (www.sccoos.org).

Kelp Data Collection-Aerial Surveys. Beginning in the early-1960s, the surface area of coastal kelp beds was calculated by aerial photography by the late Dr. Wheeler J. North of the California Institute of Technology, and later by MBC using a methodology that followed that of Dr. North's because it provided a consistent approach to determining kelp bed size (North 2001). MBC has conducted or provided support for the Region Nine surveys since its inception in 1983, and began conducting surveys for the CRKSC in 2003.

Direct downward-looking photographs of the kelp beds were taken from an aircraft modified by Ecoscan Resource Data to facilitate aerial photography. Approximately 400 high contrast digital color and infrared photos are taken during each survey. Ecoscan conducted quarterly overflights of the coastline for the Consortium from Ventura Harbor (Ventura County) to the U.S./Mexico border (Appendix D). Overflights were targeted as close to quarterly as possible. Due to prevailing weather conditions, it is not always possible to conduct them in the targeted months and, at times, multiple attempts are necessary to conduct the four quarterly surveys. Prior to each survey, the flight crew assesses the weather, marine conditions, and sun angle to schedule surveys on optimum dates. The pilot targets the following:

- Weather: greater than a 15,000' ceiling throughout the entire survey range and wind less than 10 knots,
- Marine: sea/swell less than 1.5 m and tide less than +1.0' MLLW, and
- Sun angle greater than 20 degrees from vertical.

Kelp Data Analysis. All photographs were reviewed after each overflight and the canopy surface area of each kelp bed was ranked in size by subjectively comparing them to the average historical bed size and to each quarterly survey. The ranking scale ranges from 1 for well below average, 2 for below average, 2.5 for average, 3 for above average, and 4 for well above average (Tables 4 and 5). Such ranking allows the archiving of the quarterly survey slides for later retrieval and assembly of a digitized photo-mosaic of each kelp bed that represents the greatest areal extent for each survey year. Individual beds in the composite were selected for detailed evaluation and the surface area of all visible kelp canopies in each distinct kelp bed was calculated.

All digital photographs from one of the four surveys that showed the greatest areal coverage were digitally assembled into a composite photo-mosaic that provided a regional view of whole kelp bed areas. If all of the kelp beds displayed the most canopy during a single survey, then the photographs from that survey would be used in the photo-mosaics. However, this rarely occurs. Data from one or two surveys are usually used to make the mosaics in order to provide a realistic estimate of the maximum canopy cover at any time (usually within about three months) during the year. The Photoshop mosaics were then transferred to Geographic Information System (GIS; ArcGIS 10.3.1) to geo-reference them, and to place them into specific CDFW geo-spatial shape files. Each mosaic was geo-referenced to match several prominent features (usually more than three) on the map and converted to Universal Transverse Mercator (UTM) or other acceptable coordinate system, and ultimately converted to a geo-referenced JPEG file. Surface canopy areas were calculated using the image classification function, an extension to the ArcGIS program. The kelp beds from the photos were then layered on standard base maps to facilitate inter-annual comparisons. The “Hard Substrate” layer on the base maps was obtained through the CDFW Biogeographic Information and Observation System.

The “Average Bed Area Per Year” (ABAPY) was plotted with results from individual beds to compare canopy sizes and patterns of growth/decline to averages for particular regions. Those regions were: the northern and central portions of the Central Region (upcoast from Palos Verdes); the area from Malibu Point to Sunset; Orange County; and San Diego County (excluding La Jolla and Point Loma). Kelp beds off Palos Verdes, La Jolla, and Point Loma were treated separately because they are typically larger beds and react differently than the other beds within their regions. Each ABAPY was calculated by summing the annual canopy estimates for the relevant beds during each year, and dividing the total by the number of beds included.

Vessel Surveys. Once per survey year, typically between October and December, a vessel survey is conducted of all of the Region Nine kelp beds. Due to persistent large swells that forced delays (Figures 13 and 14), the vessel survey for the 2015 survey year was conducted from Imperial Beach to Oceanside on 4 February 2016 and from Oceanside to Newport Harbor on 16 February 2016. During each survey, biologists visually locate the main canopies (or during poor years by latitude and longitude coordinates of the last remaining canopy) and determine the depth of the inshore and offshore edge of the kelp beds. Once located, there is a focused examination of the kelp health that includes documentation of:

- Extent and density of the bed
- Tissue color - tissue colors range from pale yellow (indicating poor nutrient uptake) to dark brown (indicating good nutrient intake)
- Frond length on the surface
- Presence/absence of apical meristem (scimitar = growing tips)
- Extent of encrustations of hydroids or bryozoans
- Sedimentation on blades
- Any evidence of disease - holes or black rot
- Composition of fronds - young, mature, or senile

During the vessel survey, two or three beds are usually selected for focused biologist-diver surveys. Typically, these surveys will investigate apparent causes of a bed's atypical condition (where it disappears or is greatly reduced) during a period when closely aligned regional beds are increasing. For example, a persistent hole in the San Mateo kelp bed was investigated and urchin grazing was found to be the cause.

RESULTS

WATER TEMPERATURES AND NUTRIENTS

Temperatures at the sea surface (SST) are a useful surrogate for nutrient availability. Additionally, there appears to be convincing evidence that seawater density can also be used as a surrogate, and in some cases predict nutrient availability better than temperature; however, long-term measurements of density on smaller scales than the SCB have not been available in the past. In contrast, nearshore temperature measurements have been ongoing for decades, resulting in readily accessible data sets. Two temperature/nutrient indices—one for each region—are presented in Figures 5 and 6. Based on the monthly Nutrient Quotient (NQ) Index described by North and MBC (2001), the average, early-morning SST at each station was correlated with the amount of nitrate that is theoretically available for uptake by kelp (in micrograms-per-gram per-hour) (Haines and Wheeler 1978; Gerard 1982).

The value for each month was summed for the indexed year (July 1 to June 30). For example, a month with an average temperature of 14.5°C has an NQ value of 4 while a temperature of 12°C corresponds to a value of 14. This method allows for an inter-annual comparison between nutrients available to kelp, making it possible to pinpoint those years when nutrients were abundant or depleted, and to establish possible temporal trends. Sea surface temperatures from Point Dume, Santa Monica Pier (SM Pier), Newport Pier, San Clemente Pier (SC Pier), Scripps Pier in La Jolla, and the Point Loma South CDIP buoy were used to determine the theoretical availability of nutrients in the region. Graphs of SSTs at all of these locations are presented in Appendix C.

In general, southern California waters were warmer than average and upwelling was lower than average during 2015. Chlorophyll a and nitrate values from the California Cooperative Oceanic Fisheries Investigations (CalCOFI) study area off southern California were among the lowest on record from July 2014 to April 2015 (Leising et al. 2015).

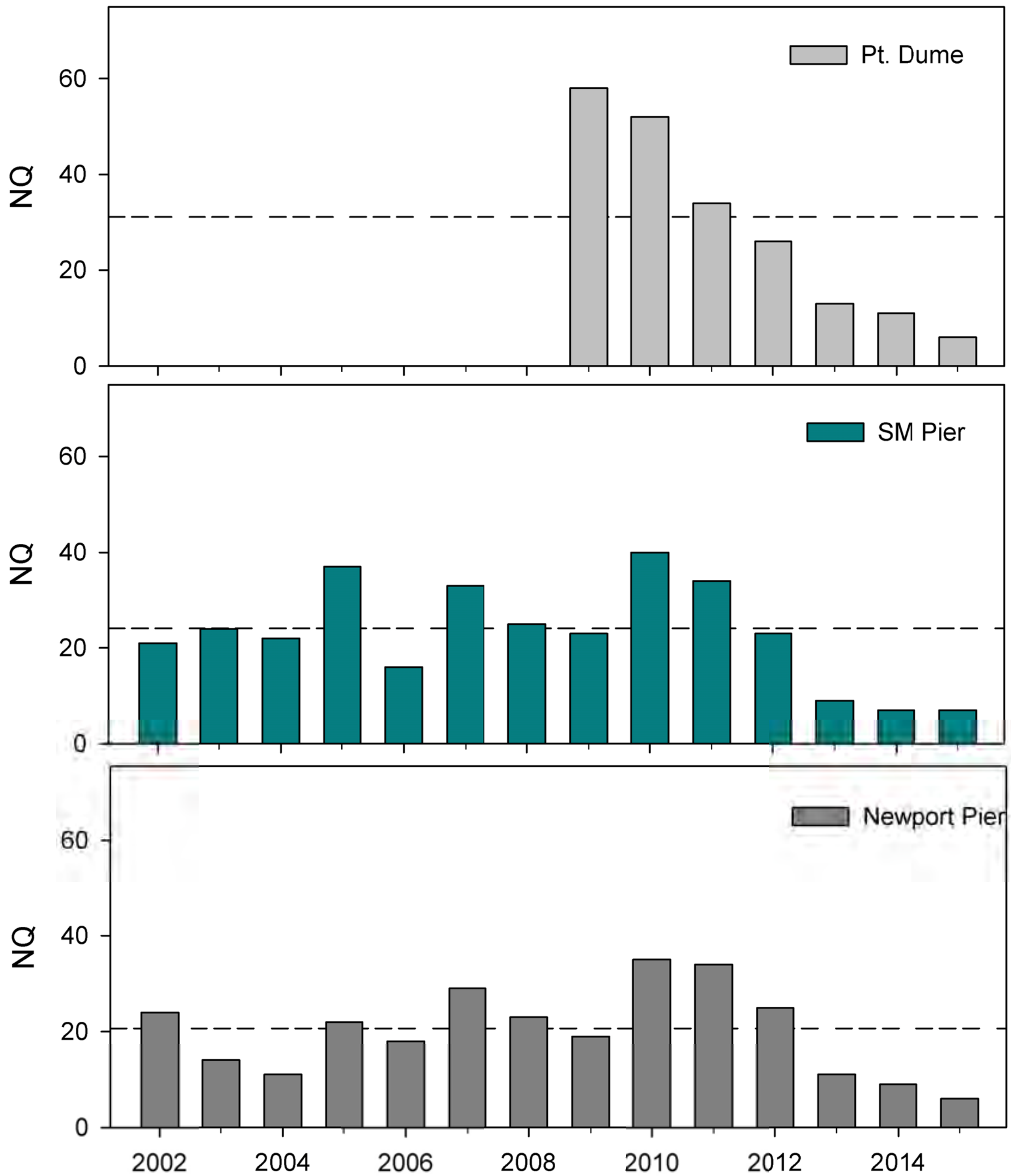


Figure 5. Nutrient Quotient (NQ) values in the Central Region, 2002–2015. "NQ values are calculated from SSTs collected from these locations: Point Dume (Pt. Dume), Santa Monica Pier (SM Pier), and Newport Beach (Newport Pier). Dashed line is the mean NQ for the years shown.

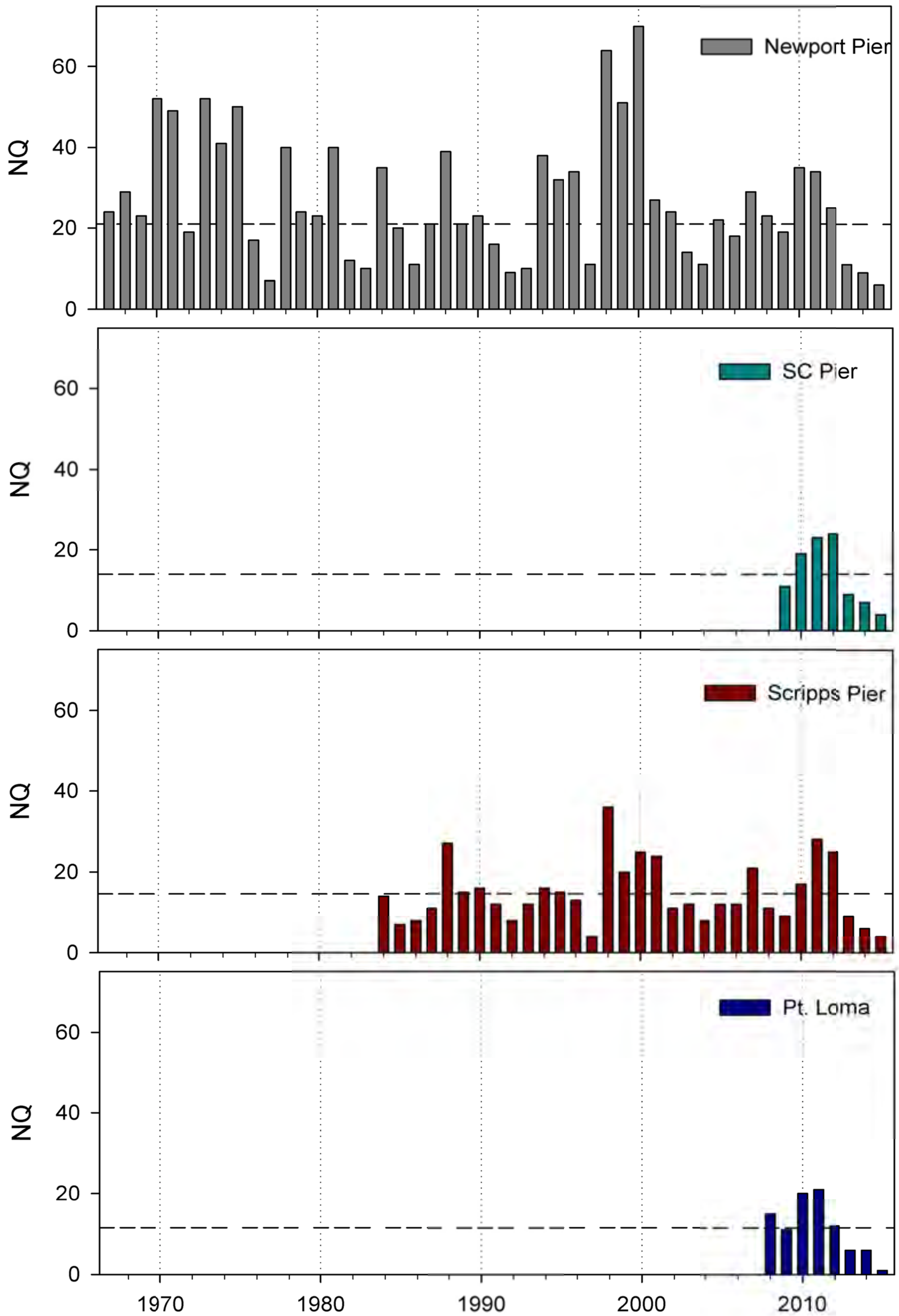


Figure 6. Nutrient Quotient (NQ) values in Region Nine, 1967–2015. NQ values are calculated from SSTs collect at these locations: Newport Beach (Newport Pier), San Clemente Pier (SC Pier), Scripps Pier, La Jolla, and the Point Loma South CDIP Buoy (Pt. Loma). Dashed line is the mean NQ for the years shown.

The variability of SSTs in 2015 across most of the southern California coast line was similar from Point Dume in the north, Newport Pier in the middle, and to Scripps Pier in the south (Figures 7–8). Water temperatures in southern California were warmer than average from January through mid-April, and from August through December. However, there were multiple periods of cold-water influx (likely from upwelling) from April through July. Estimated upwelling and upwelling anomaly values from a location approximately 161 km west of Solana Beach are presented in Figure 9. Upwelling was most pronounced at the Scripps and Newport Piers during this period, and less so at Point Loma, San Clemente, and Point Dume. Region-wide upwelling was calculated to be above average during only three months in 2015: August, November, and December (Figure 9).

The summer and fall of 2014 and the first three months of 2015 were warmer than average. Steep decline in temperature occurred from March through August, but SSTs were consistently above average from mid-August through December in both regions. The resulting NQ values in both regions were among the lowest on record during 2015 (Figures 5 and 6). Coolest SSTs were recorded in May at Newport Pier and in April at Scripps Pier.

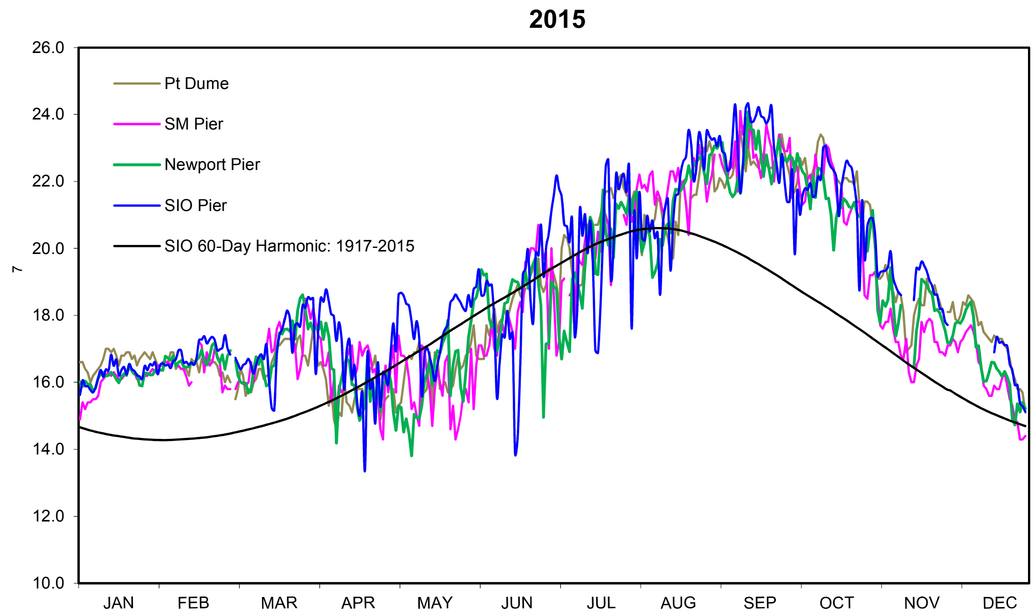


Figure 7. Sea surface temperatures (SSTs) at Point (Pt.) Dume, Santa Monica (SM) Pier, Newport Pier, and Scripps (SIO) Pier for 2015, and the long-term (1917-2015) harmonic mean from SIO Pier.

Temperatures at Santa Monica Pier followed a similar pattern, with coolest temperatures recorded in May (Figure 7). The NQ at Santa Monica Pier was the lowest on record (Figure 5). Temperatures were also recorded at two stations off the Palos Verdes peninsula: Station PVN was in the northern section near Lunada Bay, and Station PVS was in the southern end at Royal Palms (Appendix C). Both stations are at a depth of 23 m. The surface temperatures at these two 23-m stations tracked closely to the SSTs shown in Figure 7, although warmer SSTs were recorded at Station PVN.

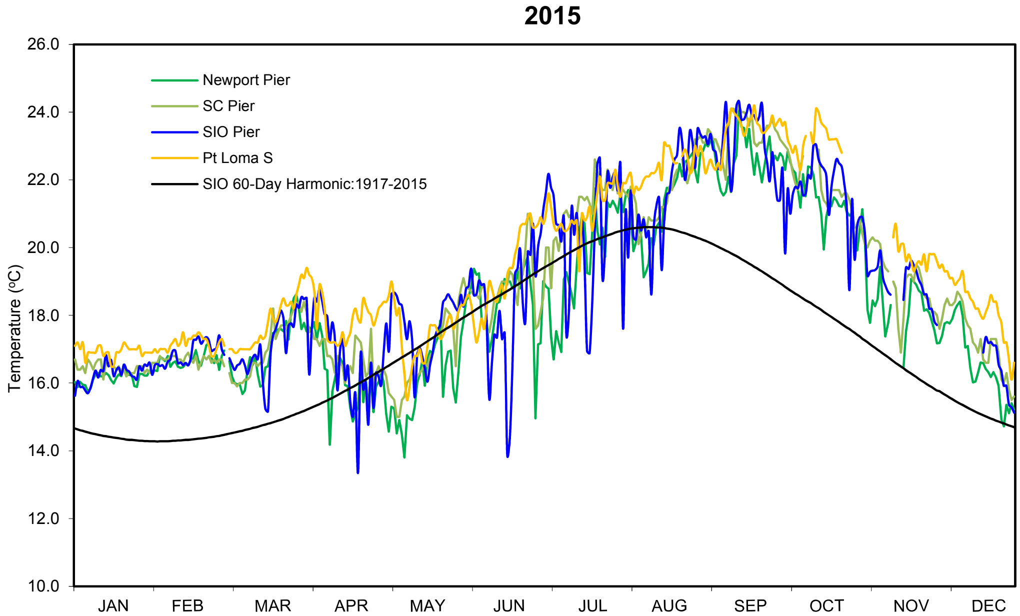


Figure 8. Sea surface temperatures (SSTs) at Newport Pier, San Clemente (SC) Pier, Scripps (SIO) Pier, and Point (Pt.) Loma South (S) for 2015, and the long-term (1917-2015) harmonic mean from SIO Pier.

At the juncture of the Central Region and Region Nine, SSTs at Newport Pier were generally well above average from January through mid-April, below average at times from April through August, and above average for the remainder of 2015 (Figures 7 and 8). The 2015–2016 NQ of 6 at Newport Pier was the lowest recorded since 1992–1993 (Figure 6). Newport Pier is located near the mouth of Newport Canyon, and strong upwelling usually occurs in distinct pulses at this location.

The SSTs at San Clemente Pier, in the mid-section of Region Nine, were similar to those at Newport Pier, except the periods of cold-water influx from April through August were less pronounced (Figure 8). The SSTs at Scripps Pier were the most variable in Region Nine in 2015, with marked upwelling events from April through August. The southern portion of Region Nine was tracked by the Point Loma South buoy, and by a thermistor string deployed off Point Loma by the City of San Diego (Figure 10). Similar to previous years, variability in Point Loma SSTs was muted in comparison to that at the Scripps and Newport Piers. However, the Point Loma South buoy is farther offshore than the other stations, and is moored at a water depth of 1,100 m.

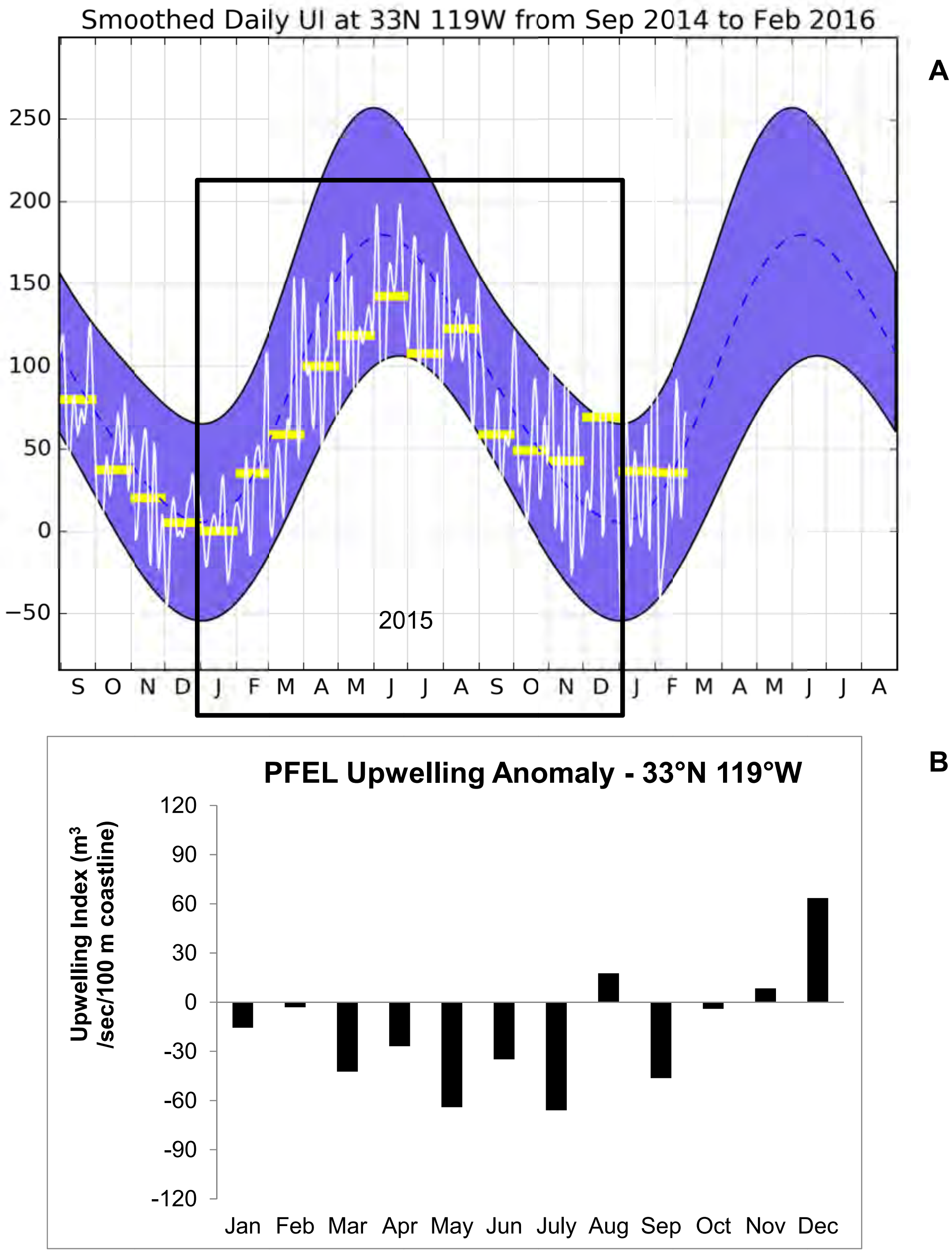


Figure 9. (A) Daily Upwelling Index (UI) at 33°N 119°W. The dashed curve is a smoothed biharmonic fit to the daily UI from 1967–1991. The purple area represents one standard error, and the yellow bars are monthly means. Units are cubic meters per second per 100 meters of coastline. (**B) UI anomaly at 33°N 199°W (2015 compared to the 69-year monthly mean from 1946–2014).** Source: (NOAA PFEG 2015).

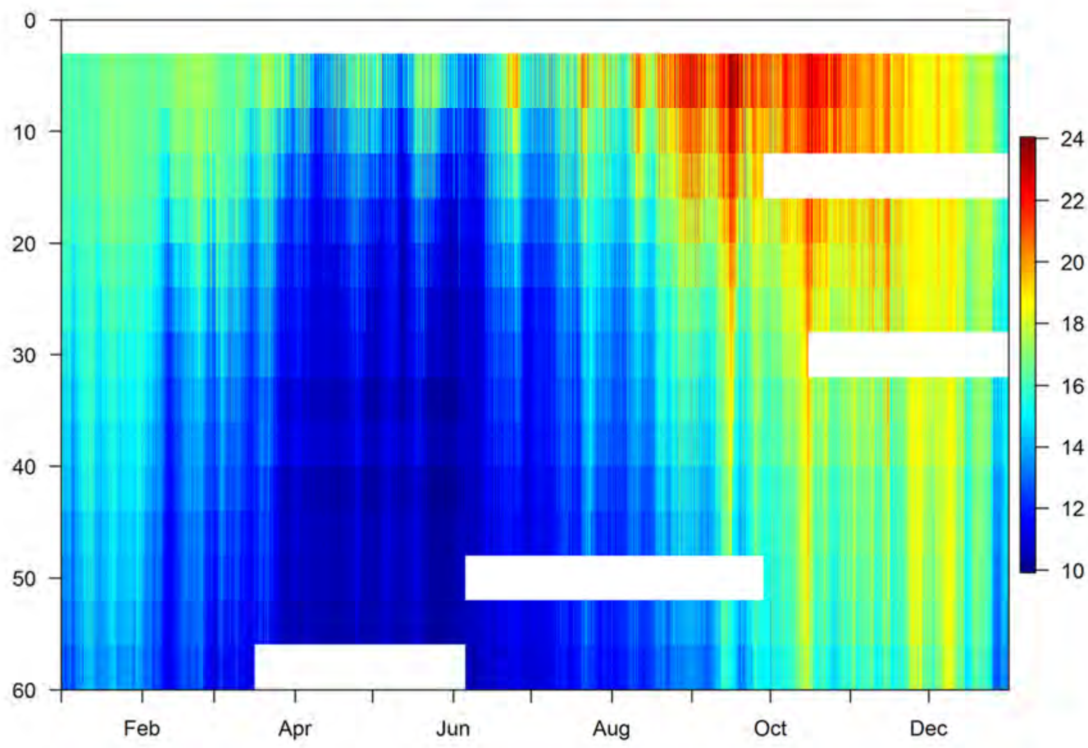


Figure 10. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2015. White bars indicate no data available. Source: CSD (2016).

The long-term average NQ values at Scripps Pier (15), Point Loma South (12), and San Clemente Pier (15) are relatively low compared to those at Newport Pier (27) and Santa Monica Pier (24), and suggest the kelp beds from San Clemente to San Diego have had comparatively low nutrient availability (Figure 6). The NQ values in Region Nine were below average at all stations from 2013 through 2015. The long-term average NQ at Newport Pier (1967–present) is substantially higher than at the other stations, and highlights the variability of nutrient supply in southern California. The nitrate climate shifted from waters with sufficient nitrate prior to the 1976–1977 regime shift to depleted conditions afterward (Parnell et al. 2010). The response of giant kelp beds to nutrient replete years before the regime shift was dampened compared to their response afterward. The sensitivity of kelp canopies to nutrient limitation appears to have increased after 1977, and this intensification of physical control (as opposed to biological control) after 1977 is evident in the strong correlation of seawater density (δ_t) and density of giant kelp (Parnell et al. 2010).

Seawater density values were calculated from available temperature, salinity, and pressure data at three locations in 2015: Santa Monica Pier, Newport Pier, and Scripps Pier (Figure 11; data for Santa Monica Pier were only available through late April 2015). Density values were mostly >24 (kg/m^3-1000) from January through May, and then decreased through September/October. Because these data were collected near the sea surface, they are likely not indicative of densities on the sea floor. However, they are useful in highlighting seasonal variability in seawater density.

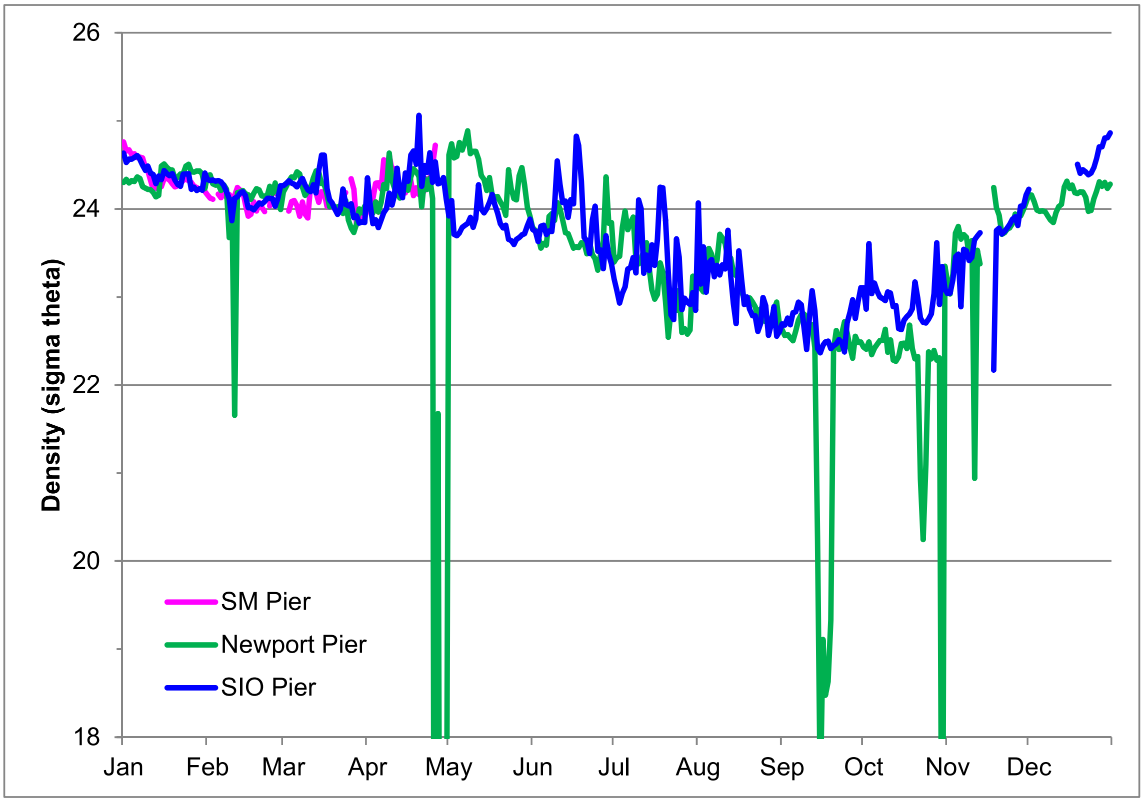


Figure 11. Densities (δ_t; kg/m^3-1000) at Santa Monica (SM) Pier, Newport Pier, and Scripps (SIO) Pier in 2015. Data from SCCOOS (2016).

The NQ index recorded during the 1997–1998 El Niño indicated a particularly bad year for kelp beds in the SCB. During that season, NQ values ranged from 3 to 11. In contrast, during 1988–1989 (a year in which kelp beds reached their maximum extents in several decades) NQ values ranged from 27 to 39 (Figure 6). The NQ values at all stations in both regions were above average in 2012–2013, but below average in 2014 and 2015. Values throughout the region in 2015 ranged narrowly from 6 to 12. The variability in SSTs and nutrients is driven by prevailing flow characteristics and bathymetric features that result in periodic upwelling along the rocky shores of the coastline, particularly from Deer Creek to Point Dume and along the Palos Verdes Peninsula, and at the Dana Point, La Jolla, and Point Loma kelp beds.

INDICES

The Multivariate ENSO Index (MEI) and the Pacific Decadal Oscillation (PDO) changed phase about the same time; the MEI transitioned from negative to positive in April 2014, and the PDO went positive in January 2014 (Figure 12; Mantua [2016] and NOAA-ESRL [2016]). The North Pacific Gyre Oscillation (NPGO) changed from positive to negative in October 2013, and has stayed negative for most of the time since then (Di Lorenzo 2016). All three indices changed phase at some point during the winter of 2013/2014. The MEI changed to positive, signaling the pending arrival of an equatorial El Niño. Based on peak MEI value in August–September 2015, the 2015–2016 El Niño was the third largest since 1950. The PDO transition indicated warmer temperatures in the North Pacific, while the NPGO transition was indicative of lower productivity along the coast (Leising et al. 2015).

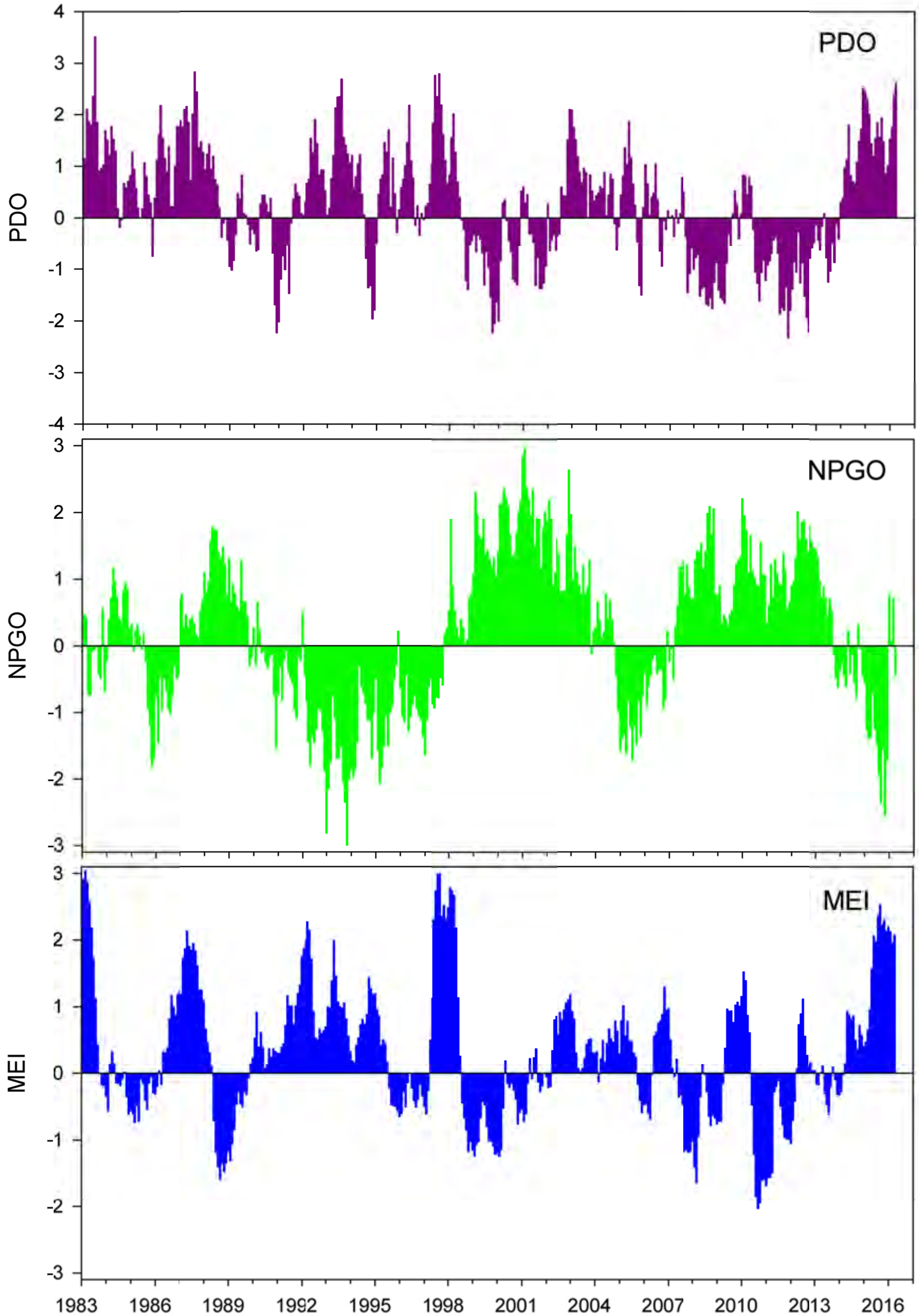


Figure 12. The PDO, NPGO, and MEI from Jan. 1983–April 2016. Data from Di Lorenzo (2016), Mantua (2016) and NOAA-ESRL (2016).

WAVE HEIGHTS

Typical swell sizes and directions were observed through most of 2015, and at the northern portion of the range near Port Hueneme (Anacapa Passage), waves approached from the west to southwest about 80% of the time (Figure 13). Off San Pedro, waves originated out of the west about 60% of the time, the southwest 20% of the time, and the south about 20% of the time (Figure 13). Offshore of Point Loma, waves were from the south (40%), southwest (15%), and west (45%), with only a few measurements from the west-northwest (<1%) (Figure 14).

High-energy waves that negatively impact the kelp beds usually are low-frequency, high-amplitude waves approaching from the west. Significant wave heights (H_s) at Anacapa Passage (CDIP Buoy 111 off Ventura) exceeded three meters in November and December 2015 (Figure 13). At the San Pedro Bay Buoy (092), H_s exceeded three meters in February, November, and December. Waves in February exceeded 4.5 m at this location, and coincided with high winds, but no rainfall. At Oceanside (CDIP Buoy 045), wave heights reached nearly five meters in November and December (Figure 14). Off Point Loma (CDIP Buoy 191) high-amplitude waves exceeded three meters in February, five meters in November, and four meters in December (Figures 14 and 15). The large swell in November originated from the northwest, and much of the SCB coastline was relatively protected due to island shadowing (Figure 16). Large swells become breaking waves as they approach shallow coastal waters and can rip loose kelp holdfasts and cause the loss of entire kelp beds (as recorded at La Jolla and Point Loma during several large storms) (Seymour et al. 1989).

RAINFALL AND PHYTOPLANKTON

Periods of sustained high turbidity in southern California waters often result from high rainfall; however, rainfall was well below average for the fifth straight year (Figure 17). Therefore, turbidity from storm runoff did not likely play an important role in kelp health last year. Rainfall totals varied by location, with more rain in San Diego than in Costa Mesa and Los Angeles.

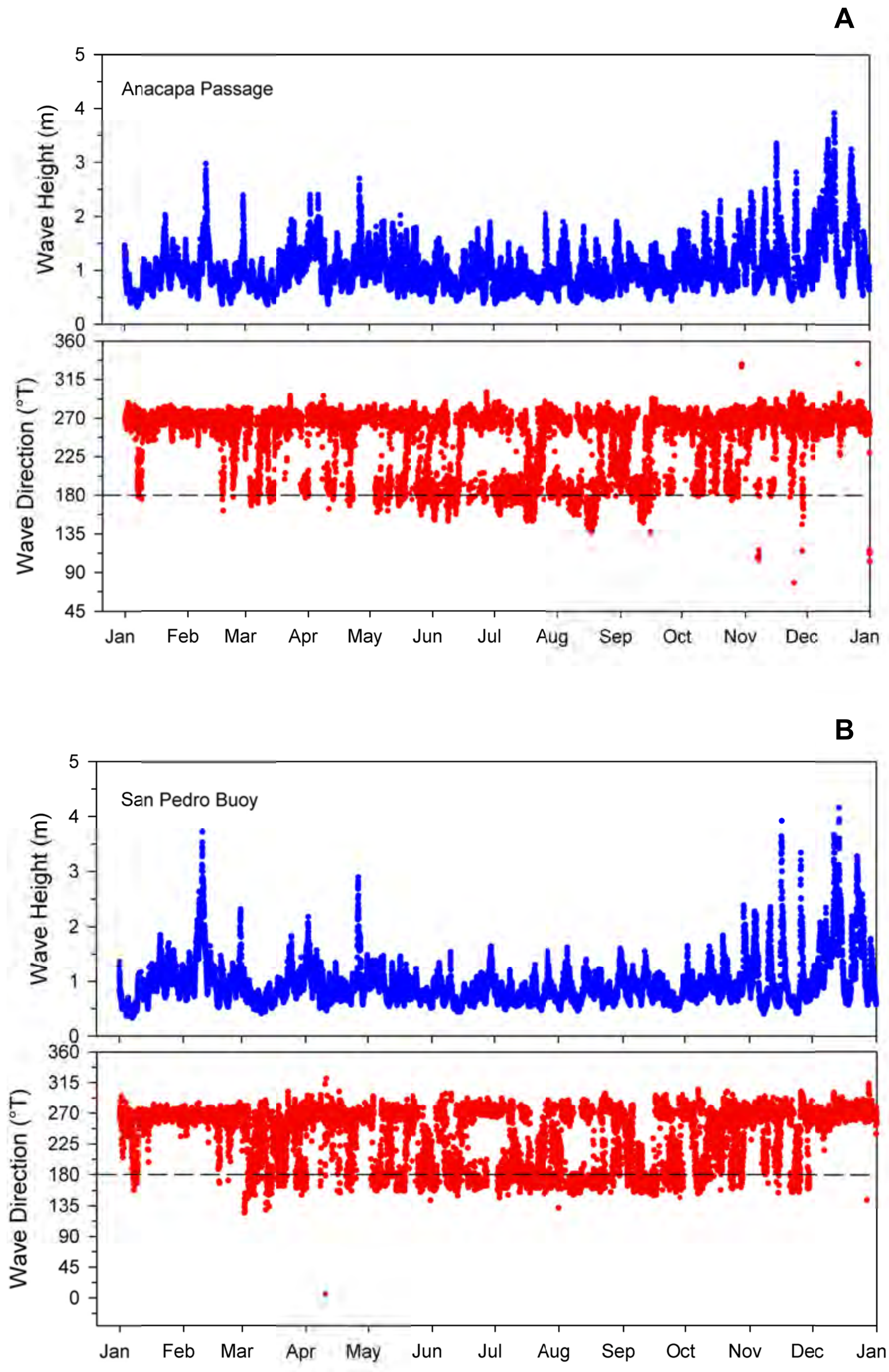
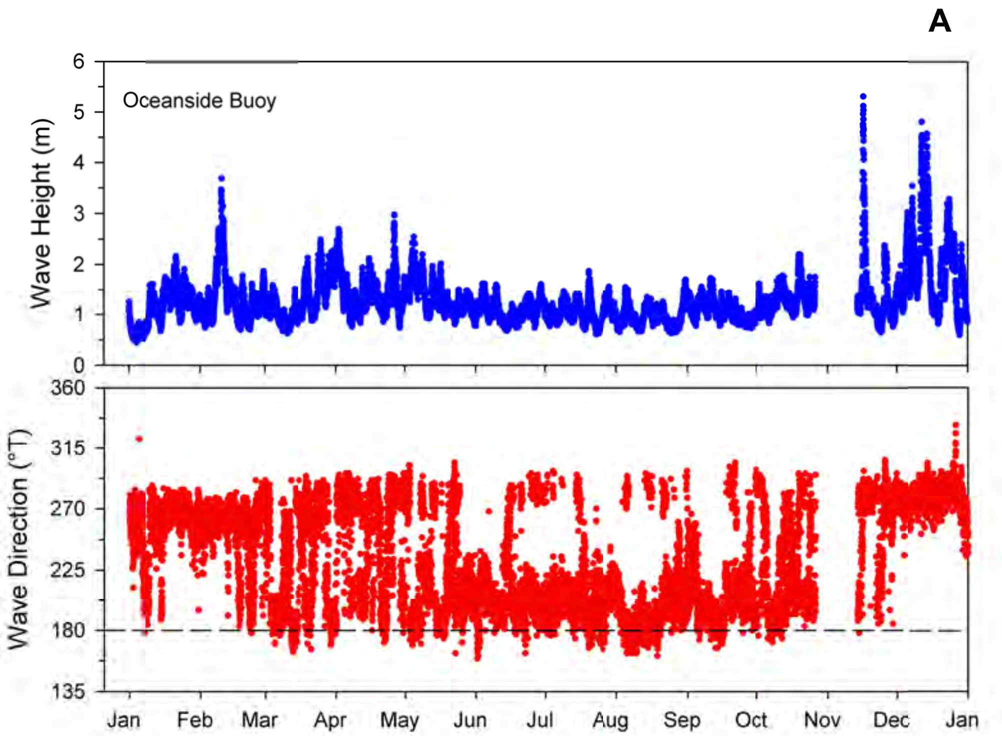


Figure 13. Wave height (blue) and direction (red) at (A) Anacapa Passage Buoy and (B) San Pedro Buoy from January 2015 through December 2015. Data from CDIP (2015).



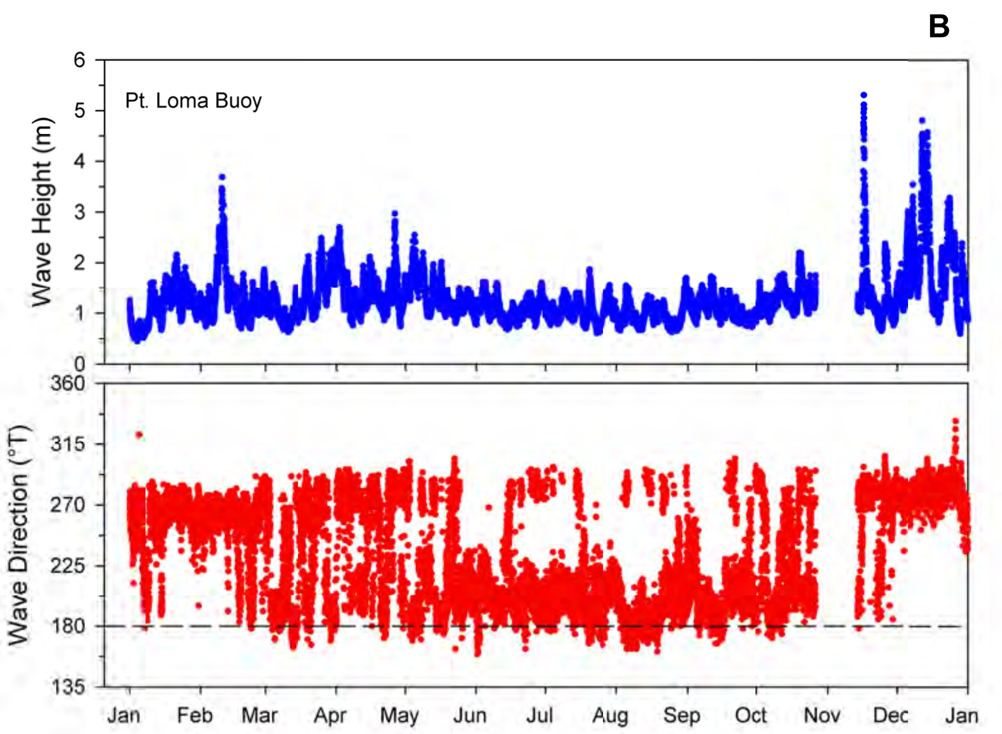


Figure 14. Wave height (blue) and direction (red) at (A) Oceanside Buoy and (B) Point Loma Buoy (bottom) from January 2015 through December 2015. Data from CDIP (2015).

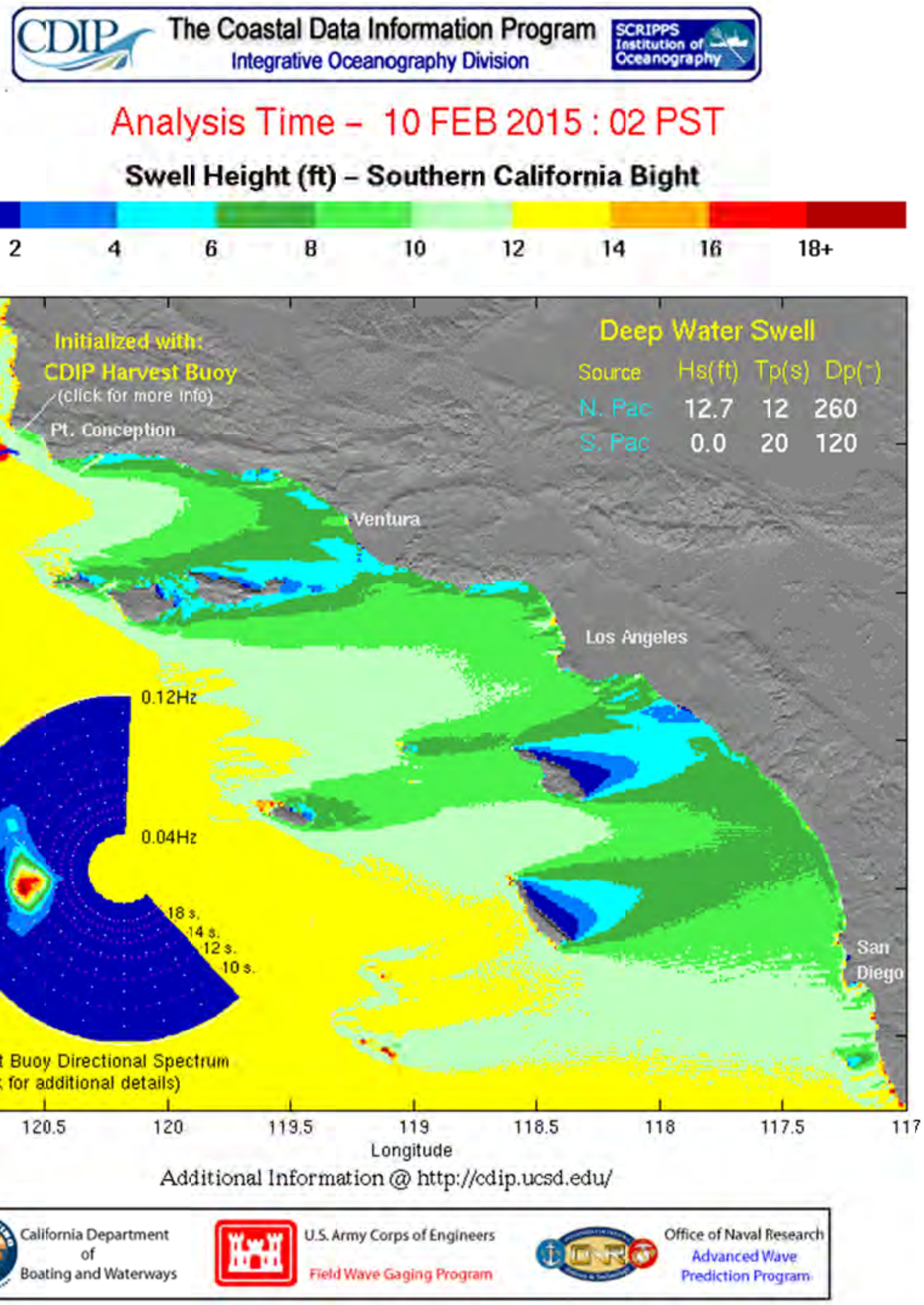


Figure 15. Swell height and direction in the SCB, 10 February 2015. Source: CDIP (2015).

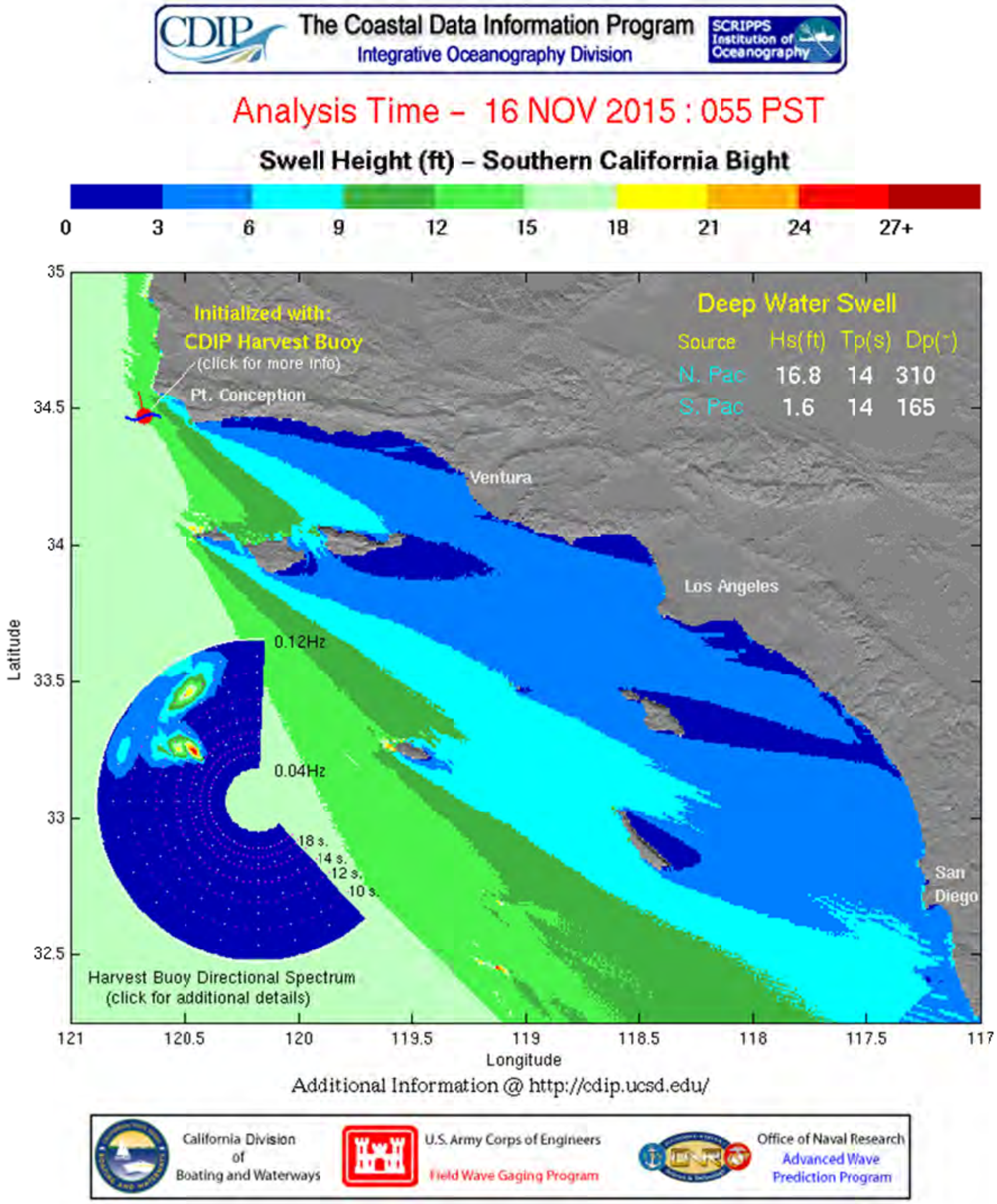


Figure 16. Swell height and direction in the SCB, 16 November 2015. Source: CDIP (2015).

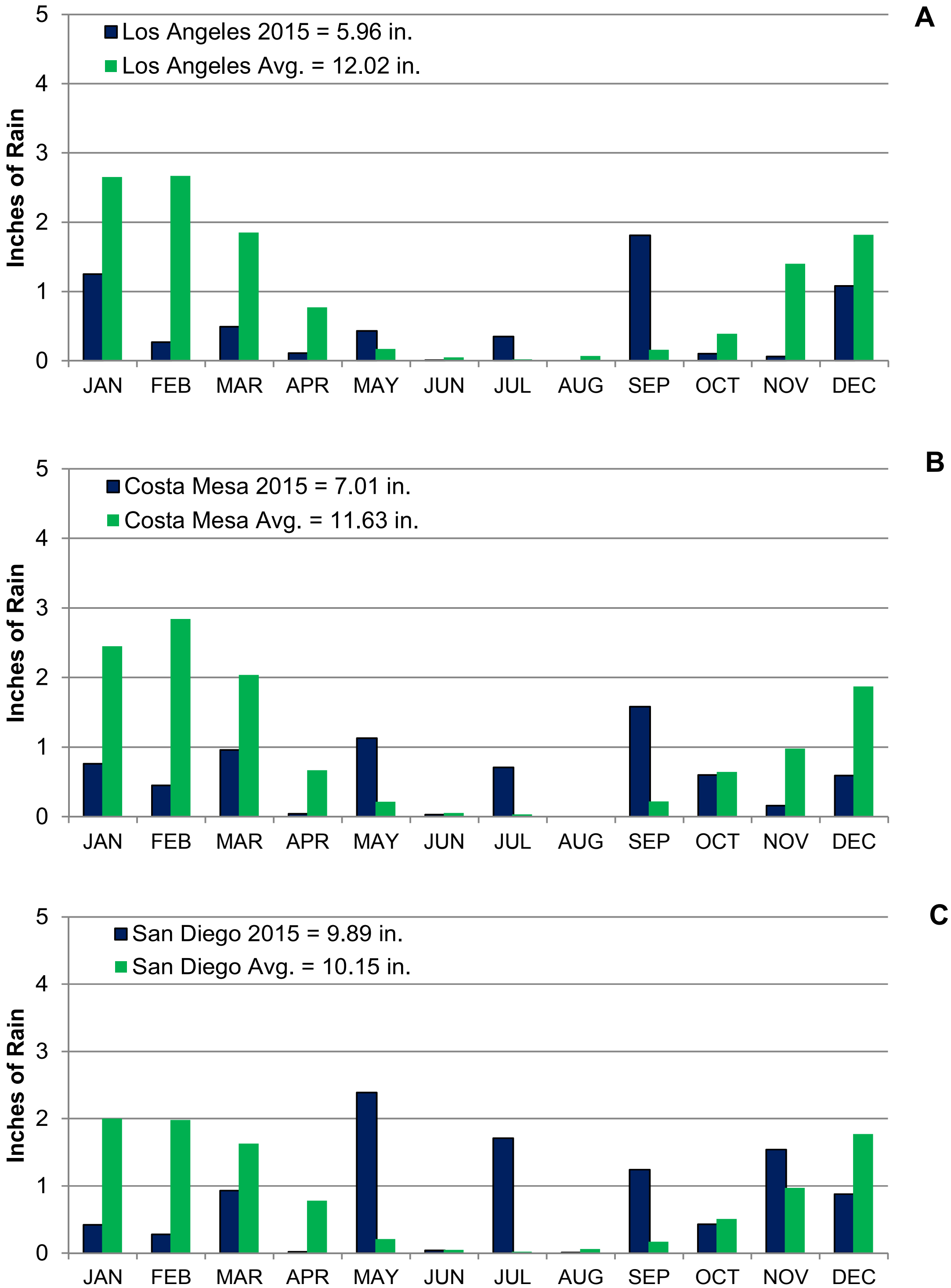


Figure 17. Monthly 2015 rainfall and average monthly rainfall recorded for (A) Los Angeles International Airport (Los Angeles), (B) Costa Mesa, and (C) Lindbergh Field (San Diego). Monthly averages include: LAX: 1936-2015; Costa Mesa: 1955-2015; and San Diego: 1939-2015. Source: NOAA CNRFC (2016).

Concentrations of the phytoplankton *Pseudo-nitzschia delicatissima* peaked in fall at Santa Monica Pier, while *P. seriata* (associated with harmful algal blooms) peaked in spring/summer at Newport Pier (Figure 18).

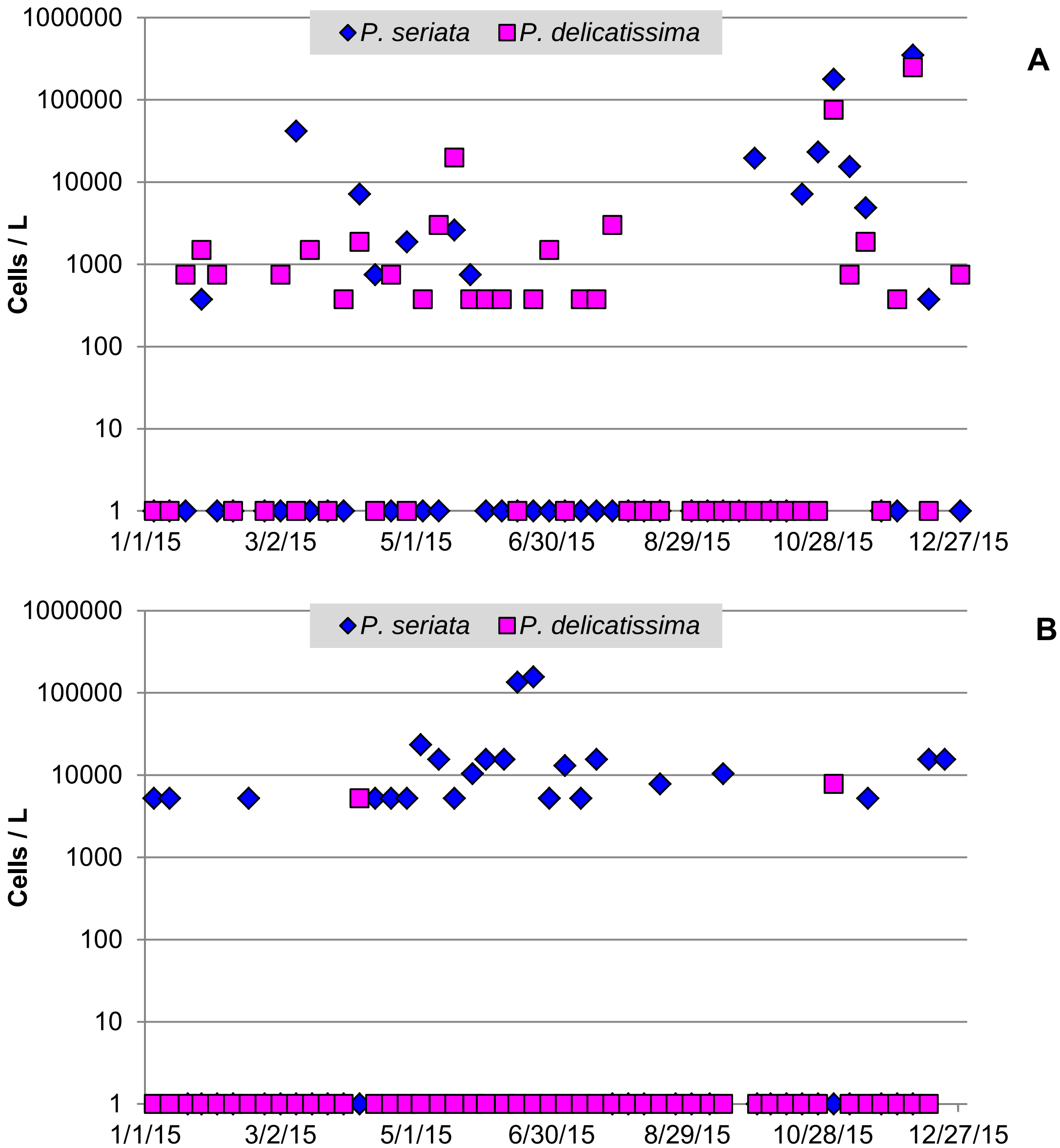


Figure 18. Concentrations of harmful algal bloom (HAB) species at (A) Santa Monica Pier and (B) Newport Pier in 2015. Source: SCCOOS (2015).

Periods of increased phytoplankton concentrations (exceeding 10^4 cells/liter) were recorded in Santa Monica Bay from October through December, and at Scripps Pier from May–July during 2015 (Figure 18). No widespread red tide (plankton bloom) was recorded during the year at either location. Concentrations at over 350,000 cells per liter (R. Shipe, pers. comm.) can effectively exclude light from all but the shallowest depths. This limits photosynthetic activity at depth and may have been responsible for a portion of the severe impacts on the kelp bed resources observed in 2005 and 2006 (Gallegos and Jordan 2002, Gallegos and Bergstrom 2005).

2015 QUARTERLY OVERFLIGHT SUMMARY

Aerial surveys were flown on 9 April, 20 June, 13 September, and 6 December 2015. Reasonable attempts were made to conduct one aerial overflight within each of the four quarters in the year (Table 3, Appendix D). Most of the beds in both regions displayed maximum canopies during the June overflight, although some appeared larger in December than in June (Tables 4 and 5).

Table 3. Status of planned aerial overflights in 2015.

Target Date	Actual Date	Comments
1st Quarter – March 2015	9 April 2015	Favorable conditions. Delayed for aircraft maintenance.
2nd Quarter – June 2015	20 June 2015	Favorable conditions.
3rd Quarter – Sept. 2015	13 Sept. 2015	Favorable conditions.
4th Quarter – Dec. 2015	6 Dec. 2015	Favorable conditions.

2015 VESSEL SURVEY SUMMARY

Boat surveys were conducted periodically throughout the year from Newport Beach to Barn kelp (during ongoing physical and biological surveys). A focused survey of the kelp from a vessel was conducted from Oceanside to Imperial Beach on 6 February 2016, and from Newport Beach to Oceanside on 16 February 2016. These surveys were conducted in 2016 (instead of 2015) because of prevailing poor ocean conditions in late 2015 (Figure 14). Results from these surveys are presented in the individual summaries of each kelp bed and in Appendix D.

Table 4. Rankings assigned to the 2015 aerial photograph surveys of the kelp beds between Ventura Harbor and Newport / Irvine Coast. The basis for a ranking was the status of a canopy during surveys from recent years, excluding periods of El Niño or La Niña conditions or following exceptional storms.

	2015 Surveys			
Kelp Beds	9 April	20 June	13 September	6 December
Ventura Harbor *	-	-	-	-
Channel Islands *	-	-	-	-
Port Hueneme *	-	-	-	2.0
Deer Creek	2.5	3.5	3.0	1.5
Leo Carillo	2.5	3.5	3.0	1.5
Nicolas Canyon	2.5	3.5	2.0	1.0
El Pescador/La Piedra	1.0	3.0	2.0	1.0
Lechuza Kelp	0.5	3.5	2.0	1.0
Point Dume	0.5	3.0	1.0	1.5
Paradise Cove	0.5	2.0	1.0	1.0
Escondido Wash	-	2.0	1.0	1.0
Latigo Canyon	0.5	1.0	-	1.0
Puerco/Amarillo	0.5	1.0	-	1.0
Malibu Pt.	-	-	-	0.5
La Costa	-	-	-	0.5
Las Flores	-	-	-	0.5
Big Rock	-	3.0	-	0.5
Las Tunas	-	1.0	-	-
Topanga	-	0.5	-	-
Sunset	0.5	0.5	0.5	0.5
Marina Del Rey *	-	-	-	0.5
Hyperion Pipeline *	-	-	-	0.5
Redondo Breakwater *	-	-	-	0.5
Malaga Cove - PV Point (IV)	3.0	3.0	2.5	1.5
PV Point - Point Vicente (III)	4.0	4.0	2.5	2.5
Point Vicente - Inspiration Point (II)	3.0	4.0	2.0	2.0
Inspiration Point - Point Fermin (I)	1.0	2.0	1.0	2.0
Cabrillo	3.0	4.0	1.0	2.0
LB/LA Harbor and Breakwaters	-	2.5	1.0	2.0
Horseshoe Kelp	-	-	-	-
Huntington Flats	-	-	-	-
Newport Harbor *	-	-	-	1.0
Newport / Irvine Coast	0.5	2.5	1.0	1.0

Notes:
Ranking values: 0.5 = trace or very small amount of kelp present; 1 = well below average; 2 = below average; 2.5 = average; 3 = above average; and 4 = well above average. Red indicates maximum canopy size for the year; " - " = no canopy present; * = not part of the monitored beds; NI = no image due to clouds or fog.

Table 5. Rankings assigned to the 2015 aerial photograph surveys of the kelp beds between Newport / Irvine Coast and Imperial Beach. The basis for a ranking was the status of a canopy during surveys from recent years, excluding periods of El Niño or La Niña conditions or following exceptional storms.

	2015 Surveys			
Kelp Bed	**9 April**	**20 June**	**13 September**	**6 December**
Newport / Irvine Coast	0.5	2.5	1.0	2.0
No. Laguna Beach	0.5	3.0	1.0	1.5
So. Laguna Beach	0.5	2.0	0.5	-
South Laguna	0.5	2.0	1.0	0.5
Salt Creek-Dana Point	0.5	2.0	1.0	2.0
Dana Marina *	-	-	-	1.0
Capistrano Beach	0.5	1.0	1.0	1.0
San Clemente	-	3.0	2.5	2.5
San Mateo Point	-	1.0	1.0	2.5
San Onofre	-	1.0	1.0	1.0
Pendleton Reefs *	-	-	-	-
Horno Canyon	-	1.0	-	1.0
Barn Kelp	-	1.0	-	0.5
Santa Margarita	-	-	-	-
Oceanside Harbor *	-	-	-	0.5
North Carlsbad	1.0	3.0	2.0	0.5
Agua Hedionda	-	2.5	1.0	0.5
Encina Power Plant	0.5	3.0	2.0	1.0
Carlsbad State Beach	0.5	2.5	1.0	2.0
North Leucadia	2.0	4.0	2.0	1.0
Central Leucadia	0.5	3.0	2.0	1.0
South Leucadia	-	2.0	2.0	1.0
Encinitas	1.0	2.5	1.0	1.0
Cardiff	1.0	2.5	1.0	2.0
Solana Beach	2.0	4.0	2.5	1.0
Del Mar	-	3.0	-	-
Torrey Pines Park	-	-	-	-
La Jolla Upper	0.5	4.0	3.0	2.0
La Jolla Lower	0.5	3.0	2.0	2.0
Point Loma Upper	2.0	4.0	4.0	2.5
Point Loma Lower	1.0	4.0	3.5	2.5
Imperial Beach	2.0	4.0	3.0	2.5

Notes:
Ranking values: 0.5 = trace or very small amount of kelp present; 1 = well below average; 2 = below average; 2.5 = average; 3 = above average; and 4 = well above average. Red indicates maximum canopy size for the year; " - " = no canopy present; * = not part of the monitored beds; NI = no image due to clouds or fog.

2015 KELP CANOPY SUMMARY

Central Region. The following changes since 2014 were documented in the 26 CRKSC kelp beds in 2015:

- 9 kelp beds increased in size
- 1 kelp bed remained the same
- 11 kelp beds decreased in size
- 5 kelp beds were not visible (and 2 have been absent for decades: Horseshoe kelp since at least 1989 and Huntington Flats since the 1920s)

Overall, the maximum measured kelp canopy increased by 23% from 2014 (from 4.283 km^2 to 5.255 km^2) (Table 1). However, this was skewed by the four-fold increase in the PV IV canopy.

Region Nine. The following changes since 2014 were documented in the 24 RNKSC kelp beds in 2015:

- 7 kelp beds increased in size
- 15 kelp beds decreased in size
- 2 kelp beds were not visible (Santa Margarita and Torrey Pines, both since 2013)

Overall, the maximum measured kelp canopy decreased by 10% from 2014 (14.053 km^2 to 12.667 km^2) (Table 2). Graphical depictions of each bed are presented in Appendix A, results of the vessel surveys are presented in Appendix D, and a mosaic of the kelp canopies along the coastline is presented in Appendix E.

STATUS OF THE 50 KELP BEDS ALONG THE CENTRAL REGION AND REGION NINE THROUGH 2015

The following is a synopsis of the status of each individual bed during the 2015 survey year based upon the quarterly surveys. This section also includes a summary of canopy size variability over time. Maps of kelp coverage are provided in Appendix A, a historical summary is provided in Appendix B, and aerial photographs are included in Appendix E. The kelp bed areas are presented from upcoast to downcoast in Appendix D, which includes the aerial extent of the kelp beds in 2013. That year kelp coverage was relatively high in both regions, and smaller beds at La Costa, Santa Margarita, and Torrey Pines were visible.

CENTRAL REGION KELP SURVEYS

The combined kelp bed coverage of the Central Region has been above the long-term average since 1967 (4.151 km^2) for eight of the past nine years (Figure 19). The ABAPY values by year for the Central Region (off north and central Los Angeles County, and beds from Sunset Malibu) and for Region Nine (off Orange County, and beds off San Diego County except Point Loma and La Jolla) are presented in Figure 20.

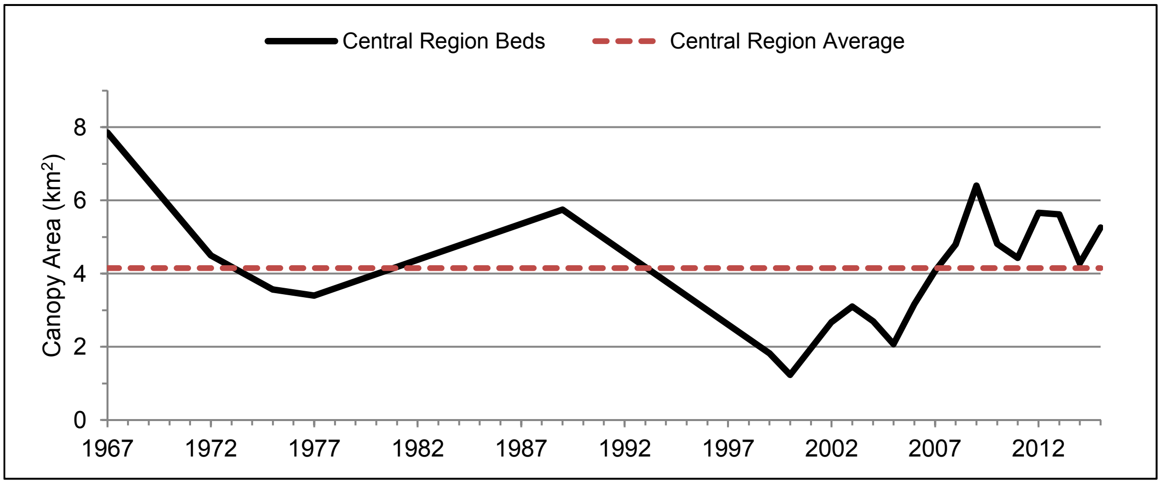


Figure 19. Combined canopy coverage of all kelp beds in the Central Region from Ventura to Newport Harbor/Irvine Coast.

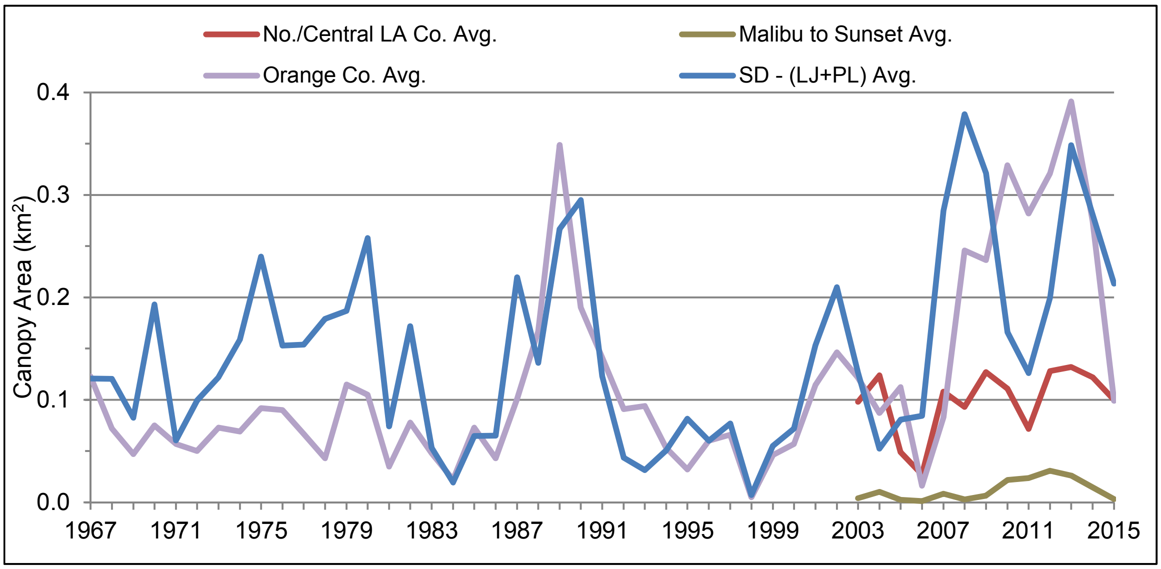


Figure 20. Average Bed Area Per Year (ABAPY) for four different areas: from 2003 through 2015 for (1) offshore north and central Los Angeles County, and (2) Malibu to Sunset; and from 1967 through 2015 for (1) offshore Orange County, and (2) offshore San Diego County (minus La Jolla and Point Loma).

Ventura Harbor to Point Mugu State Park. A small amount of kelp was noted growing along the breakwaters of Ventura Harbor (0.006 km^2), Channel Islands Harbor (0.007 km^2), and at Port Hueneme (0.010 km^2) in 2015 (Figure 1; Appendices A.1, A.4, A.5, D.1, and E.1). No kelp was noted offshore of the Mandalay and Ormond Beach Generating Stations (Appendices A.2, A.3, A.5, A.6, D.1 and E.1), and no kelp was visible between Port Hueneme and Deer Creek (Appendices A.5 through A.10, D.1, D.2, and E.1). These results are consistent with those from 2014.

POINT MUGU TO POINT DUME

Deer Creek. The Deer Creek kelp bed increased in size by 8% between 2014 (0.103 km^2) and 2015 (0.124 km^2) (Figure 1; Appendices A.10, D.2, and E.1). The Deer Creek canopy was compared to the ABAPY of the northern and central portions of the Central Region to determine whether it was responding synoptically with the beds from the same area. The ABAPY decreased 8% over the past year (Figure 21).

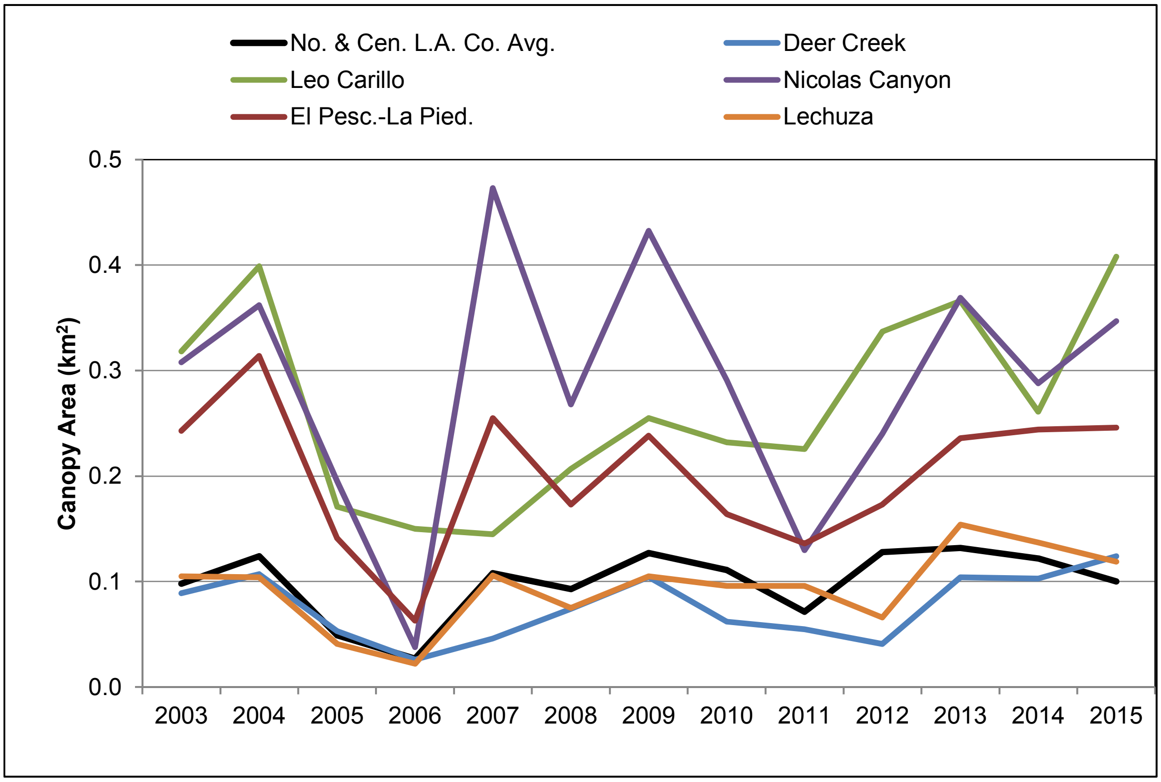


Figure 21. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverage from Point Mugu through Point Dume from 2003 through 2015.

Leo Carillo. Leo Carillo kelp bed increased by 56% in 2015 (from 0.261 km^2 to 0.408 km^2). With the exception of 2007 and 2008, Leo Carillo kelp has reacted synoptically with the kelp beds in the region (Figures 1 and 21; Appendices A.11, D.2, and E.1). The increase of the Leo Carillo kelp bed in 2015 (56%) was counter to the decrease of the ABAPY by 8%, and the kelp bed reached its maximum size to date.

Nicolas Canyon. The Nicolas Canyon kelp bed increased by 20% in 2015 (from 0.288 km^2 to 0.347 km^2). The Nicolas Canyon and Leo Carillo kelp beds have usually been the two largest beds between Point Mugu and Point Dume (Figures 1 and 21; Appendices A.12, D.2, and E.1).

El Pescador/La Piedra. The El Pescador/La Piedra kelp bed Increased from 0.244 km^2 to 0.246 km^2 in 2015 (an increase of 1%) (Figures 1 and 21; Appendices A.12, D.2, and E.1). The changes in size at the El Pescador/La Piedra kelp bed have typically mirrored other beds within the Central Region, although the bed increased slightly in 2014 and 2015 while the ABAPY decreased.

Lechuza. In 2013, Lechuza kelp bed reached its largest extent (0.154 km^2), exceeding that of surveys recorded in the last century. However, it decreased in size each of the next two years (Figures 1 and 21; Appendices A.13, D.2, and E1). In 2015, the area of the bed decreased by 13% (to 0.119 km^2). The patterns of change of the Lechuza kelp bed size were nearly identical to those of the average bed in the region until 2012, when the Lechuza kelp bed unexpectedly decreased while most beds in the region increased. Even though the ABAPY was similar in 2012 and 2013, the size of the Lechuza kelp bed more than doubled in 2013. Despite the decrease in size in 2015, the area of the bed in 2015 was still larger than observed from 2003 through 2012.

POINT DUME TO MALIBU POINT

Point Dume. In 2012, Point Dume kelp bed increased to a 10-year maximum size (0.154 km^2), although it decreased the following two years. In 2015, the bed size increased 84% and it reached its maximum size (0.169 km^2). Until 2015, the canopy size of the Point Dume kelp bed typically fluctuated in synchrony with the ABAPY (Figures 1 and 22; Appendices A.14, D.3, D.4, and E.1).

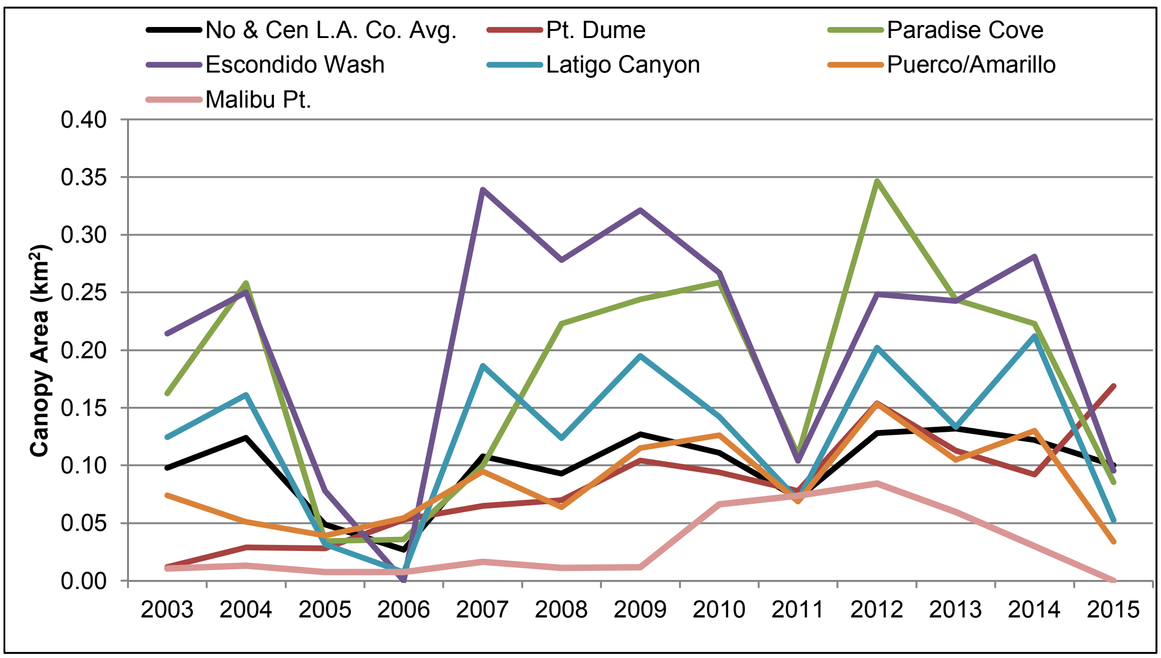


Figure 22. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverage of the six kelp beds between Point Dume and Malibu Point from 2003 through 2015.

Paradise Cove. The Paradise Cove kelp bed was larger than average during most of the last decade, and has usually trended in relative concert with the ABAPY. The bed reached its maximum size in 2012 (0.346 km^2), but decreased each of the last three years. From 2014 to 2015, the maximum canopy cover decreased by 62% (from 0.223 km^2 to 0.086 km^2) (Figures 1 and 22; Appendices A.14, D.3, and E.1). Paradise Cove kelp bed was well below its average size of 0.186 km^2.

Escondido Wash. The Escondido Wash kelp bed increased in size by 16% in 2014, but decreased by 66% in 2015 (from 0.281 km^2 to 0.095 km^2) (Figures 1 and 22; Appendices A.14, A.15, D.3, and E.1). This bed is typically larger than the ABAPY, and its fluctuations in size generally mirrored those of the ABAPY. In 2015, both trended downward, but the downward trend of this kelp bed was more pronounced than the ABAPY.

Latigo Canyon. In 2014, the Latigo Canyon kelp bed grew to its largest size on record (0.212 km^2) (Figures 1 and 22). However, it decreased in size by 75% in 2015 (Appendices A.15, D.3, and E.1). The Latigo Canyon kelp bed is usually near the ABAPY for the region, and has tracked the ABAPY closely during most of the 13 years of monitoring.

Puerco/Amarillo. Like many other beds upcoast of Palos Verdes, the Puerco/Amarillo kelp bed was larger in December 2012 (0.153 km^2) than during any previous CRKSC survey. The following two years, the bed was still within 32% of its maximum size (Figures 1 and 22). In 2015, however, the Puerco/Amarillo kelp bed decreased in size by 74% (Appendices A.16, D.3, and E.1). This bed typically trended with the ABAPY after 2007, although it responded differently than the ABAPY in 2013 and 2014.

Malibu Point. The canopy size at Malibu Point was 0.084 km^2 in 2012, the largest extent of kelp since CRKSC surveys began. However, the Malibu Point kelp bed decreased in size the following two years, and it was not visible in 2015 (Figures 1 and 22; Appendices A.17, D.3, and E.1). The size of this kelp bed was smaller than the ABAPY during most years, and it has not correlated well with the ABAPY.

MALIBU POINT TO SANTA MONICA PIER

The five kelp beds from La Costa to Sunset are usually among the smallest beds in the Central Region. Due to their small size (≤0.010 km^2 in 2015), the beds have not typically reacted in discernible patterns since 2003 (Figures 22 and 23). Exceptions to this include growth spikes at many beds in 2004 and 2012.

La Costa. In 2012, the La Costa kelp bed was not present in the June or October surveys, but it appeared as a very small bed (0.003 km^2) in December, the largest in 10 years of monitoring. In May 2013, canopy size was unchanged since 2012. However, in 2014, the bed decreased in size to just 0.001 km^2, consistent with its average size since 2003, and in 2015 it was no longer visible (Figures 1 and 23; Appendices A.17, A.18, D.3, D.4, and E.2).

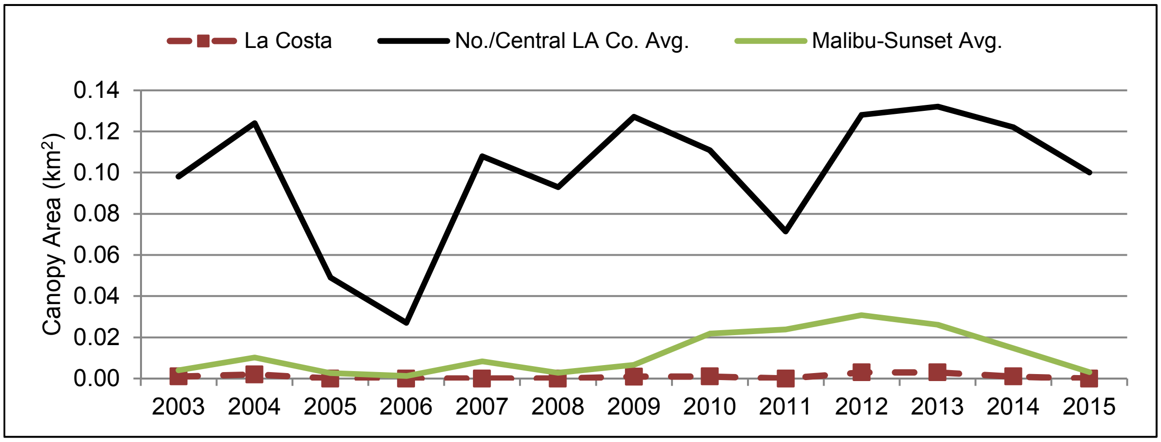


Figure 23. Comparisons between the average Northern and Central Los Angeles County ABAPY, the Malibu to Sunset ABAPY, and the canopy coverage of the kelp bed off La Costa from 2003 through 2015.

Las Flores. The Las Flores kelp bed reached its maximum size in December 2012, and at 0.025 km^2, it was slightly larger than in 2004. Canopy size decreased by 12% in 2013, and another 28% in 2014 (to 0.016 km^2) (Figures 1 and 24; Appendices A.19, D.3, D.4, and E.2). However, no canopy was visible during the four overflights in 2015.

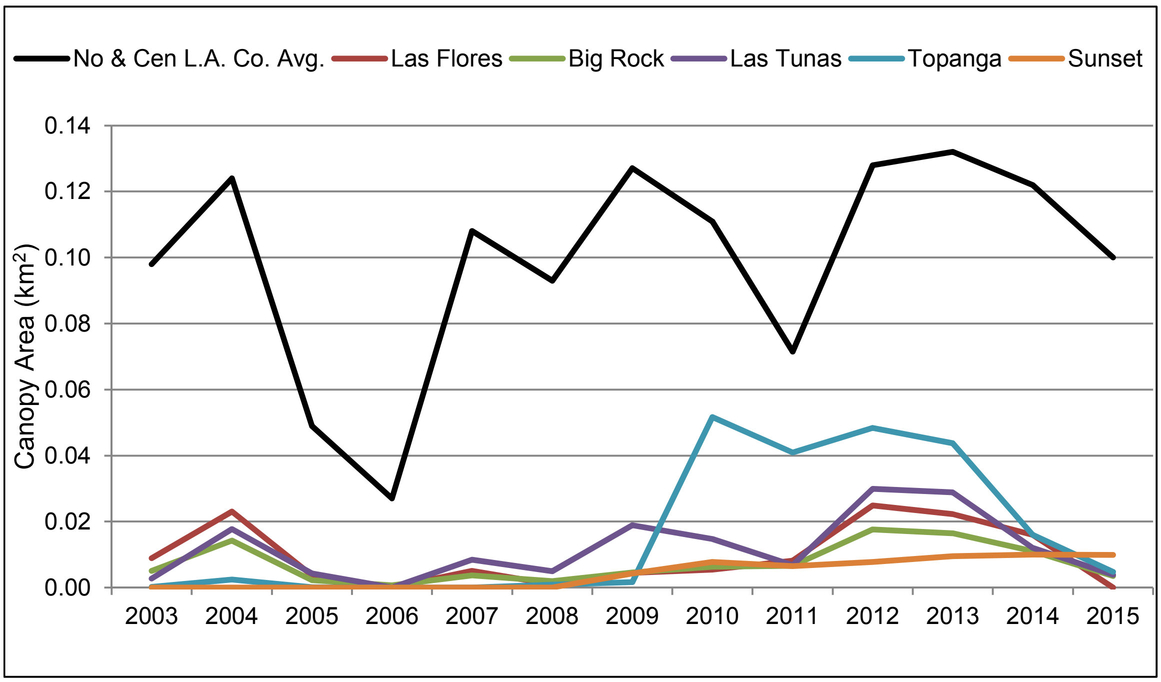


Figure 24. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverage of the five kelp beds from Las Flores to Sunset from 2003 through 2015.

Big Rock. In December 2012, the small kelp bed at Big Rock reached its largest size (0.018 km^2) since the inception of the CRKSC program. Canopy size decreased in 2013 and 2014, and in 2015 the bed size decreased from 0.011 km^2 to 0.004 m^2 (a 64% decrease) (Figures 1 and 24; Appendices A.18, A.19, D.4, and E.2). This kelp bed has generally not mirrored the ABAPY (due in part to its relatively small size), but the two have trended together since 2012.

Las Tunas. Las Tunas kelp bed canopy size reached 0.030 km^2 in December 2012. Canopy size decreased in 2013 and 2014, and in 2015 the bed size decreased by two-thirds (from 0.012 km^2 to 0.004 m^2). Similar to Big Rock, Las Tunas is a very small bed, and well below the ABAPY for the region, but has usually responded in synchrony with the ABAPY (Figures 1 and 24; Appendices A.19, D.4, and E.2).

Topanga. Topanga kelp bed reached its maximum size in 2010 at 0.052 km^2. However, it has decreased in size four of the past five years. In 2015, the bed decreased in size from 0.016 to 0.005 km^2. Topanga is a relatively small bed, and well below the ABAPY for the region, and therefore its extent has generally not mirrored the ABAPY (Figures 1 and 24; Appendices A.20, D.4, and E.2).

Sunset. Sunset kelp bed—once a very large bed—has not been observed in any of the CRKSC surveys through 2012, but a small amount of kelp was noted on the submerged breakwater offshore of Santa Monica at the southern end of the bed from 2009 through 2015. The bed size was essentially the same from 2013 through 2015 (0.010 km^2) (Figures 1 and 24; Appendices A.20, A.21, D.4, and E.2).

SANTA MONICA PIER TO REDONDO BEACH BREAKWATER

Santa Monica Pier to King Harbor. Although no kelp was noted in 2003 or 2004 from the Santa Monica Pier to Marina del Rey Harbor, a small amount of kelp was noted along the breakwaters at Marina del Rey Harbor and King Harbor in April 2005 and at slightly higher concentrations in December 2006. No kelp was seen between the two harbors along the Hyperion Treatment Plant outfall pipeline, offshore the Scattergood and El Segundo Generating Stations, Chevron Oil Refinery, Manhattan or Hermosa Beach, or the Redondo Beach Generating Station in 2015 (Figure 1; Appendices A.22 through A.27, D.4, D.5, and E.2). Since at least 2005, kelp has been visible at both the Marina del Rey and King Harbor breakwaters during some portion of the year (Appendices A.23, A.27, D.5, and E.2).

Redondo Beach Breakwater to Malaga Cove, Torrance. This stretch of coastline appears to have been unsuitable for kelp since the Crandall survey of 1911, implying that it continues to be sandy bottom with no substantial hard substrate. In 2015, no kelp was seen between King Harbor and Malaga Cove at the Palos Verdes Peninsula (except for that observed at the King Harbor Breakwater) (Figure 1; Appendices A.27, A.28, D.6, E.2 and E.3).

MALAGA COVE TO POINT FERMIN

The Palos Verdes (PV) kelp beds are typically quite large and have been more accessible to researchers than other areas, resulting in many more comprehensive surveys of this region (Table 6). The CRKSC divides the two beds that CDFW recognizes into four distinct kelp regions since they have at times responded differently to oceanographic conditions. Maps of the kelp beds at Palos Verdes Peninsula from 1890 (and possibly earlier) indicate that the kelp beds were large even then, but major fluctuations in extent of Palos Verdes kelp beds have occurred at least since 1911, when 9.124 km^2 of kelp was reported (Table 6 and Appendix B.2).

Table 6. Historical record of kelp canopy coverage of the Palos Verdes Peninsula.

Year	km^2	Acres	Hectares	Naut. Mi^2 [A] ($N mi^2$)	Sources
2015	3.140	775.81	313.96	0.915	CRKSC IR Survey (4 Surveys)
2014	1.647	406.98	164.70	0.480	CRKSC IR Survey (4 Surveys)
2013	2.600	642.47	260.00	0.758	CRKSC IR Survey (4 Surveys)
2012	2.599	642.22	259.90	0.758	CRKSC IR Survey (4 Surveys)
2011	2.396	592.06	239.60	0.699	CRKSC IR Survey (4 Surveys)
2010	2.494	616.41	249.45	0.727	CRKSC IR Survey (4 Surveys)
2009	3.998	987.92	399.80	1.17	CRKSC IR Survey (4 Surveys)
2008	2.916	720.56	291.60	0.85	CRKSC IR Survey (3 Surveys)
2007	2.062	509.53	206.20	0.60	CRKSC IR Survey (4 Surveys)
2006	2.187	540.49	218.73	0.64	CRKSC IR Survey (4 Surveys)
2005	1.099	271.57	109.90	0.32	CRKSC IR Survey (4 Surveys)
2004	0.589	145.54	58.90	0.17	CRKSC IR Survey (4 Surveys)
2003	1.425	352.12	142.50	0.42	CRKSC IR Survey (4 Surveys)
2002	2.837	701.00	283.68	0.83	CDFG/Ocean Imaging (2 Surveys)
2000	1.230	303.94	123.00	0.36	W.J. North IR Survey (1 Survey)
1999	1.267	313.00	126.67	0.37	CDFG IR Survey (1 Survey)
1998	0.498	123.00	49.78	0.15	CDFG IR Survey (3 Surveys)
1997	1.048	259.00	104.81	0.31	CDFG IR Survey (2 Surveys)
1996	1.356	335.00	135.57	0.40	CDFG IR Survey (2 Surveys)
1995	1.493	369.00	149.33	0.44	CDFG IR Survey (2 Surveys)
1994	2.703	668.00	270.33	0.79	CDFG IR Survey (2 Surveys)
1993	1.214	300.00	121.41	0.35	CDFG IR Survey (1 Survey)
1992	1.731	427.70	173.08	0.50	CDFG IR Survey (3 Surveys)
1991	2.964	732.50	296.43	0.86	CDFG IR Survey (4 Surveys)
1990	3.641	899.60	364.06	1.06	CDFG IR Survey (4 Surveys)
1989	4.549	1124.20	454.95	1.33	CDFG IR Survey (2 Surveys)
1988	3.379	835.00	337.91	0.99	CDFG IR Survey (4 Surveys)
1987	4.242	1048.30	424.23	1.24	CDFG IR Survey (4 Surveys)
1986	3.097	765.20	309.67	0.90	CDFG IR Survey (4 Surveys)
1985	2.627	649.20	262.72	0.77	CDFG IR Survey (4 Surveys)
1984	2.861	707.00	286.11	0.83	CDFG IR Survey (4 Surveys)
1983	1.963	485.00	196.27	0.57	CDFG IR Survey (4 Surveys)
1982	2.871	709.40	287.08	0.84	CDFG IR Survey (4 Surveys)
1981	2.424	598.90	242.37	0.71	CDFG IR Survey (4 Surveys)
1980	2.397	592.40	239.74	0.70	CDFG IR Survey (4 Surveys)
1979	1.842	455.25	184.23	0.54	CDFG IR Survey (4 Surveys)
1978	1.205	297.80	120.52	0.35	CDFG IR Survey (4 Surveys)
1977	0.365	90.30	36.54	0.11	CDFG IR Survey (4 Surveys)
1976	0.262	64.80	26.22	0.08	CDFG IR Survey (4 Surveys)
1975	0.095	23.50	9.51	0.03	CDFG IR Survey (3 Surveys)
1974	0.015	3.70	1.50	0.00	CDFG IR Survey (2 Surveys)
1967	1.062	262.4	106.2	0.31	SAI (1 Survey)
1959[B]	0.034	8.48	3.43	0.01	SWQCB 1964
1958	0.171	42.38	17.15	0.05	SWQCB 1964
1957	0.446	110.18	44.59	0.13	SWQCB 1964
1955	0.823	203.41	82.32	0.24	SWQCB 1964
1953	1.509	372.92	150.92	0.44	SWQCB 1964
1947	3.601	889.93	360.14	1.05	SWQCB 1964
1945	5.591	1381.51	559.08	1.63	SWQCB 1964
1928	9.912	2449.42	991.25	2.89	SWQCB 1964
1911	9.124	2254.58	912.40	2.66	Crandall 1912

A - Data in nautical mi^2 are from SWQCB (1964);
B - 1959 value as reported by SWQCB (1964) is actually <0.01 N mi^2. This was changed to 0.01 N mi^2 (8.5 acres).

2003-2015 data includes Cabrillo. 1911-1959 values were converted using 1 N mi^2 $(6076.13\ ft)^2 = 36{,}919{,}368\ ft^2$ = 847.55 acres = 342.99 hectares = 3.43 km^2. Values from 1974 to present are maximum coverage for each year in the CDFG or CRKSC aerial surveys.

Despite the region-wide decline of kelp beds since 1911, the extent of the decline in the Palos Verdes kelp forest over the first half of the 20th century was unusual. Appendix B presents representative survey results of 2.676 km^2 from 21 February 2002 since that particular survey provided information on all four sections of the Palos Verdes Peninsula. The varying estimates probably reflect the time of year the surveys were conducted and suggest the February 2002 survey did not represent the annual maximum canopy at Palos Verdes. The total of nearly 4.0 km^2 of kelp by June 2009 was the largest measurement of kelp at Palos Verdes in the 20 years since the 1989 survey total of about 4.5 km^2 of kelp. The beds off of Palos Verdes increased in size by 91% between 2014 and 2015, but the increase was not synoptic among the four beds.

The Portuguese Bend landslide is an important local factor in limiting kelp forests on reefs along the southern face of Palos Verdes (Appendix A.29). It affects areas in the Palos Verdes (PV) I and PV II kelp beds. This slide, which has been active since 1956, has contributed as much as 9.4 million metric tons of sediment to the nearshore waters (Kayen et al. 2002). Besides increasing water column turbidity with attendant effects on sea floor light availability, sediment from the slide buried many low-lying reefs that would otherwise support kelp beds (LACSD 2003). Kayen et al. (2002) compared bathymetry in the region to assess the magnitude of the historic accretion of sediment on these reefs. Comparing 1933 and 1976 bathymetric surveys, they found shoaling of the seafloor of greater than one meter between the 3- and 15-m isobaths, within the depth range suitable for kelp bed formation.

The Bay Foundation mapped and recorded 0.615 km^2 of urchin barrens around the PV III and PV II kelp beds in 2010 (Ford et al. 2015). Beginning in 2013, commercial urchin divers started harvesting and smashing sea urchins from Honeymoon Cove in an effort to provide suitable habitat for kelp restoration. Urchin eradication will continue at three additional areas off the Palos Verdes Peninsula through July 2015. Analyses of gonadosomatic indices of urchins, species richness of fishes, and fish biomass, as well as increased density of giant kelp, indicate preliminary results from the restoration effort are positive (Ford et al. 2015). Kelp coverage within the restoration areas (identified in yellow in Appendix A.81) was fairly sparse in 2015, but at Honeymoon Cove it appeared to be slightly denser in 2015 than it was in 2009, the year with the highest canopy coverage in the last 25 years.

Palos Verdes IV. The Palos Verdes IV (PV IV) kelp bed has historically been the largest of the beds on the Palos Verdes Peninsula. In 2014, the bed decreased in size by 73% (to 0.264 km^2). The PV IV kelp bed rebounded in 2015, and increased more than four-fold to its largest size since 2009 (Figures 1 and 25; Appendices A.28, D.6, and E.3). The PV IV kelp bed is typically much larger than the average kelp bed in the region. It is apparent from the ABAPY graph that 2003–2005 and 2014 were poor years for growth at Palos Verdes. It is equally clear from the ABAPY that the PV IV kelp bed responded similarly to other beds in the region, though generally with a sharper upward or downward trend.

Palos Verdes III. Palos Verdes III (PV III) kelp bed includes the area from Palos Verdes Point to Point Vicente. Since PV III kelp bed is physically connected to PV IV kelp bed, its areal coverage has historically tracked that of PV IV kelp bed, with the exception of periods of area-wide kelp canopy decline when Palos Verdes III kelp bed declined to an even greater degree than PV IV. In 2015, the PV III kelp bed increased in size by 60% (to 0.750 km^2), the largest canopy coverage measured for this bed since 2003 (Figures 1 and 25; Appendices A.29, A.81, D.6, and E.3). Prior to 2010, PV III was well below the ABAPY, but in 2010, 2014, and 2015 the kelp bed outperformed the ABAPY. It has generally corresponded to the ABAPY since 2010.

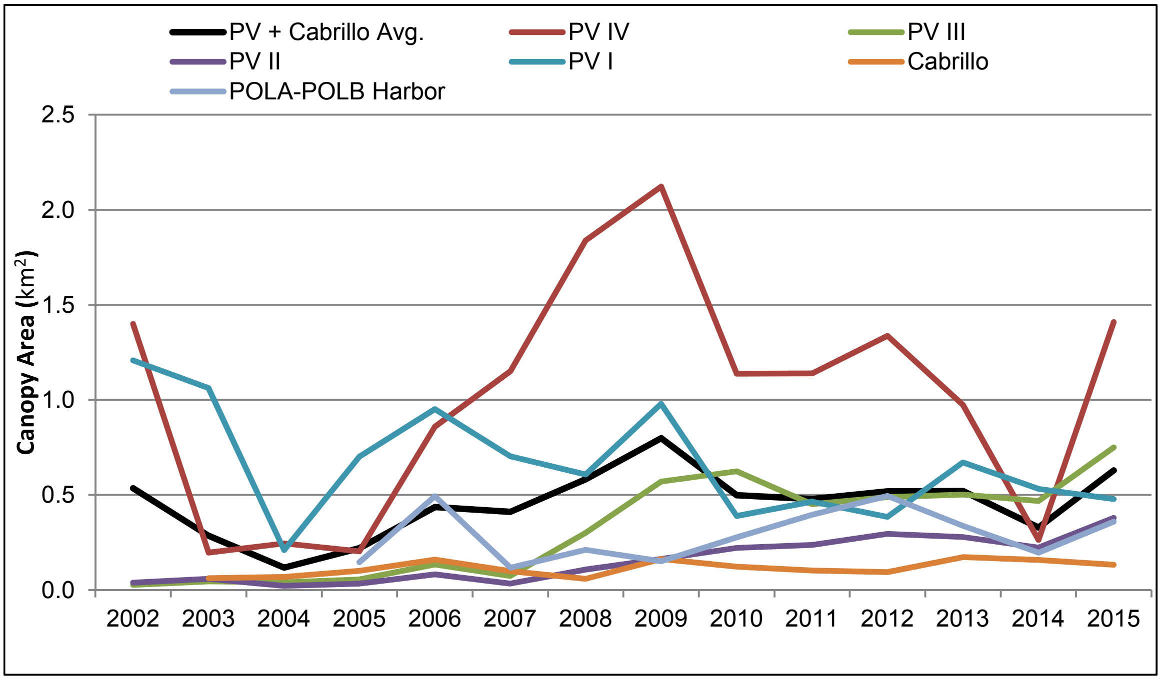


Figure 25. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverage of the kelp beds off Palos Verdes from 2002 through 2015.

Palos Verdes II. Palos Verdes II (PV II) kelp bed includes the kelp from Point Vicente to Inspiration Point. Unlike the PV III and PV IV beds, canopy size at PV II increased for five consecutive years (2008 through 2012), and in December 2012 it covered 0.295 km^2, the largest total of any CRKSC survey. The bed decreased in size in 2013 and 2014, but in 2015, it reached its maximum size since 2003 (0.379 km^2; Figures 1 and 25; Appendices A.29, A.81, D.6, and E.3). PV II kelp bed is much smaller than the ABAPY, and patterns of bed size have been muted. However, with the exception of continued growth from 2009 through 2010, the bed has generally corresponded with the ABAPY. A turbid plume from the Portuguese Bend landslide area was visible during the April and September overflights, prominent in the December overflight (Figure 39), but absent during June 2015 (the month when the PV II canopy was estimated to be at its peak during the year).

Palos Verdes I. Palos Verdes I (PV I) kelp bed includes the area from Inspiration Point to Point Fermin. Unlike the other Palos Verdes kelp beds, PV I increased substantially (75%) in 2013, and the canopy coverage was the highest recorded since 2009 (Figures 1 and 25; Appendix A.30). In 2014, canopy size decreased 21%, and in 2015 it decreased by 10% to 0.478 km^2. PV I kelp bed was considerably larger than the ABAPY during some years, and its size and growth patterns have corresponded to the ABAPY during most years since 2008 (Figure 25). However, PV I decreased in size in 2015 while the ABAPY increased. A turbid plume from the Portuguese Bend landslide area was visible during the April and September overflights, prominent in the December overflight (Figure 39), but absent during June 2015 (the month when the PV I canopy was estimated to be at its peak during the year).

POINT FERMIN TO NEWPORT BEACH

Cabrillo. The Cabrillo kelp bed includes the area east of Point Fermin up to and including the western end of the San Pedro Breakwater. In 2013, Cabrillo kelp bed increased in size by 83%, and the measured area was the highest recorded since 2003. The canopy area decreased by 9% in 2014 and by 16% in 2015 (to 0.133 km^2), but the bed was still about

14% larger than average. The bed is relatively small, but with the exception of declines in opposition to the ABAPY in 2008, 2012, and 2015, it has corresponded to the ABAPY (Figures 1 and 25; Appendices A.31, D.6, and E.3).

Los Angeles and Long Beach Harbors (POLA-POLB). Kelp grows along the POLA-POLB breakwaters, on the armored edges of the outer harbors, and in some places it extends into the inner harbors (Figure1; Appendices A.31 through A.34, D.6, D.7, and E.4). This kelp was not adequately considered in CRKSC reports before 2005, but it has been measured on a yearly basis since. The existence of these beds was known for some time, but the extent was not thought to be great. In response to growing curiosity as to the extent of the kelp in the Port Complex, it was requested that the overflight photographs for the third quarterly survey in 2005 (28 September 2005) include the entire outer harbors. Analysis revealed a narrow band of dense kelp (0.147 km^2) on both the inside and outside of the riprap. Only a small portion of the berths in the southern part of the Port Complex was included in the photographs, and it was suggested that the outer harbor be included in future overflights. The more inclusive survey of the harbor complex in 2006 measured 0.494 km^2 of giant kelp on the inner and outer breakwaters (Table 1). Due to reports of kelp along a number of the inner breakwaters, the entire Port Complex was photographed and surveyed by biologists to determine whether the algae in the infrared photographs was giant kelp, feather boa kelp (*Egregia menziesii*), and/or *Sargassum* spp. The visual inspection of the growth along the breakwaters and within the confines of the Ports confirmed that the major portion was giant kelp. Diver surveys in the Ports in 2013 and 2014 confirmed that *Macrocystis* was estimated to comprise >95% of the kelp coverage, with *Egregia* comprising <5%.

The canopy area within the Ports peaked in 2012 at 0.495 km^2, decreased in size in 2013–2014 to 0.196 km^2, and increased in 2015 by 83% to 0.359 km^2 (Figure 25; Appendices A.31 through A.34 and E.4). With the exception of the three-year period of 2009–2011, the patterns of the POLA-POLB kelp have generally not corresponded to the ABAPY. The coverage of the kelp in the Port Complex was also smaller than the ABAPY during most years, but the two have been relatively similar in size during the last five years.

Although much of the area downcoast from the Ports of Los Angeles and Long Beach breakwaters to the Newport/Irvine Coast is along a broad, alluvial fan from the San Bernardino Mountains, the area once supported several kelp beds. Rocky habitat existed off of San Pedro in the Horseshoe kelp area, and offshore of Huntington Beach in an area known as Huntington Flats (Figure 3; Appendices A.31, A.35, A.36, D.7, D.8, and E.5).

Horseshoe Kelp. No giant kelp canopy has formed at the site of Horseshoe kelp in more than 60 years. Subsurface kelp has been observed at this location; in 2004, the kelp *Pterygophora californica* was photographed growing at depths of 20–30 m (Wong et al. 2012). *Pterygophora* is present in dense stands on a considerable portion of the hard substrate in the region. No giant kelp was observed at Horseshoe kelp in 2015 (Appendices A.31, D.7, and E.4). The approximate location of this site is 10 km south of the Angel's Gate, the entrance to the POLA.

Huntington Flats. No giant kelp canopy was apparent at Huntington Flats in 2015 (Appendices A.35, A.36, D.8, and E.5).

Huntington Flats to Newport Harbor. No kelp was observed from Huntington Flats to Newport Harbor, which includes the area offshore of the Huntington Beach Generating Station and Orange County Sanitation District outfalls (Appendices A.36 through A.40, D.8, E.5). However, narrow bands of kelp were visible on the Newport Harbor jetties during the 2015 quarterly surveys (Appendices A.40, A.41, D.8, and E.5).

NEWPORT BEACH TO ABALONE POINT, LAGUNA BEACH

Newport/Irvine Coast: Newport Harbor to Crystal Cove, including Corona del Mar. Downcoast from Newport Harbor, giant kelp grows in a number of small beds (collectively called the Newport/Irvine Coast kelp bed, and referred to in some reports as the Corona del Mar kelp bed). Canopy coverage during December 2013 was the highest on record, and represented an 8% increase since 2012. Canopy size decreased slightly (by 15%) in 2014, and even more (by 88%) in 2015 (to 0.045 km^2). Kelp restoration efforts from 1986 through 2009 revived these beds from their total extirpation in the early 1980s (MBC 2010c). The Newport/Irvine Coast bed followed the ABAPY for other beds of the region until giant kelp was eliminated from Newport/Irvine Coast during the El Niño of 1982–1984, and it did not return until about 1989 (due to restoration efforts). Kelp disappeared from this stretch of coast again in the 1990s, returned due to further restoration efforts in 2003. Low coverage or no canopy coverage was reported until 2005, and following that survey, the canopy area increased through 2014. However, in 2015 the canopy declined to an area similar to that found in 2007 (Figures 2 and 26; Appendices A.41, A.42, D.8, D.9, and E.5). During the vessel survey in February 2016, scattered canopy was visible from Corona del Mar to Crystal Cove and a dense canopy was observed at Whistlers reef off Corona del Mar. Only scattered kelp was observed off of Reef Point even though a fair amount was observed in the December 2015 overflight. Only scattered kelp was observed on the surface in locations where dense beds previously thrived. However, subsurface kelp was visible from the vessel. Kelp tissue color at Crystal Cove was medium yellow, indicating a recent lack of nutrients.

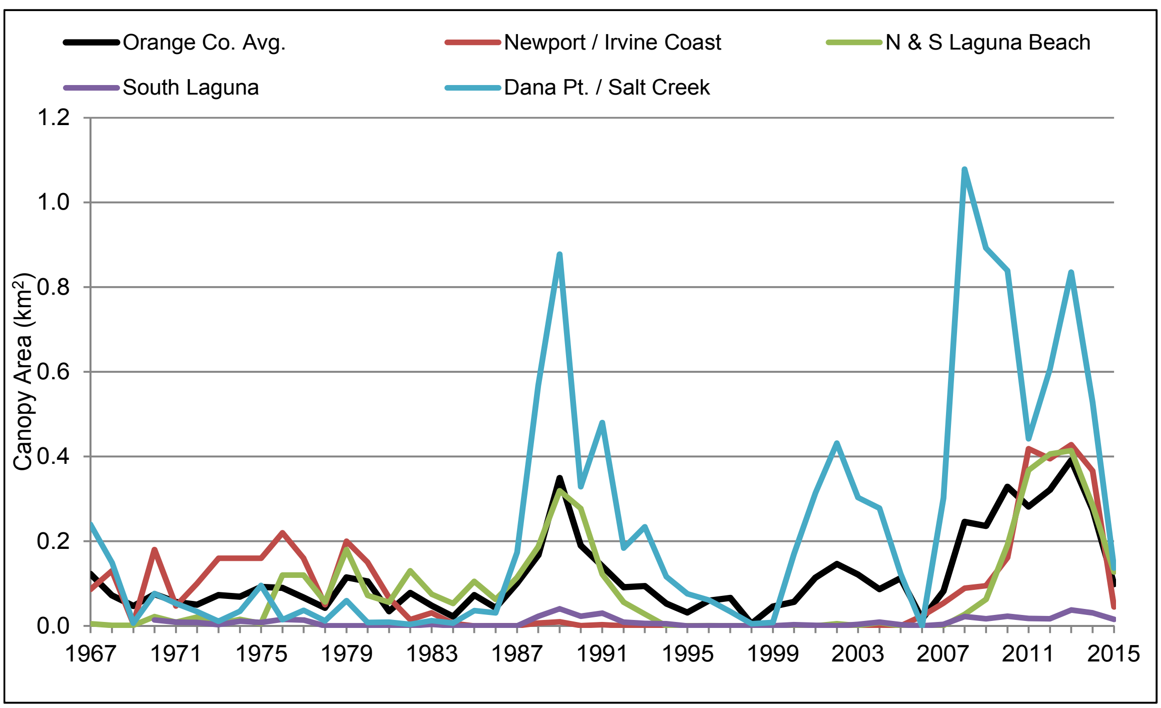


Figure 26. Comparisons between the average Orange County ABAPY and the canopy coverage of the kelp beds from Newport/Irvine Coast to Dana Point/Salt Creek from 1967 through 2015.

REGION NINE KELP SURVEYS

The Region Nine program identifies 24 individual kelp beds, although many are comprised of two or more distinct beds. As described previously, the boundary between the Central Region and Region Nine is Abalone Point in Laguna Beach. However, the Region Nine surveys have historically included the beds from Newport Harbor to Abalone Point (described above). The combined RNKSC kelp canopy coverage has been well above average during each of the last nine years (Figure 27). Each bed is also compared to the average for the beds in both Orange and San Diego County, excluding the very large beds of La Jolla (LJ) and Point Loma (PL), because these two beds skew the data (Figures 2, 26, 27, and 28; Appendices A.41 through A.80, D.9 through D.15, and E.5 through E.9).

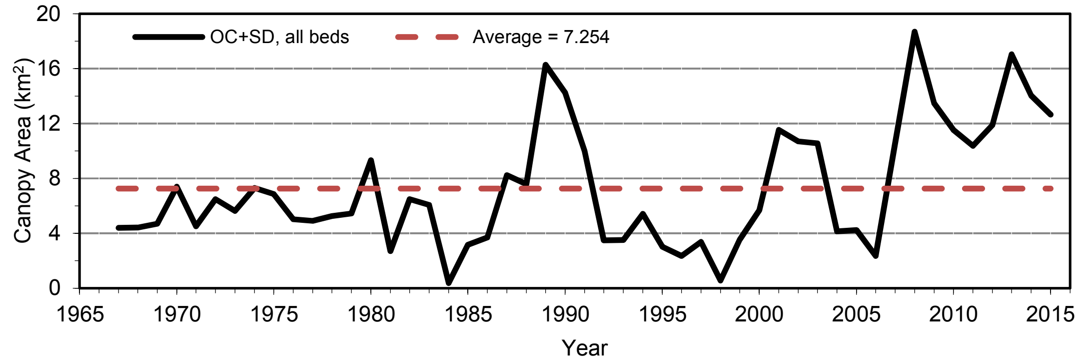


Figure 27. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2015.

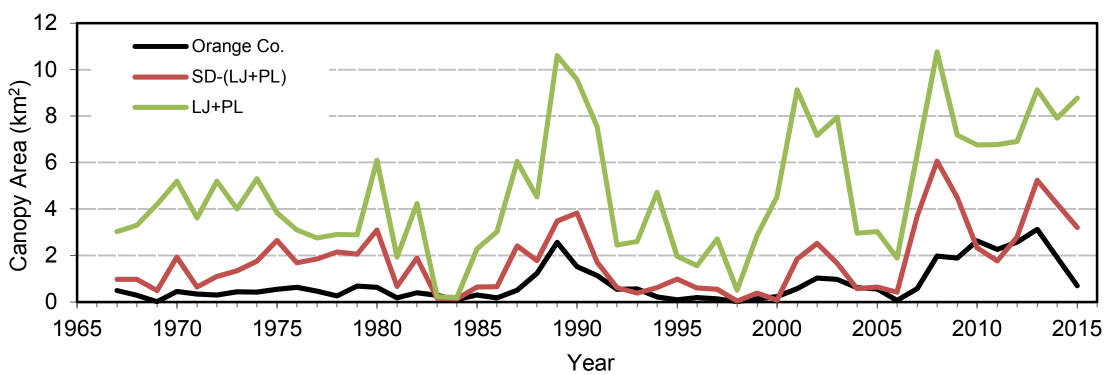


Figure 28. Diagram showings components of the Total Area graph partitioned into the kelp beds of: Orange County; San Diego County less La Jolla and Point Loma (SD-[LJ+PL]); and La Jolla plus Point Loma (LJ+PL) from 1967 through 2015.

ABALONE POINT TO CAPISTRANO BEACH

North Laguna Beach/South Laguna Beach. Based upon the combined annual total kelp canopy coverage, the total area calculated at these two areas in 2013 (0.415 km^2) was the largest on record. However, canopy declined by 55% from 2014 through 2015. Still, coverage was more than ten times higher than the long-term average of 0.0945 km^2 (Figures 2 and 26; Appendices A.42, A.43, D.9, and E.5). The two Laguna Beach beds followed the patterns of the ABAPY (when canopy was apparent), and survived the El Niño of 1982–

1984, but were extirpated in 1994. The Laguna Beach beds were not visible until about 2006 when they reappeared as a result of restoration efforts, and have since followed the ABAPY. By the 2016 vessel survey, the existing canopy measured about 150 by 200 m, with scattered kelp on the surface throughout the area. There was also solid subsurface kelp visible on the fathometer. Tissue color was dark yellow, and about 80% of the inspected fronds were mature.

South Laguna. In 2013, the South Laguna kelp bed more than doubled in size from 2012, and it reached its largest extent since 1989. The bed decreased in size by 48% in 2015 (to 0.016 km^2). The South Laguna kelp bed was much smaller than the ABAPY during most years, and canopy size at this site has not trended well with the ABAPY. However, the bed responded to relatively large stimuli such as the 1989–1990 La Niña, and since 2007 has usually trended in the same direction as the ABAPY (Figures 2 and 26; Appendices A.45, D.9, and E.6). Its size in 2015 was near the long-term average of 0.015 km^2. During the 2016 vessel survey there was no visible kelp on the surface, although kelp was observed on the fathometer throughout the area.

Dana Point/Salt Creek. The canopy at Dana Point/Salt Creek has fluctuated greatly over the last 49 years. Maximum canopy size was reported in 2008, but it decreased by more than half (59%) by 2011. Water conditions changed and the kelp bed increased by 22% through 2013, only to decreased in area by 58% through 2015 (Figures 2 and 26; Appendices A.46, D.9, and E.6). The beds at Dana Point/Salt Creek have been much larger than the ABAPY for much of the past decade. Canopy growth/reduction has usually corresponded with the ABAPY, although canopy decreases in 2009 and 2010 were out of synchrony with the Orange County average. During the February 2016 vessel survey, no surface canopy was observed but a large amount of subsurface kelp was observed in scattered areas of the bed's footprint. The subsurface kelp was visible out to the 15-m isobath.

Capistrano Beach. In 2015, the Capistrano Beach kelp bed decreased in size (from 0.034 in 2014 to 0.007 km^2). Canopy size in 2015 represented about 3% of the maximum canopy size observed in 1989 (0.233 km^2). The Capistrano Beach bed (combined with San Clemente beds) have responded in synchrony with the ABAPY—increasing during good years and decreasing during stressful periods (Figures 2 and 29; Appendices A.47 A.48, D.10, and E.6). During the vessel survey, kelp was sparse and there was no coherent canopy at Capistrano Beach. However, some subsurface kelp was visible on the fathometer. The subsurface kelp was three to four meters tall.

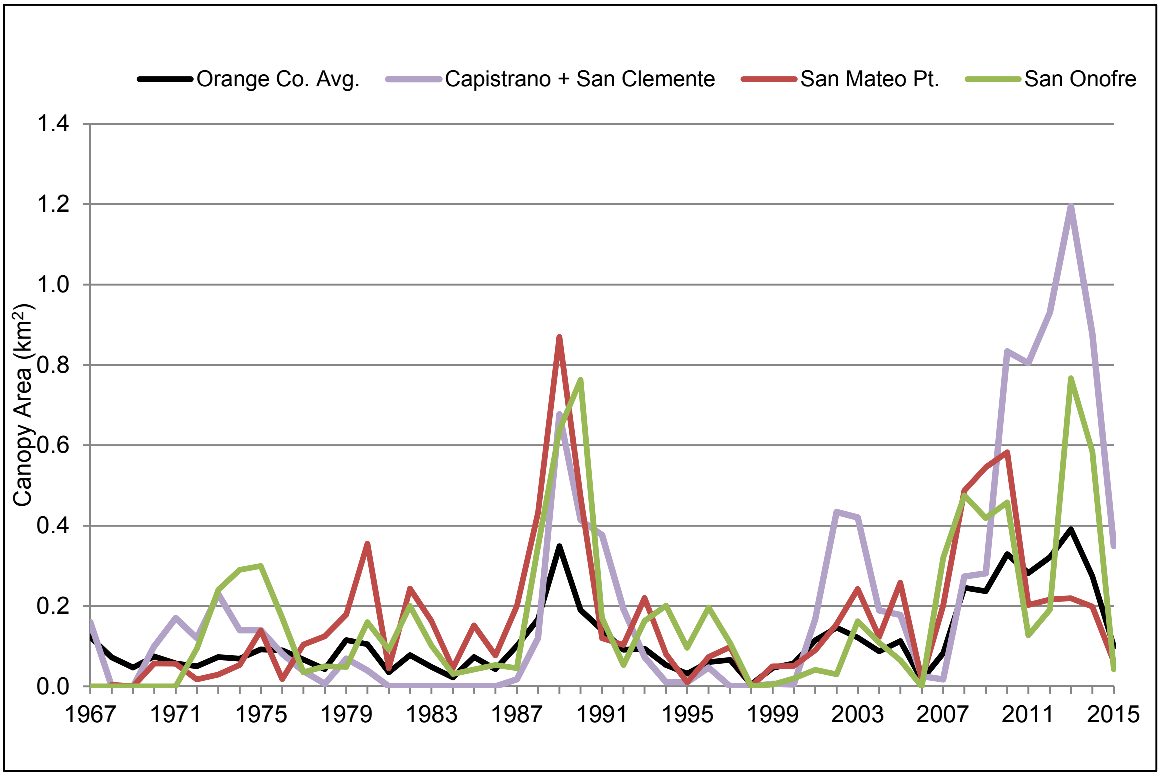


Figure 29. Comparisons between the average Orange County ABAPY and the canopy coverage from Capistrano Beach to San Onofre from 1967 through 2015. The Capistrano and San Clemente kelp bed areas are combined to facilitate visualization.

SAN CLEMENTE TO SAN ONOFRE

San Clemente. Beginning in 2002, the kelp beds at San Clemente were enhanced by the placement of approximately 50 small artificial reefs (each measuring 40 m x 40 m) on barren sand at depths of about 12 to 15 m. Kelp immediately recruited to these reefs, and canopies in the shape of small squares were visible during most of the aerial surveys of 2002 and 2003. In early 2008, Southern California Edison (SCE) added additional reef material (covering 0.712 km^2 in total) and kelp recruited to the new reefs in late 2008. After increasing in size for seven consecutive years (from 0.014 km^2 in 2006 to 1.097 km^2 in 2013, a 98% increase), the canopy coverage of this reef decreased by 69% from 2013 to 2015, with 59% canopy loss from 2014 to 2015 (Figures 2 and 29; Appendices A.49, A.50, D.10, and E.6). Despite this, observations by divers indicated good recruitment in 2015 (K. Anthony, pers. comm.). The canopy area was still much larger than the long-term Orange County average in 2015, and San Clemente was the fifth largest bed in Region Nine. The San Clemente beds (combined with the Capistrano Beach beds) have responded synchronously with the ABAPY. During the January 2015 vessel survey, there was a cohesive canopy more than 1.6 km long. However, during the February 2016 vessel survey, only scattered plants were observed on the surface, and they consisted of an even mix of mature and young fronds. Kelp was observed on bottom with the fathometer in widely scattered areas within the footprint of the reef.

San Mateo Point. The kelp bed off San Mateo Point decreased in size by 69% between 2014 and 2015 (from 0.199 km^2 to 0.062 km^2) (Figures 2 and 29; Appendices A.50, D.10, and E.6). The bed was much smaller than the maximum sizes measured in 1989 (0.870 km^2)

and 2010 (0.583 km^2). The average change in canopy size in Region Nine between 2012 and 2013 was a 22% increase; however, the San Mateo bed remained about the same size. Still, the San Mateo kelp bed has closely followed the patterns of the Orange County long-term average (Figure 29). There was a 200-m by 300-m canopy observed during the February 2016 vessel survey, with scattered individual kelp surfacing in the surrounding area. The coherent canopy extended out to a depth of 17 m, and consisted of young, dark yellow fronds. Kelp was visible on the fathometer inshore to a depth of 11 m.

San Onofre. Canopy size at San Onofre in 2013 (0.767 km^2) represented more than a four-fold increase from 2012, and that canopy size was the largest recorded by the RNKSC in this century (Figures 2 and 29; Appendices A.50, A.51, D.10, and E.6). In 2015, the San Onofre kelp bed decreased in size by 93%, and canopy area was the smallest measured since 2006. Because of their location in a similar geographically area, San Mateo kelp bed has been used in several scientific studies as a control station for San Onofre kelp, and the two beds usually react similarly (Figure 30). The San Onofre kelp bed has also followed the ABAPY for Orange County and San Diego County (Figure 29). In February 2016, no canopy was visible during the vessel survey, but scattered kelp was visible and observed on the fathometer. All of the fronds observed were young with good apical tips, and tissue color was medium yellow.

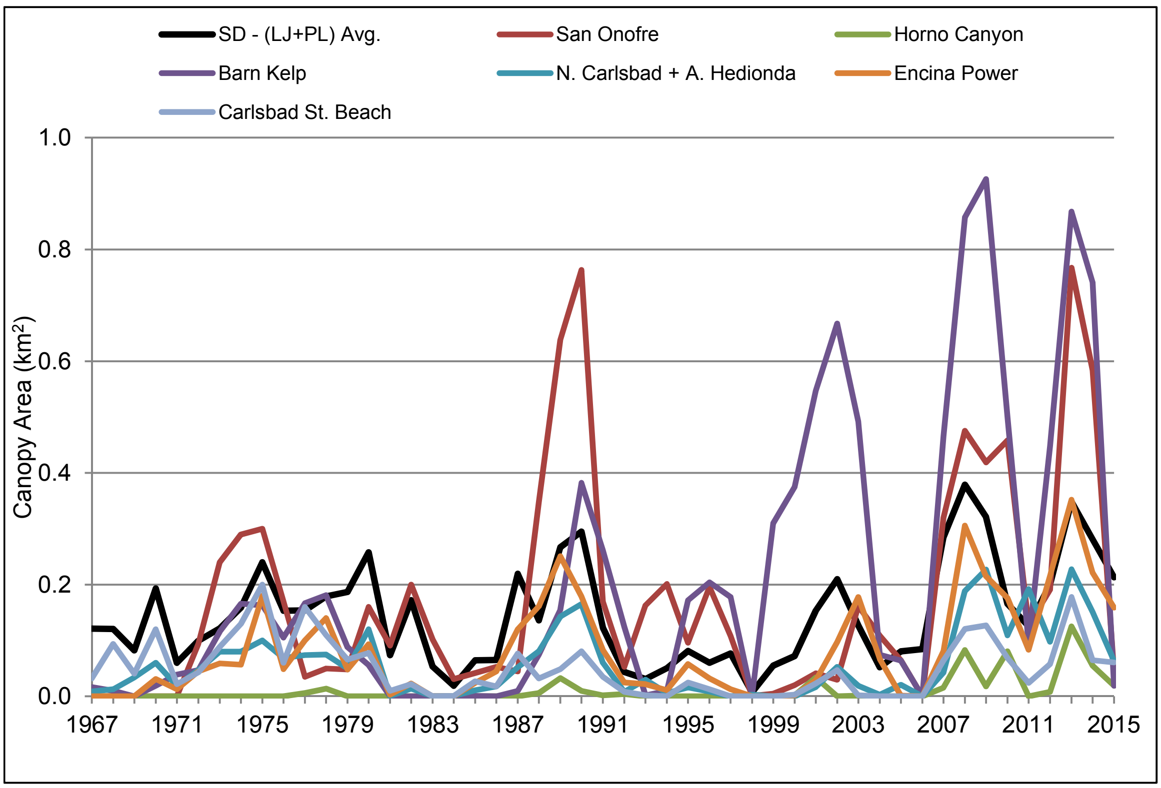


Figure 30. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverage from San Onofre to Carlsbad State Beach for the years shown.

HORNO CANYON TO SANTA MARGARITA RIVER

Horno Canyon. The Horno Canyon kelp beds are small and have been viable only during very large stimuli—such as the La Niñas of 1989–1990, 2001, and 2007–2008—and during the last four years (Figures 2, 12 and 30; Appendices A.52, A.53, D.11, and E.7). In 2013, kelp coverage at Horno Canyon (0.125 km^2) was the highest on record since 1911. The canopy area decreased by 56% in 2014, and by another 65% in 2015 (Figure 30). Pendleton Artificial Reef (PAR) is just upcoast from Horno Canyon (Appendix A.52). During the February 2016 vessel survey, no kelp was observed growing at PAR, nor was any kelp visible below the surface.

Barn Kelp. In 2014, Barn kelp decreased in size by 15%, similar to the change of the average San Diego kelp bed (19%) (Figures 2 and 30; Appendices A.53, A.54, D.11, and E.7). Only one year earlier, Barn kelp was more than three times larger than average, and it was the fifth largest kelp bed in Region Nine. However, in 2015, it decreased in size by 89%, and it was the eleventh largest bed (out of 24 beds). No kelp was visible downcoast from Barn kelp offshore Camp Pendleton (Appendices A.55, D.11, and E.7). Other than the severe downturn from 1980 to 1987, Barn kelp reacted similarly to the other beds in the San Diego region (Figure 30).

Because of the importance of this bed as a long-term control for San Onofre kelp bed, a dive survey was conducted here on two 50-m by 2-m transects in February 2016. A total of 104 adult, juvenile and recruiting kelp were observed on one transect and 95 on the other transect. There were about 20 recruits counted on each transect, which could enhance recovery if environmental conditions become favorable. There was some sediment and encrusting bryozoans on the blades, and tissues were medium to dark yellow, which suggested recent nutrient availability.

Santa Margarita. The Santa Margarita kelp bed is a small bed that occasionally forms a canopy off the Santa Margarita River mouth (Figure 2; Appendices A.56, D.11, and E.7). In 1911, Santa Margarita was the site of a substantial kelp bed that covered 0.858 km^2. Kelp disappeared here sometime before regular surveys began in 1967 by Dr. North. No kelp was seen during any of the vessel or aerial surveys until 1991, when a small bed covered an area of 0.049 km^2; it was much smaller in 1992, and disappeared in 1993. No canopy was observed at Santa Margarita for the next two decades, but a small kelp bed was visible during the December 2013 overflight. The size of the bed in 2013 (0.080 km^2) was 63% larger than in 1991. No canopy was observed at this site in 2014 or 2015. During the vessel survey in February 2016, no kelp was visible on or below the surface despite a thorough search of the area.

NORTH CARLSBAD TO CARLSBAD STATE BEACH

North Carlsbad. The North Carlsbad kelp bed is comprised of several small beds (Figures 2 and 30; Appendices A.59, A.60, D.12, and E.7). In 2015, the beds decreased by 45% (to 0.047 km^2). The North Carlsbad and Agua Hedionda kelp beds disappeared or became very small during warm-water periods , but reacted strongly to stimuli such as large La Niña events (Figures 12 and 29). The two beds combined followed the ABAPY fairly close, but were out of synchrony during the 2011–2012 surveys (Figures 2 and 30; Appendix A.59). During the February 2016 vessel survey, one patch measuring 100 m by 30 m, and small patches of scattered kelp were observed in the area. Tissues were dark yellow, and apical meristems (scimitars) on growing tips were tattered, likely due to 4-m to 5-m swells the previous week.

Agua Hedionda. Similar to the North Carlsbad kelp bed, the Agua Hedionda kelp bed decreased in size by 75% in 2015 (Figures 2 and 30; Appendices A.59, D.12, and E.7). The North Carlsbad and Agua Hedionda kelp beds disappeared or became very small during periods of below-average nutrient availability, but reacted strongly to stimuli such as large La Niña events. The two beds combined followed the ABAPY fairly close, but remained below the San Diego long-term average, and were out of synchrony during 2011–2012 (Figure 30 and Appendix A.59). During the vessel survey, the bed at Agua Hedionda was very patchy with only a few adult plants observed in the water column. Fronds were four to five meters long, and tissues were medium yellow and dark yellow.

Encina Power Plant. The Encina Power Plant kelp bed reached its maximum size in 2013 (0.352 km^2). The canopy decreased by 37% in 2014, and by 28% in 2015 where it fell below the San Diego long-term mean (Figures 2 and 30; Appendices A.60, A.61, D.12, and E.8). The canopy in this area has oscillated above and below this mean since 1999 (Figure 30).The Encina Power Plant kelp bed mirrored the other beds in the San Diego region, and its size is similar to the ABAPY (Figure 30). Because this bed was so vibrant during the December 2014 vessel survey and was quite diminished by the February 2016 vessel survey, a dive survey was conducted at this location. On two 50-m by 2-m transects, adult, juvenile and recruiting kelp were observed on the bottom: 73 on one transect and 30 on the other. There was some sedimentation, and many of the adult kelp were lacking blades. Urchins were observed in holes and did not appear to be mobile, and there were several old holdfasts that may have been dislodged due to the heavy surge caused by the recent high surf.

Carlsbad State Beach. The Carlsbad State Beach (Carlsbad State Park) kelp bed made considerable gains in 2013, and increased three-fold to 0.178 km^2 (Figures 2 and 30; Appendices A.60, A.61, D.12, and E.7). However, like most of the other beds in Region Nine, it decreased in size in 2014 by 63%. In 2015, it decreased in size another 6% (to 0.061 km^2). This bed grew or decreased in size similarly to the other beds in the San Diego region through about 1977. It acted in opposition to the ABAPY in 1978–1979, but while muted, acted in concert with the ABAPY during the last three decades (Figure 30). During the vessel survey, the bed off Carlsbad State Beach consisted of only scattered kelp, and a few fronds reached the surface. Many of those fronds consisted of missing or tattered meristems.

LEUCADIA TO TORREY PINES

Leucadia. The Leucadia kelp bed is comprised of the North, Central, and South Leucadia kelp beds (surveyed as three separate beds because of distinct breaks in the beds; see Figure 2; Appendices A.62, A.63, D.12, and E.7). In 2013, Leucadia kelp bed increased to its highest coverage in the last 30 years (0.541 km^2), but the bed size decreased by 48% in 2014 (Figure 31). Most of the kelp beds between Carlsbad and Imperial Beach increased in size in 2015, including Leucadia kelp bed, which increased in size by 48%. The North bed (off Batiquitos Lagoon) grew by 37%, the Central bed grew by 68%, and the South bed grew by 104% since 2014. The Leucadia kelp beds have usually mirrored the other beds in the San Diego region (Figure 31). During the vessel survey, the canopy at North Leucadia was extensive but sparse. Fronds were three to five meters long, with about 40% having encrustations. The canopy in the Central bed was also extensive but scattered, and about 40% of the blades inspected had encrustations. Fronds were about two meters long, and tissues were dark yellow. At the southern bed, tissues were dark yellow and fronds were tattered.

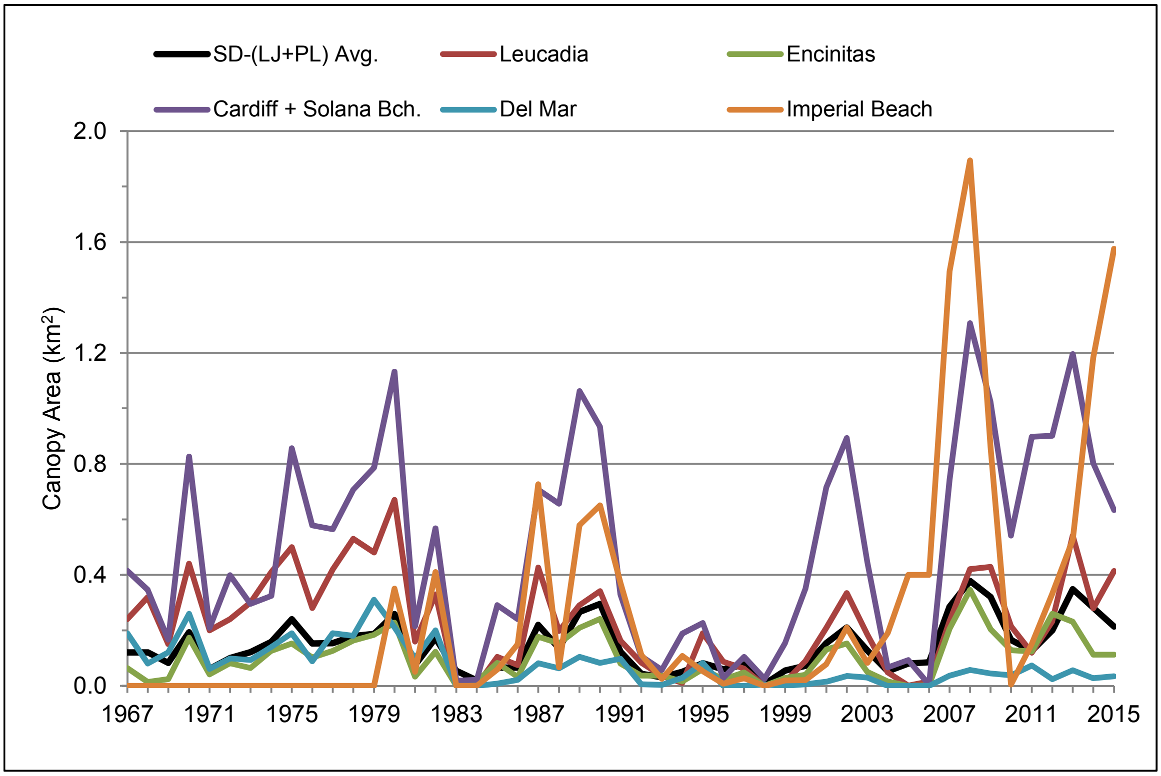


Figure 31. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverage from Leucadia to Del Mar (and Imperial Beach) for the years shown.

Encinitas. The Encinitas kelp bed maintained its size between 2014 (0.112 km^2) and 2015 (0.113 km^2) (Figure 2; Appendices A.63, A.64, D.12, D.13, and E.7). The size of this bed has mirrored the other beds in the San Diego region (Figure 31).). For unknown reasons, Encinitas kelp decreased in size by about 50% in 2014 while most beds in Region Nine grew. The small increase in size from 2014 to 2015 was consistent with the other beds upcoast and downcoast of Encinitas. During the vessel survey, a thin kelp canopy covered an area measuring 300 m by 100 m; however, most of the growing apical scimitars were missing or tattered.

Cardiff and Solana Beach. In 2015, the Cardiff kelp bed increased in size by 6%, and the Solana Beach kelp bed decreased in size by 37% (Figures 2 and 31; Appendices A.64, A.65, D.13, E.7, and E.8). Combined, these two beds are more than three times larger than the ABAPY in the San Diego region. Changes in Cardiff/Solana Beach kelp bed sizes have usually mirrored the other beds in the San Diego region, although the magnitude of the changes was generally greater because of the relatively large size of these two beds; both were still larger than their long-term averages despite the large decrease in the Solana beach bed in 2015 (Figure 31). During the vessel survey, there was a thin canopy measuring about 50 m by 100 m off Cardiff, and a larger area measuring 200 m by 400 m off Solana Beach. Scattered kelp was present in both beds, and extensive subsurface kelp was metered at Cardiff. Most of the visible growing tips were tattered. Frond lengths were four to five meters off Solana Beach, and three to five meters off Cardiff. Tissues were medium yellow at both locations.

Del Mar. The Del Mar kelp bed is typically one of the smallest beds in Region Nine, and in 2014 it is the smallest kelp bed which had the smallest canopy (Figures 2 and 31;

Appendices A.66, D.13, and E.8). It increased in size by 28% (from 0.027 km^2 in 2014 to 0.034 km^2 in 2015). This bed has remained below the San Diego long-term mean since 1983 (Figure 31).The kelp bed off Del Mar was only about 43% of its long-term average size, but was consistent with its average size during the last 20 years. This kelp bed typically has mirrored the other beds in the San Diego region, although it reacted opposite the ABAPY during 2011–2012 and 2015. Its size has usually been much smaller than that of the ABAPY since 1983 (Figure 31). No surface canopy was observed during the February 2016 vessel survey, nor was any subsurface kelp seen on the fathometer.

Torrey Pines. Torrey Pines kelp bed appeared in our records as a small trace of kelp during La Niña conditions in 1988 and 1989. It reappeared in 2006 as a measurable canopy (0.010 km^2) with scattered giant kelp about 1.5 km north of Scripps Pier, another concentration about 3.5 km north, and a third concentration of scattered giant kelp was found about 1.5 km north of that position (5 km north of the pier) (Figures 2 and 31; Appendices A.67, A.68, D.13, and E.8). The canopy disappeared in 2007, but from 2008–2013 small canopies were observed in various locations in the area. In 2013, Torrey Pines kelp bed was measured at its largest extent (0.081 km^2), but no canopy was visible during the quarterly surveys of 2014–2015. Only a few giant kelp were observed at the surface during the vessel survey; no surface canopy was observed at Torrey Pines.

LA JOLLA

La Jolla. La Jolla kelp bed is composed of two canopies: northern La Jolla and southern La Jolla (Figures 2 and 31; Appendices A.69, A.70, D.13, D.14, and E.8).Between southern La Jolla and Upper Point Loma (offshore Mission Bay), nearshore habitat is mostly sandy and kelp does not grow in this area (Appendices A.70, A.71, D.14, and E.8). In 2015, La Jolla kelp canopy coverage increased by 6% and covered 2.968 km^2 (Figure 32). La Jolla kelp bed was the second largest bed in Region Nine. Changes in bed size at La Jolla have usually mirrored those at Point Loma, but in 2014 La Jolla decreased while Point Loma maintained most of its size (Figure 31). This suggests that overall they are usually affected by the same oceanographic regime, but that small differences in bathymetry and currents can still make profound differences in the availability of nutrients to kelp beds that otherwise appear very closely related. In February 2016, there was no coherent canopy along the entire northern or central La Jolla kelp bed footprint, nor was any canopy observed at southern La Jolla. There were, however, scattered individual kelp plants, as well as plentiful kelp observed on the fathometer throughout the area. Frond length was about one meter, and apical blades were tattered. Tissues were medium yellow.

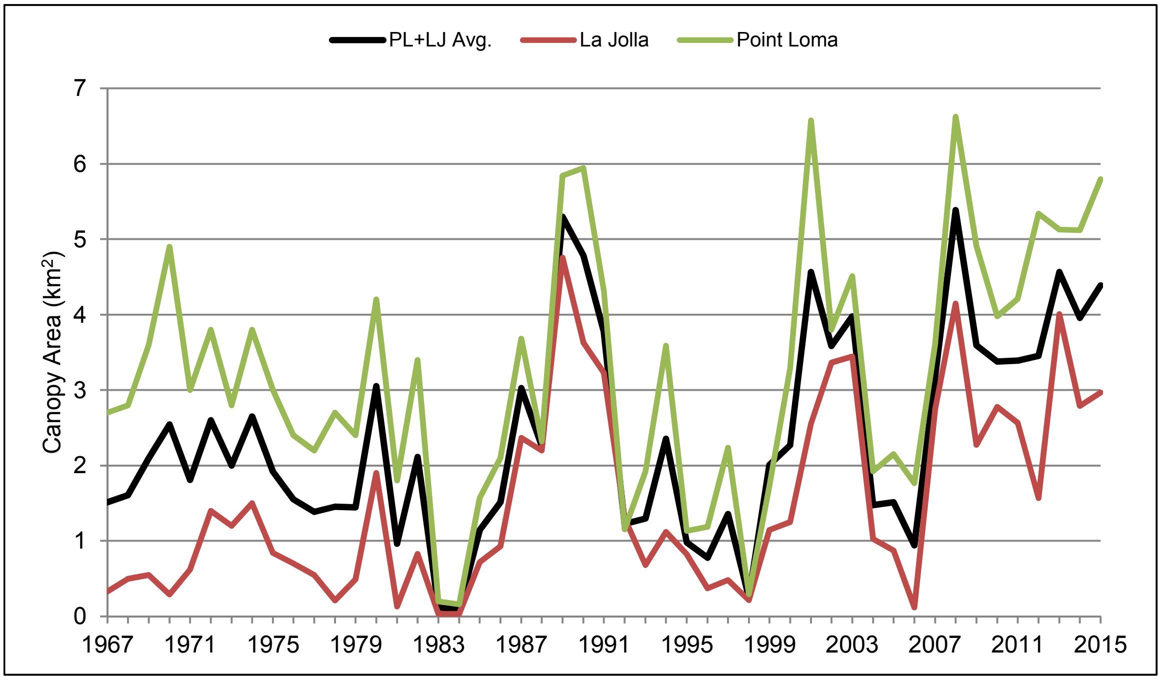


Figure 32. Comparisons between the (LJ+PL)/2 ABAPY and canopy coverage of the La Jolla and Point Loma kelp beds for the years shown.

POINT LOMA TO IMPERIAL BEACH

Point Loma. The Point Loma kelp bed is composed of many, usually contiguous, kelp canopies ranging from depths of 5 m to >30 m during years with sufficient nutrients (Figures 2 and 32; Appendices A.71 through A.74, D.14, D.15, and E.9). *Pelagophycus* is prevalent beyond about 30 m at Point Loma (Turner et al. 1968). Similar to La Jolla, the Point Loma kelp bed is divided into upper and lower sections. The canopy at Point Loma has maintained a relatively large size (>5 km^2) and has changed little during the last three years. It is the largest bed in Region Nine. The size of Point Loma kelp changed little (<1%) between 2013 and 2014, but the bed size increased 13% between 2014 and 2015 (Figures 2 and 32; Appendices A.71 through A.74). In the February 2016 vessel survey, kelp was scattered throughout the upper and lower sections of the bed, but no coherent canopy was observed. Subsurface kelp was visible on the fathometer. On the surface, fronds were two to eight meters long, and tissues were dark yellow. At Upper Point Loma (Appendix A.71), apical blades were tattered, and sedimentation was apparent on the fronds. At Lower Point Loma, apical blades were also tattered, but there was no indication of sedimentation.

IMPERIAL BEACH TO U.S./MEXICO BORDER

Imperial Beach. The canopy coverage at Imperial Beach has oscillated above and below the San Diego long-term mean since 1969 (Figures 2 and 31; Appendices A.78 through A.80, D.15, and E.9). All of the beds in Region Nine either lost or maintained canopy size in 2014, but the bed off Imperial Beach grew considerably (by 125%) (Figure 31). The kelp bed increased by 33% in 2015. It was the third largest bed in Region Nine, and even though it did not reach its size from 2008, it was still nearly five times larger than average. Canopy coverage in 2015 represented a 99.7% increase since the low coverage in 2010. Except for the period from 1967 to 1979 (when it was missing) and 2015, the Imperial Beach kelp bed generally followed the ABAPY.

The Imperial Beach kelp bed canopies have been observed in different locations during years when they were apparent. Svejkovsky (2015) noted "*major bed locations shifts and coverage area variability give the appearance in the persistence analysis that this kelp bed rarely persists longer than one year. In actuality the same bed appears to change in location slightly from year to year with some years (1999 and 2003) showing very sparse coverage and others (2008 and 2009) exhibiting much larger canopy area*."

In the vessel survey of February 2016, the Imperial Beach kelp bed was scattered but a fairly coherent canopy was estimated to cover 800 m by 800 m. Fronds were two to four meters long on the surface, and tissues were dark yellow. In addition to the surface canopy, subsurface kelp was visible on the fathometer in several locations.

UPDATE TO THE PRESENT

Two aerial surveys for 2016 have been conducted (on 18 April and 20 June 2016) and a vessel survey of the entire Region Nine area was conducted on 4 and 16 February 2016. Based on a preliminary review of the data, the following is a summary of the canopy coverage through 18 April based on a review of the quarterly photographs.

- As of 18 April 2016, most of the kelp beds in the Central Region increased in size while most beds in Region Nine decreased in size (from canopy sizes observed in December);
- Kelp beds were substantially larger from Ventura harbor to Puerco/Amarillo, and then sparse to Malaga Cove. Canopy sizes increased around the Palos Verdes Peninsula, including the breakwaters at the Ports of Los Angeles and Long Beach;
- Kelp beds from Newport Beach to San Onofre were visible, at least in part, but no substantial kelp was observed from PAR to Imperial Beach, including very little kelp at San Clemente and La Jolla; and
- No kelp canopy was visible between Dana Point and Oceanside in April (although biologists metered subsurface kelp at San Clemente, San Onofre and Barn kelp with a fathometer on a research vessel).

MBC dive surveys in early July 2016 documented good kelp recruitment at San Mateo, but poor recruitment at San Onofre. Sea surface temperatures in the Central Region and Region Nine were generally cooler from January–March 2016 than during the first quarter of 2015 (Figure 33). Surface temperatures dropped sharply at Newport and Scripps Piers in February 2016, and at Newport Pier that was the first time SST was below average since September 2015. El Niño-Southern Oscillation (ENSO)-neutral conditions were apparent at the equator by July 2016 (NOAA CPC 2016). The forecaster consensus favors the development of La Niña during summer 2016, with a 55–60% chance of La Niña during the fall and winter of 2016-17.

It is unknown how the Central Region and Region Nine kelp beds will fare in 2016. At the time of this writing (July 2016), El Niño conditions dissipated at the equator, but water temperatures in southern California are still above average (CDIP 2016; SCCOOS 2016). The biological effects of the continued presence of warm water were recently still apparent. In May 2016, thousands of pelagic red crabs (*Pleuroncodes planipes*) washed ashore in

Newport Beach and Laguna Beach (OC Register 2016), and they were frequently seen during vessel surveys during spring 2016 between Newport Beach and San Onofre. Similar observations were recorded during 2015 (MBC 2016). Pelagic red crab is associated with warm water, and some consider it a harbinger of El Niño (McPeak et al. 1988).

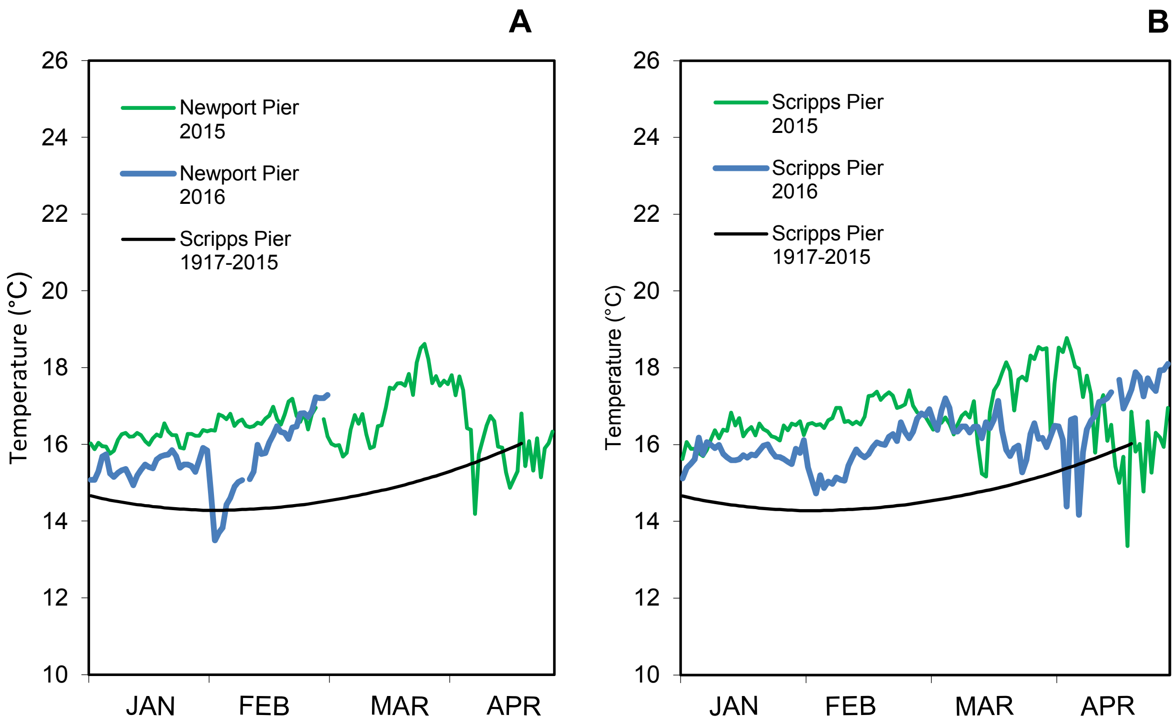
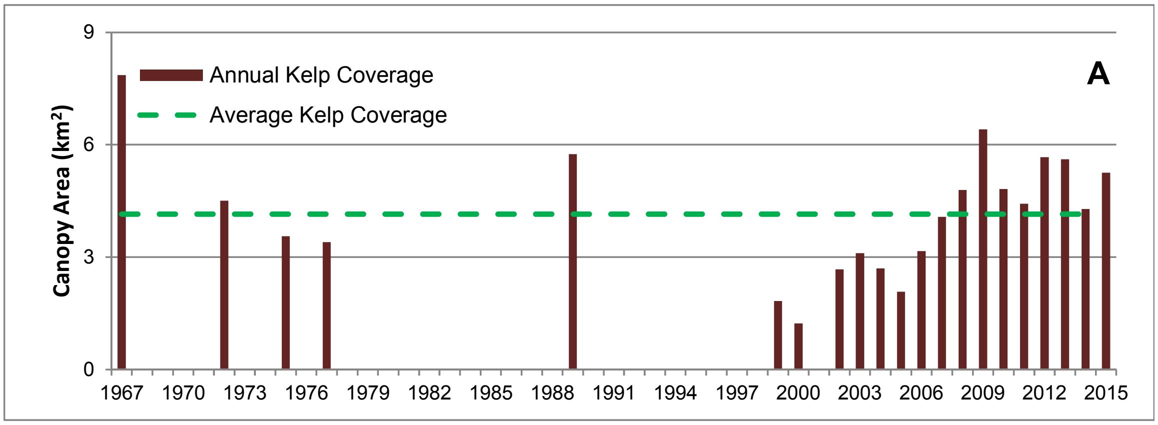


Figure 33. SSTs from January–April 2015 and 2016 at (A) Newport Pier and (B) Scripps Pier. 60-day harmonic mean from Scripps Pier (1917-2015) is presented for comparison.

DISCUSSION

Total canopy sizes within the 50 kelp beds monitored as part of the CRKSC and RNKSC programs were above their historical averages in 2015 (Figure 34). However, the combined area of both study regions decreased 2% from 2014.

Kelp coverage in the CRKSC increased by about 23%, and coverage in Region Nine decreased by about 10%. Within each region, there were major spatial differences in gains/losses. About two-thirds of the beds in the Central Region lost canopy in 2015; however, most kelp beds between Deer Creek and Point Dume, and three of the beds at Palos Verdes, gained canopy last year. The angle of the coastline from Point Dume to Santa Monica Bay is slightly different from that in other areas of Region Nine, and this affects the exposure to waves and upwelling, which is crucial in distributing nutrients. The three upcoast Palos Verdes beds increased in size (by 60–434%), while PV I and Cabrillo decreased in size by 10% and 16%, respectively. Most of the kelp beds waned during the last half of 2014, however the beds at Palos Verdes still displayed considerable canopy in the December survey even after being exposed to several months of above-average temperatures.



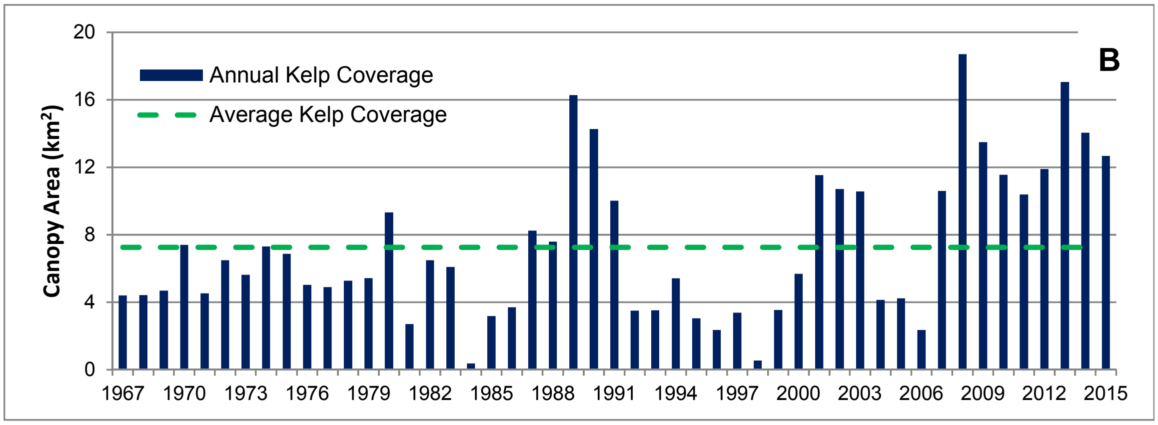


Figure 34. Annual and average kelp coverage in (A) the Central Region and (B) Region Nine.

In 2014, the four Palos Verdes kelp beds all decreased in size, with the bed farthest upcoast (PV IV) decreasing the most. This year, three of the four beds at Palos Verdes increased in size, with the increase at PV IV the greatest among those three. The five kelp beds at Palos Verdes (PV I through PV IV and Cabrillo) have only trended in the same direction as a group (in the same year) twice in the last 13 years.

Within Region Nine, most of the beds from Newport Harbor to Carlsbad State Beach lost canopy in 2015 while most beds from Leucadia to Imperial Beach grew in size in 2015. The two larger beds immediately upcoast from Imperial Beach (Point Loma and La Jolla) increased in size since 2014. Point Loma maintained its size, and increased by 13%, and La Jolla gained 6% in canopy coverage. The Imperial Beach kelp bed, however, expanded by 33%. The reason for these uneven growth patterns at Palos Verdes and the three southernmost kelp beds is not known, but is undoubtedly related to the angle of the coastline. This change in angle affects the exposure to wind, resulting waves, and upwelling (which is crucial for nutrient supply). Currents and water quality characteristics can interact with local geography and bottom topography and change on short time scales. Currents can bathe an area in nutrient-rich water in one portion of the tidal cycle and be completely absent in the next. From Salt Creek to Imperial Beach, most of the kelp was growing on the outer edges of the reefs when kelp coverage in 2015 was compared to canopies in 2008, the year with the largest coverage in Region Nine. This pattern is common, particularly in summer and fall when thermoclines develop and shallow waters warm (MBC 1994–2015).

Konotchick et al. (2012) found that the discrepancies in the persistence of giant kelp in the northern and southern portions of the La Jolla kelp bed were caused by differential, alongshore vertical variations in temperature (and thereby nutrients) and topographically induced internal wave dynamics; instrumentation to elicit these parameters are not typically available in the scale of a regional study. Parnell (2015) analyzed algal patch structure and the importance of seascapes at La Jolla and Point Loma kelp beds. Understory algae grows within the La Jolla kelp forest, and offshore of the kelp forest (in association with *Pelagophycus*, which grows in waters as deep as 35 m). This highlights the importance of small-scale differences between/among kelp beds, and even within kelp beds, in affecting the distribution and growth of kelp.

From Ventura to Imperial Beach, kelp beds were at their greatest size during the 20 June 2015 overflight. This coincided with several months (March–May) of cool-water influx (potentially upwelled) in both regions. There were similar periods of cold-water intrusions in summer and fall, but most of the SSTs were above average after July. The coolest temperatures of the year were recorded in April 2015 at Scripps Pier and in May 2015 at Newport Pier. Data from off Point Loma indicated that the water column was well mixed (i.e., no thermocline) from late-March through mid-June. Some of the kelp beds, particularly some of the smaller beds in the Central Region, were not visible in spring and reached their maximum size in December 2015. Note that November and December were two of the three months in 2015 with above-average upwelling.

Temperatures during the first three to four months of 2015 were mostly above average, but there were several cold-water influxes from mid-April through June. Eighty-four percent of the daily SST values at Scripps Pier in 2015 were above the long-term daily means and 86% were above the mean in 2014. The upwelling index (from offshore Solana Beach) indicated above-average upwelling during only three months—August, November, and December—compared to the average since 1946. Strongest upwelling occurred in December and August, although upwelling was not evident in the SSTs at any of the buoy/pier sites in December (Figures 7, 8, and 10). The SSTs throughout the region increased in summer, and upwelling was reduced. Highest SSTs occurred in September and October.

The warmer-than-average temperatures from late-2013 through most of 2015 coincided with “The Blob,” a large mass of warm water that formed off the Pacific Coast and affected coastal waters from the Bering Sea to Baja California (Bond et al. 2015). The warm waters likely resulted from (1) lower-than-average heat loss from the upper ocean to the atmosphere, and (2) weak advection of colder water in the upper ocean. Both of these were attributed to high sea level pressure over the affected areas (Bond et al. 2015). The coastal waters off southern California, and off most of the Pacific Coast, appeared warmer than average throughout most of the year (Figure 35). In November 2015, “The Blob” dissipated, but higher-than-normal temperatures remained along the southern California coast (NOAA SWFSC 2015). Typical atmospheric patterns over the northeast Pacific were replaced by a persistent ridge of high pressure that greatly affected the surface structure of the ocean (Leising et al. 2015). The Southern California Warm Anomaly (SCWA) was first evident in spring 2014 as a band of warm surface water along the shelf break. The temperature anomalies at a depth of 10 m in 2014 and 2015 were as large as those measured during the El Niño events in 1957–1958, 1982–1984, and 1997–1998.

The calculated NQ values in both regions were much lower than the long-term averages since the 2013–2014 nutrient season (beginning in July 2013 and ending in June 2014). Productivity—assessed here using chlorophyll a—was fairly unremarkable in southern

California in 2015 compared to the rest of the West Coast (Figure 36). By June 2016, there was a disparity of about 5°C between SSTs offshore Ventura (14.5°C) and La Jolla (19.1°C) (Figure 37), highlighting the difference in temperatures that can affect the two regions. Chlorophyll a and nitrate values from the California Cooperative Oceanic Fisheries Investigations (CalCOFI) study area off southern California were among the lowest on record from July 2014 to April 2015 (Leising et al. 2015).

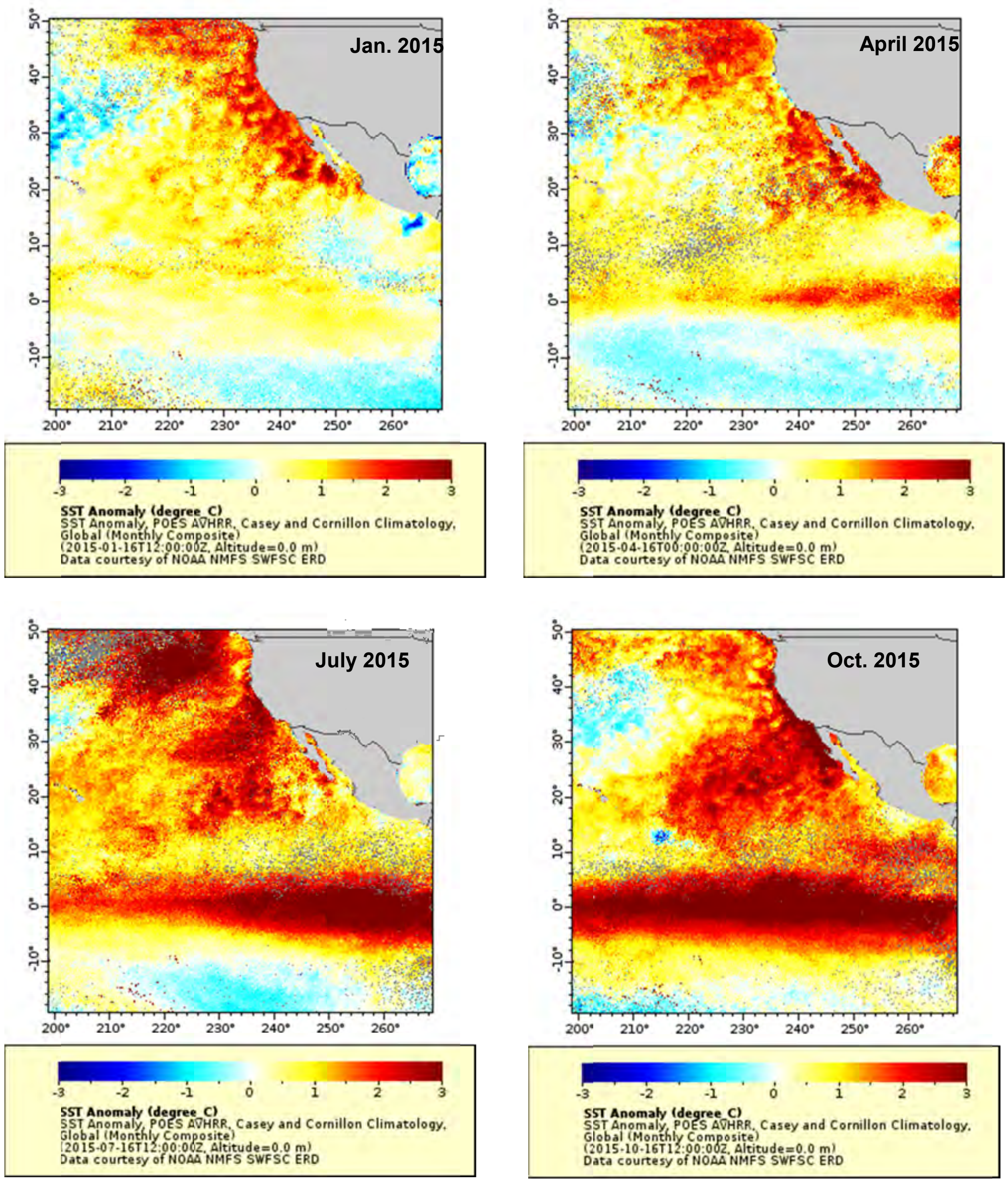


Figure 35. SST anomalies (+/- °C) off the West Coast of North America in January, April, July, and October 2015. Source: NOAA SWFSC ERD (2015).

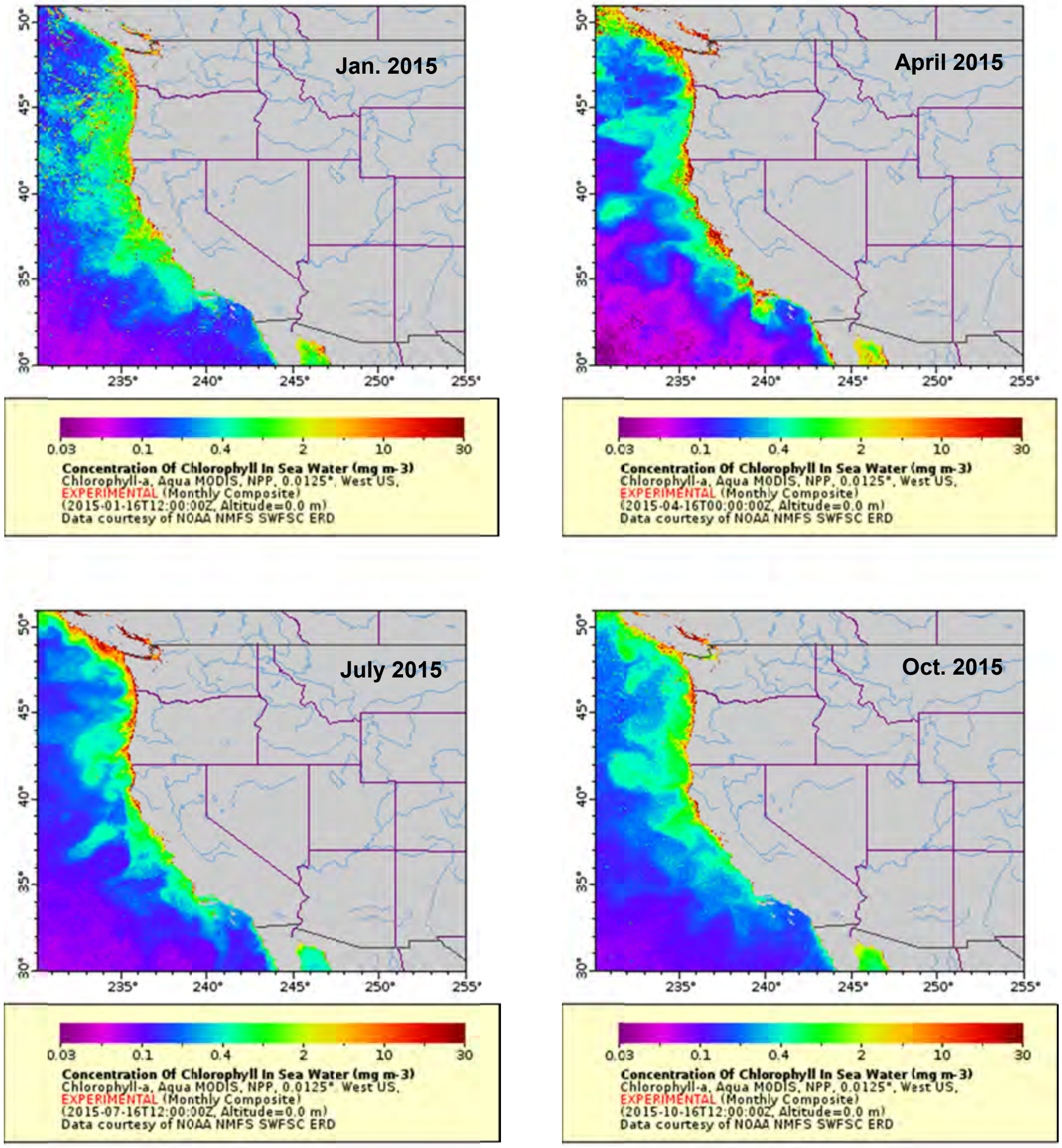


Figure 36. Chlorophyll a concentration off the West Coast of North America in January, April, July, and October 2015. Source: NASA (2015).

Three major, basin-scale indicators all changed phase at some point during the winter of 2013/2014: the PDO changed to positive (indicating warmer temperatures in the North Pacific), the NPGO changed to negative (indicating lower productivity along the coast), and the MEI changed to positive, signaling the pending arrival of an equatorial El Niño. The El Niño event was the third largest on record (NOAA-ESRL 2016).

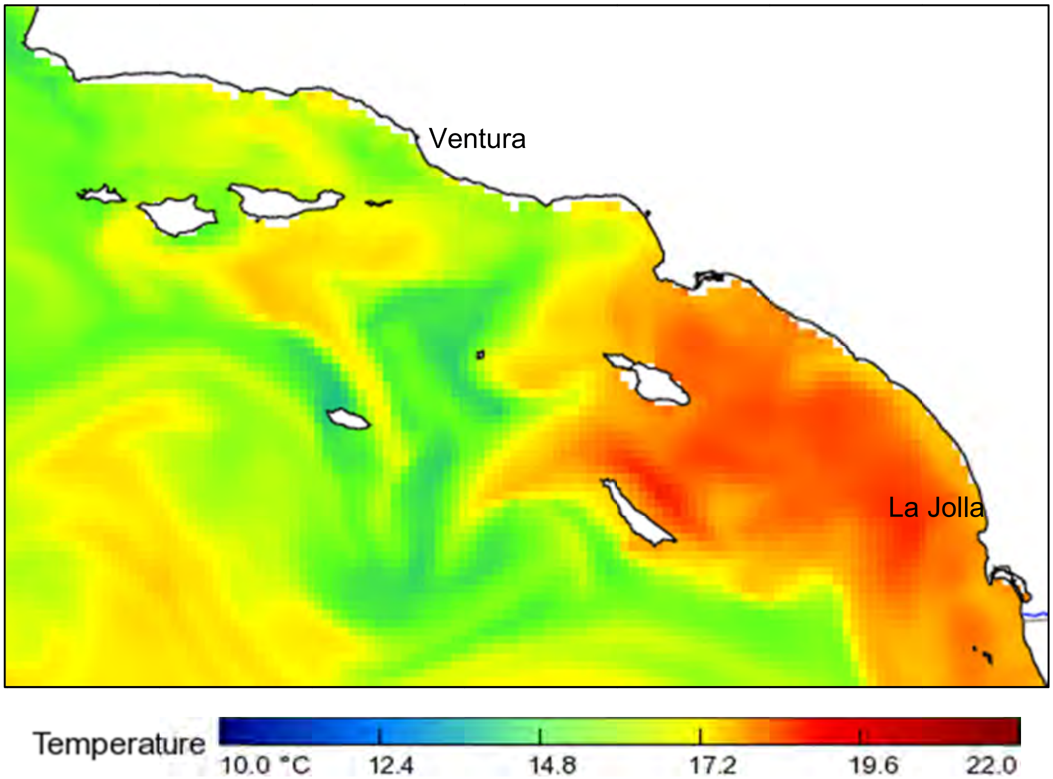


Figure 37. Sea surface temperatures of the SCB on 6 June 2016. Regional Ocean Model System (ROMS; SCCOOS [2016]).

Leising et al. (2014) reported above-average SSTs, near average upwelling, and lower-than-average chlorophyll a values in southern California in 2014. Similar conditions persisted into 2015, but upwelling was below average (Leising et al. 2015). Even though the PDO is still positive in June 2016, the MEI values have returned to normal and the NPGO appears to be changing back to positive (Di Lorenzo 2016; Mantua 2016; NOAA-ESRL 2016).

While the temperature patterns were fairly similar across southern California, and NQ values were regionally low, some distinct SST patterns have developed over the last few years. At Point Dume, the number of days with SSTs >16–20°C increased above the 20-year mean since 2011 (Figure 38). Likewise the number of days <14°C has declined substantially (to zero in 2015). From 2012 through 2015, the number of days >16–18°C at Newport Beach increased substantially from the long-term mean, and the number of days <14°C decreased considerably in 2014–2015. Lastly, at Scripps Pier, the number of days with SSTs <14°C from 2011–2013 was well above the long-term mean, which could explain the protracted kelp growth during those periods. However, the number of days below 13–14°C decreased substantially in 2014 and 2015. Conversely, the number of days with SSTs >16–20°C increased substantially in 2014 and 2015.

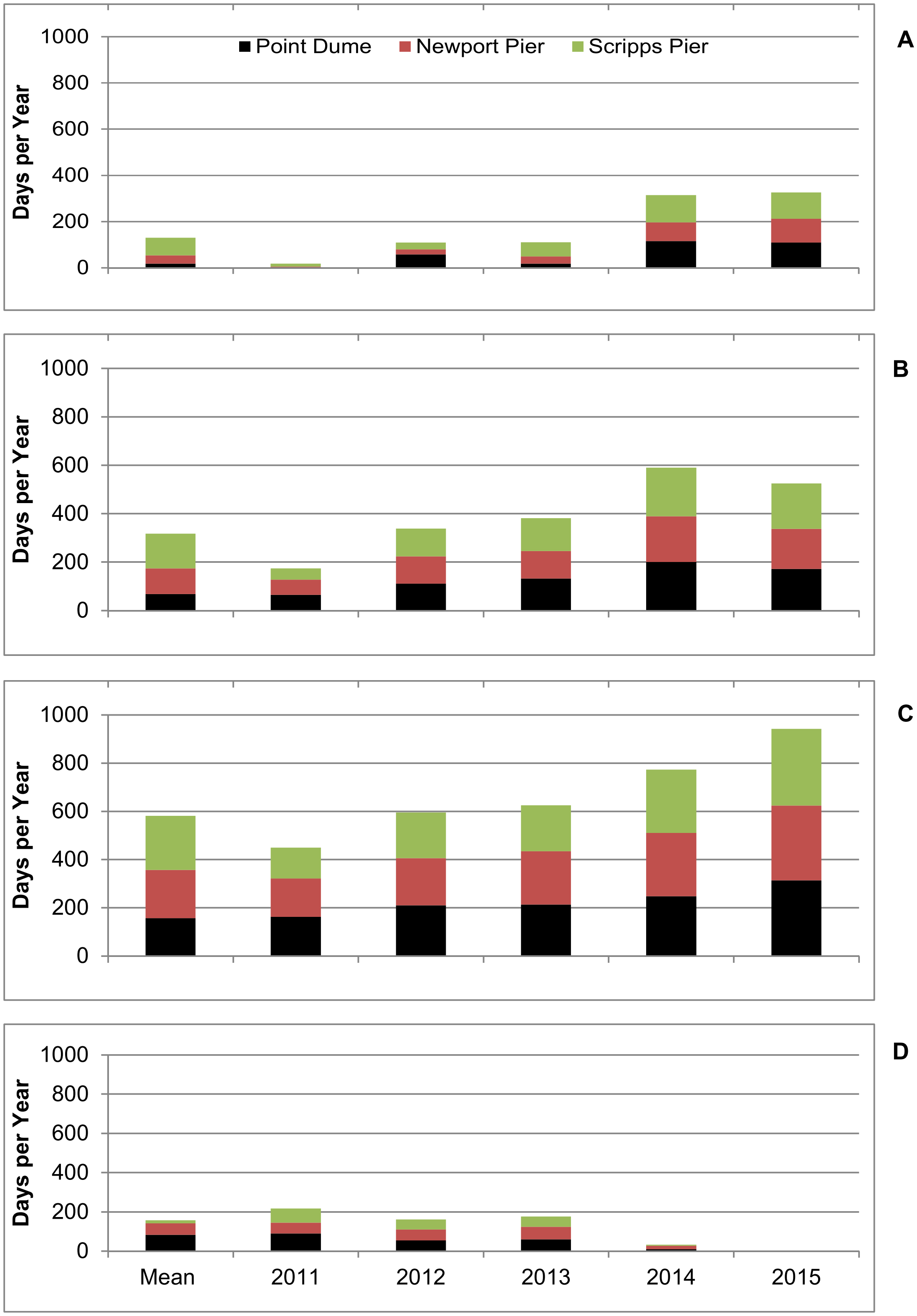


Figure 38. Number of days with SSTs (A) >20°C, (B) >18°C, (C) >16°, and (D) <14°C at three locations in southern California: 2011–2015, and the mean from 1994–2015.

The pattern in mean SST has also differed along the coast. During the last four years, annual mean SSTs at Point Dume exceeded the 20-year mean each year, and they were substantially higher (by 2.7°C) during 2015 (Table 7; MBC 2012–2015; NDBC 2016). Temperatures were also 1–2°C higher than the long-term means at Newport Beach Pier and at Scripps Pier in 2015 (MBC 2012–2015; CDIP 2016; NDBC 2016).

Table 7. Comparison of (1) mean temperature from 1994–2015, and (2) annual mean temperature during 2011–2015 at three location in southern California. Red cells indicate years above the long-term mean (16–20°C) and blue cells below the long-term mean (13–14°C).

		Annual Mean SST (°C)				
	Mean SST (°C) (1994–2015)	**2011**	**2012**	**2013**	**2014**	**2015**
Point Dume	**15.9**	15.7	16.8	16.8	18.2	18.6
Newport Pier	**16.5**	15.9	16.6	16.7	18.0	18.4
Scripps Pier	**17.7**	15.7	16.6	17.0	18.8	18.9

La Niña conditions persisted in the Pacific Ocean through half of 2010 and most of 2011, and dissipated in early 2012 (Figure 12). During this period, most of the kelp beds in the region achieved larger-than-average canopies. Despite a return to ENSO neutral conditions in 2012 and 2013, kelp coverage was higher than average, particularly in Region Nine. In light of recent studies suggesting that all of southern California has been subjected to a marine environment relatively depleted in nutrients since 1977, that respite from El Niño conditions has benefited the kelp beds. Seawater density values in the SCB in 2015 were almost all <25.0 (Figure 11; one value from Newport Pier exceeded δ_t = 25). Parnell et al. (2010) determined the relationship between density and nitrate at Point Loma was non-linear, with an inflection point near δ_t = 25. Therefore, available density data indicate nitrate concentrations from the three pier stations were not conducive to kelp growth. These data were limited to near-surface measurements at pier stations, and are likely not representative of density measurements within kelp beds, but they agree with Bight-wide reports of low upwelling and nitrate concentrations (Leising et al. 2015).

The MEI transitioned from neutral conditions in 2013 to positive values in April 2014, signaling the onset of El Niño. This coincided with higher-than-average SSTs in the SCB for most of 2014 and 2015. During a year when waters were warmer than average in both regions for most of the year, kelp canopy coverage only decreased by 2% since 2014. At the end of the El Niño events in 1982–1984 and 1997–1998, canopy area in Region Nine was <4 km^2; there was >12 km^2 of canopy cover in Region Nine in 2015. Kelp beds off northern California were reduced to record low coverages in 2015 (Catton 2016).

Other environmental factors appeared from the data to have had minimal effects on the kelp beds of both regions during 2015. Annual rainfall in 2015 was low (for the fifth year in a row) and effects from runoff (turbidity) were likely negligible. A turbid plume emanating from the Portuguese Bend landslide was visible during the April and September overflights, prominent in the December 6 overflight, but absent in June 2015 (the month when the PV I and PV II canopies were estimated to be at their peaks) (Figure 39). This nearshore source of sediment likely affects the growth dynamics of adjacent beds, but to what annual extent is unknown. Persistent turbidity at Palos Verdes could have affected surrounding beds (i.e., PV I and PV II at a minimum). A similar pattern was observed around Point Loma (Figure 40). On December 5, 2015, swell heights reached three meters at Point Loma and two meters at San Pedro. Wave energy likely enhanced nearshore turbidity during December.

Figure 39. Nearshore turbidity near the Portuguese Bend Landslide area, PV I kelp bed, on December 6, 2015.

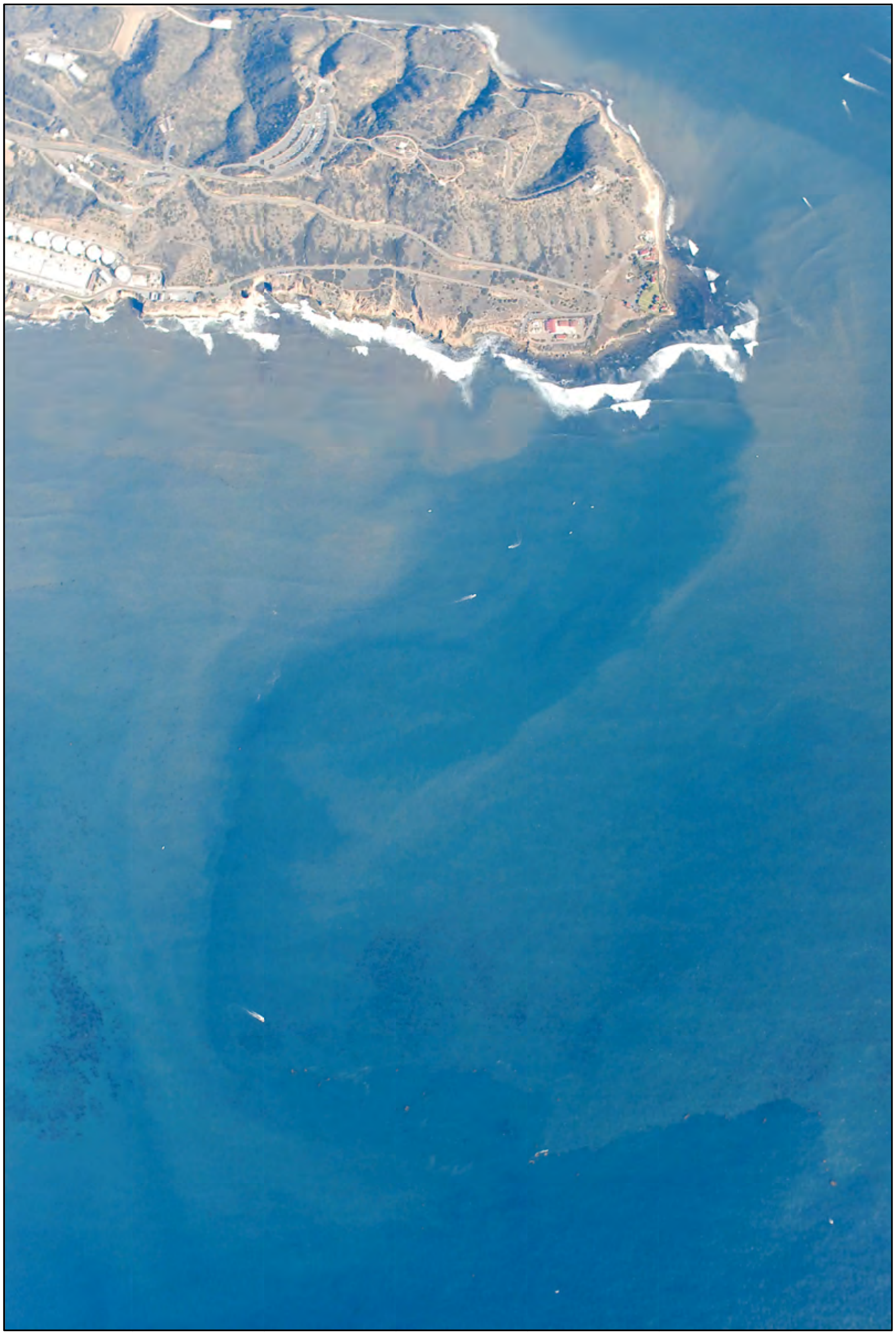


Figure 40. Nearshore turbidity near Point Loma on December 6, 2015.

The warm water in the Eastern Pacific may have enhanced a high-pressure ridge that diverted incoming storms to the north. Point Loma was one of three beds in Region Nine to wane in 2013, but it maintained its size in 2014 and increased in 2015. It is not known if kelp is being harvested from the Point Loma kelp bed, but Kelp Bed Number 3 was leased from the state in 2012. The wave climate was relatively mild for most of 2015, although there were periods with waves that exceeded four meters, where one would expect to see damage from breaking waves. The largest waves (three to five meters) were measured in late-November and early-December 2015. With the exception of some of the larger beds (i.e., at Palos Verdes, San Clemente, Point Loma, and Imperial Beach), canopy sizes in southern California were below average in December 2015. La Jolla kelp grows in shallower water than Point Loma kelp, and is more exposed to extreme wave stress (Parnell 2015). The entire coast was exposed to large waves at some point during the year. Most of the beds decreased in size between the June and September overflights, but beds often decrease in summer and fall. There were no large-wave events between February and November, so high water temperatures and seasonally low nutrient availability (and not large waves) were likely the primary factors in the canopy reduction. Even though the large swells could have damaged some of the kelp beds in February, the damage was not sufficient enough to deter continued growth during spring 2015. There were also no widespread algal blooms that persisted long enough to reduce canopy sizes.

Most of the kelp beds in southern California decreased in size from 2014 through 2015, but there were three stretches of coastline where most of the kelp beds increased in size: (1) Deer Creek to Point Dume, (2) Palos Verdes, and (3) Leucadia to Imperial Beach (Figure 41). All three areas were exposed to the large westerly swell event in February 2015 (Figure 15), but the incremental effect of exposure to relatively high surge at that time is unknown. The average loss in canopy size at the beds outside of the three areas was 59%.

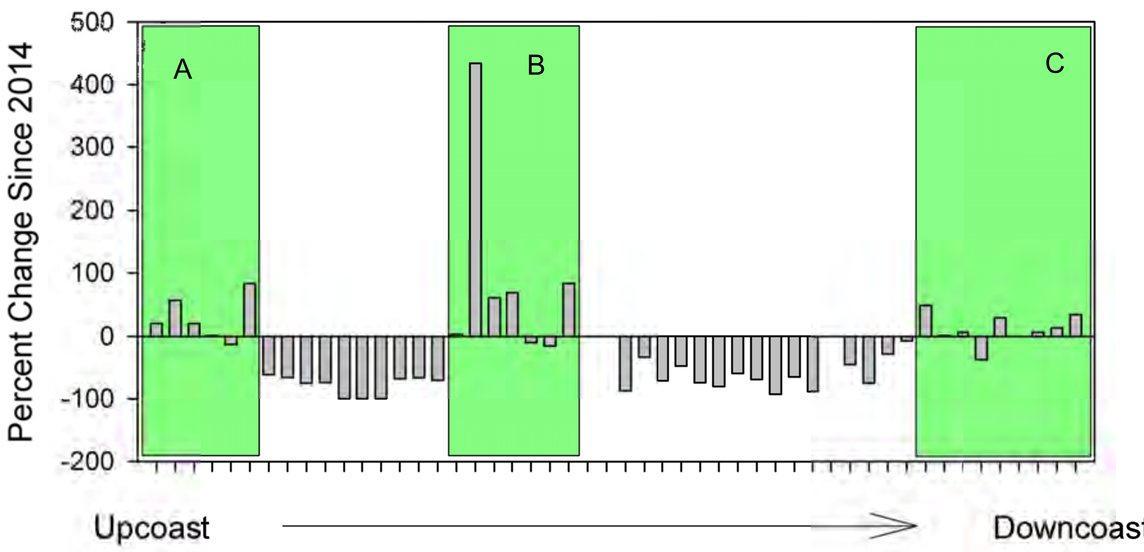


Figure 41. Percent change (from 2014 to 2015) of canopy size of monitored kelp beds from upcoast to downcoast, Central Region and Region and Region Nine. Areas depicted in green are: (A) Deer Creek to Point Dume, (B) Palos Verdes to POLA-POLB, and (C) Leucadia to Imperial Beach

Available physical data (temperature, seawater density, and nutrient concentrations) for most of 2015 suggest oceanographic conditions were not conducive to kelp growth. However, variable patterns in canopy increases/decreases in adjacent beds (e.g., PV I and PV II, Cardiff and Solana Beach, etc.) suggests physical and/or biological factor(s) at the individual bed scale (or finer) affected southern California's kelp beds in 2015, and allowed some kelp beds to expand even though most beds decreased in size.

CONCLUSION

Kelp bed canopy coverage varied by region in 2015. However, most of the beds in both regions decreased in size from 2014. Five of the six kelp beds between Deer Creek and Point Dume increased in size, and three of the four Palos Verdes kelp beds also increased. However, the adjacent beds at PV I and Cabrillo decreased in size, while canopy cover at POLA-POLB increased, highlighting what slight variations in geographic location and underwater topography can have on nutrient availability and kelp dynamics. In Region Nine, only 7 of the 26 beds increased in size. All kelp canopies upcoast of Leucadia lost coverage in 2015, while most downcoast from Leucadia gained canopy. Despite the region-wide declines, the total canopy coverage in 2015 remained above the long-term mean in both regions.

Most areas offshore southern California were subjected to similarly large temperature fluctuations, but responses by kelp beds differed among areas. Sea surface temperatures have been above average during the last four years, and periods of cold-water intrusions have been shorter than average.

Results from 2015 were consistent with those from past kelp consortium surveys, and oceanographic conditions controlled the fate of the Central Region and Region Nine kelp beds. Variations in bed growth (or decline), sometimes within relatively small distances, were likely related to variations in bathymetry, current flow, nutrient availability, etc. There was no apparent correlation between kelp bed growth, or lack thereof, with the various discharges in the region, and there was no evidence to suggest any perceptible influence of the various dischargers on the persistence of the region's giant kelp beds.

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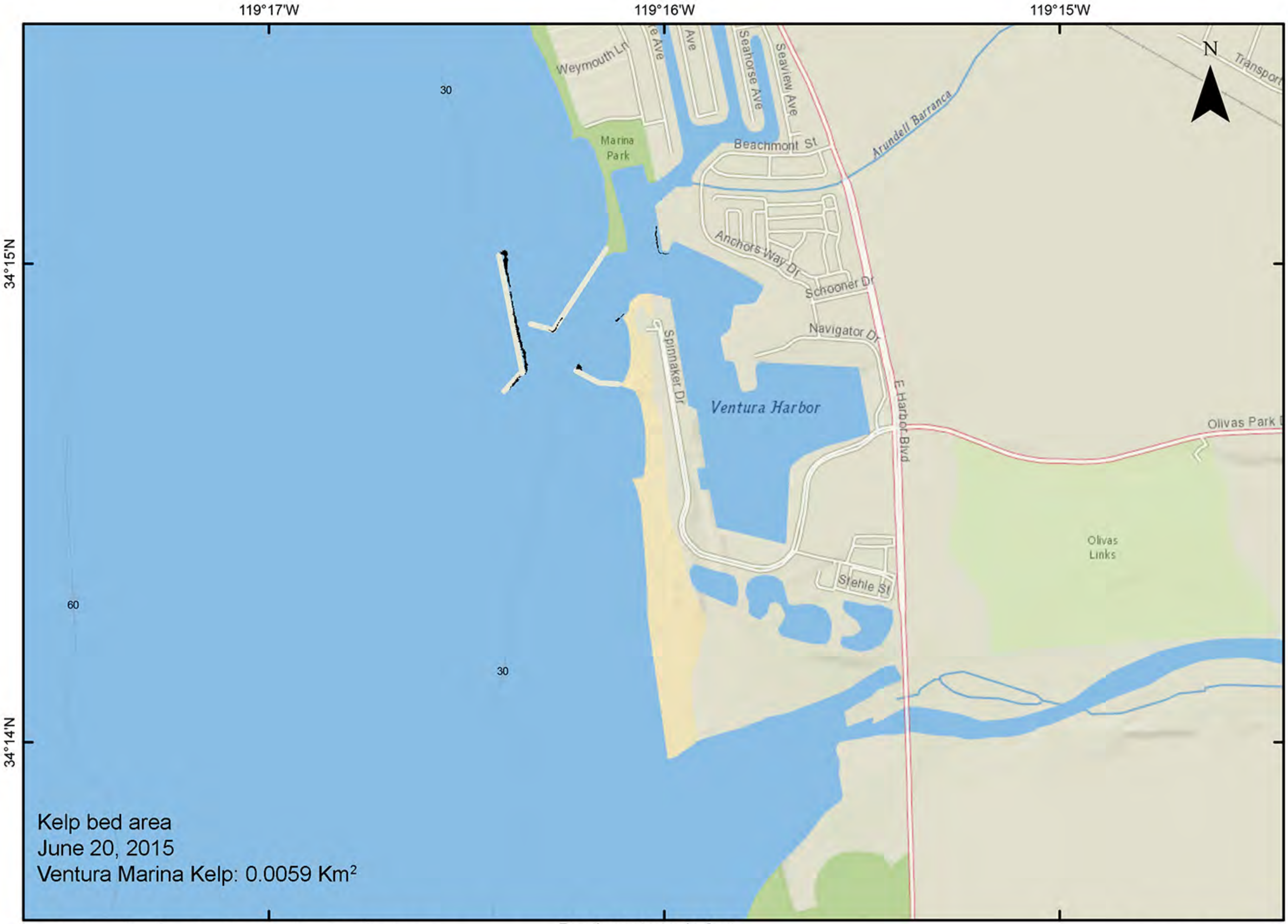
PERSONAL COMMUNICATIONS

Anthony, K. 2016. Kim Anthony, Southern California Edison. Comments transmitted by email to S. Beck (MBC) on 11 July 2016.

Shipe, R. 2006. Dr. Rebecca Shipe is an Assistant Professor in the Department of Ecology and Evolutionary Biology at the University of California, Los Angeles. Her expertise is phytoplankton ecology and physiology, particularly in southern California coastal zones. Throughout 2005 and 2006, Dr. Shipe investigated the distribution of phytoplankton species within Santa Monica Bay and their relationship to coastal processes.

APPENDIX A

Kelp Canopy Maps



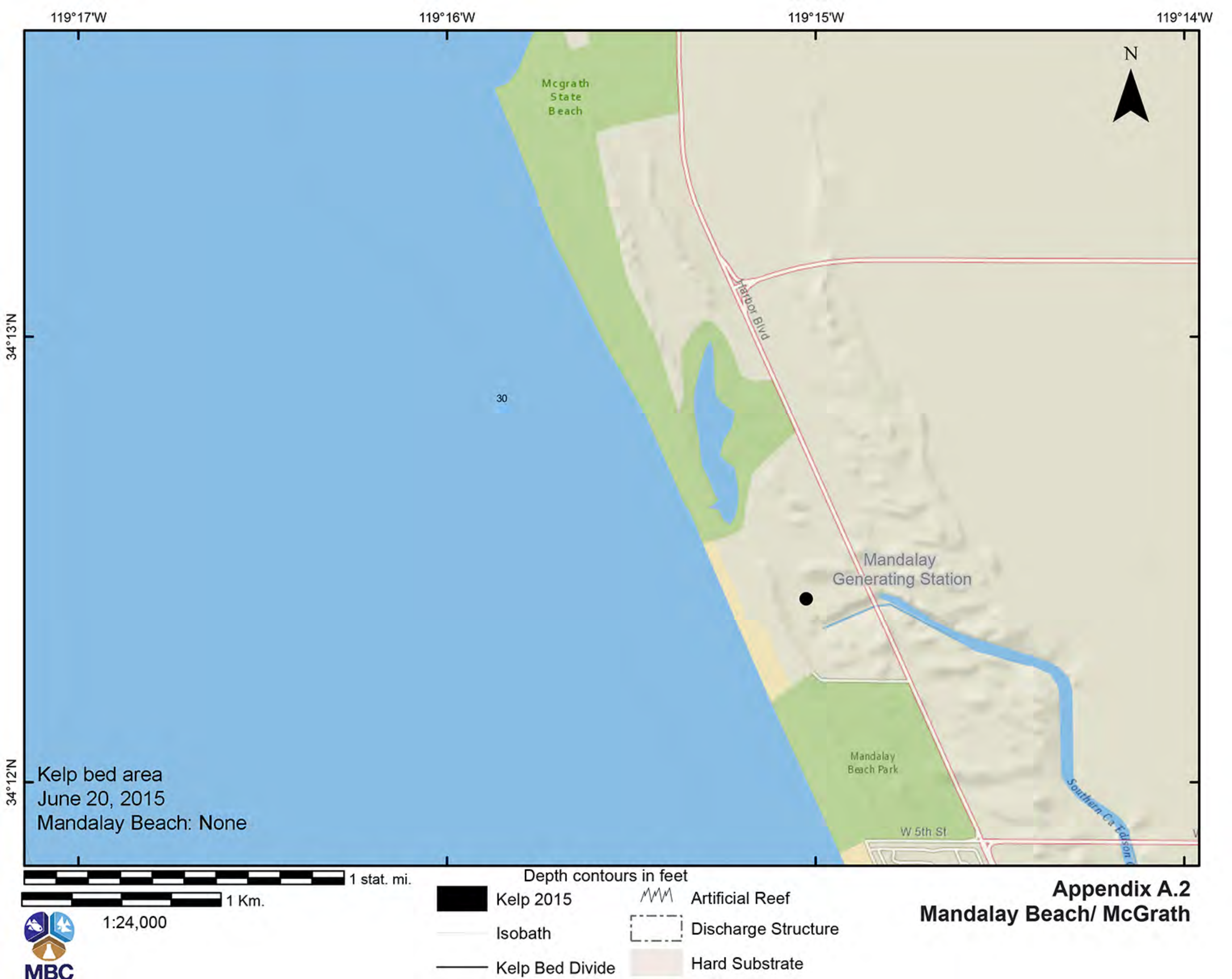
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

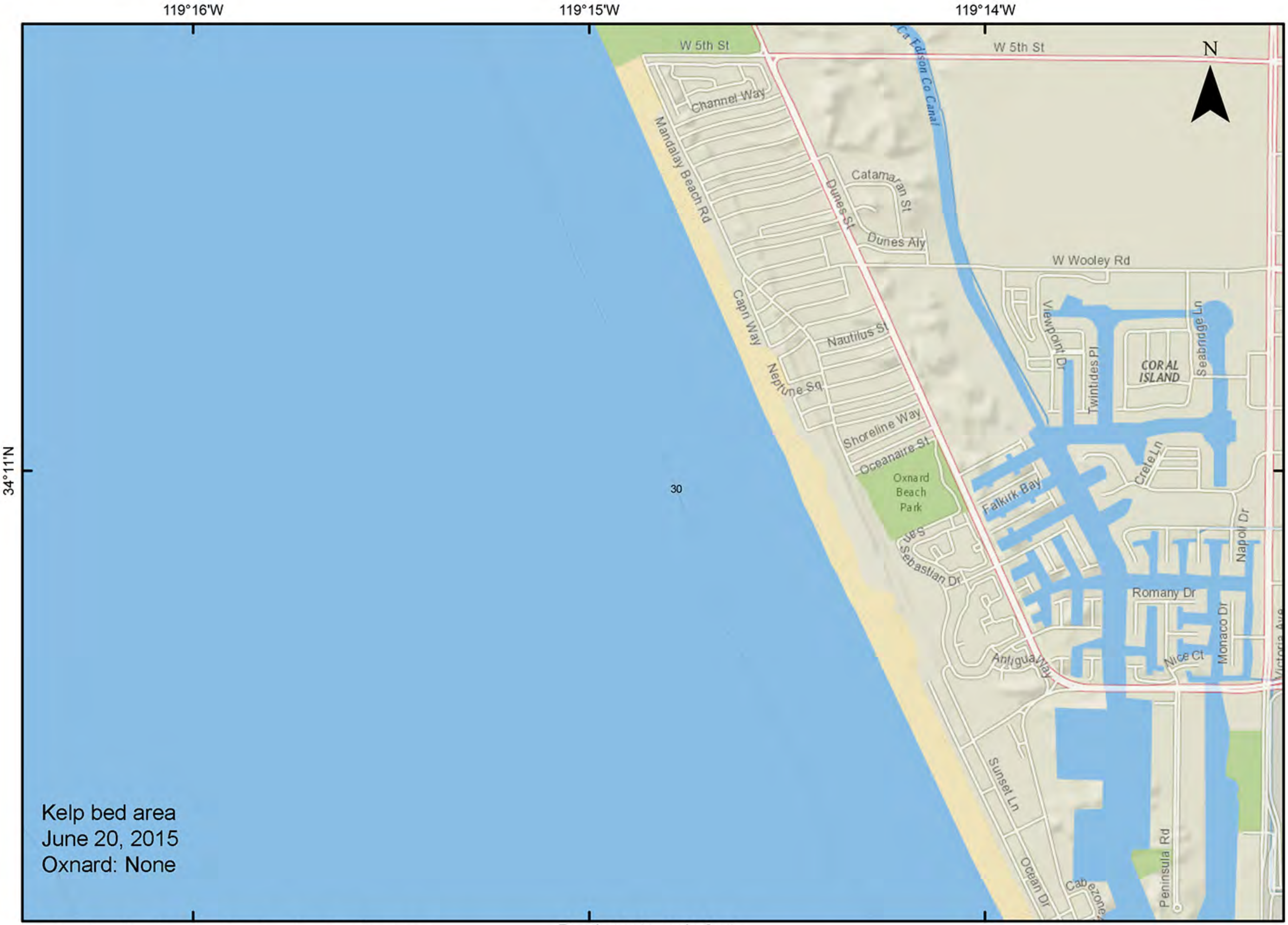
Kelp 2015
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

MBC

Appendix A.1
Ventura Marina



Appendix A.2
Mandalay Beach/ McGrath



1 stat. mi.

1 Km.

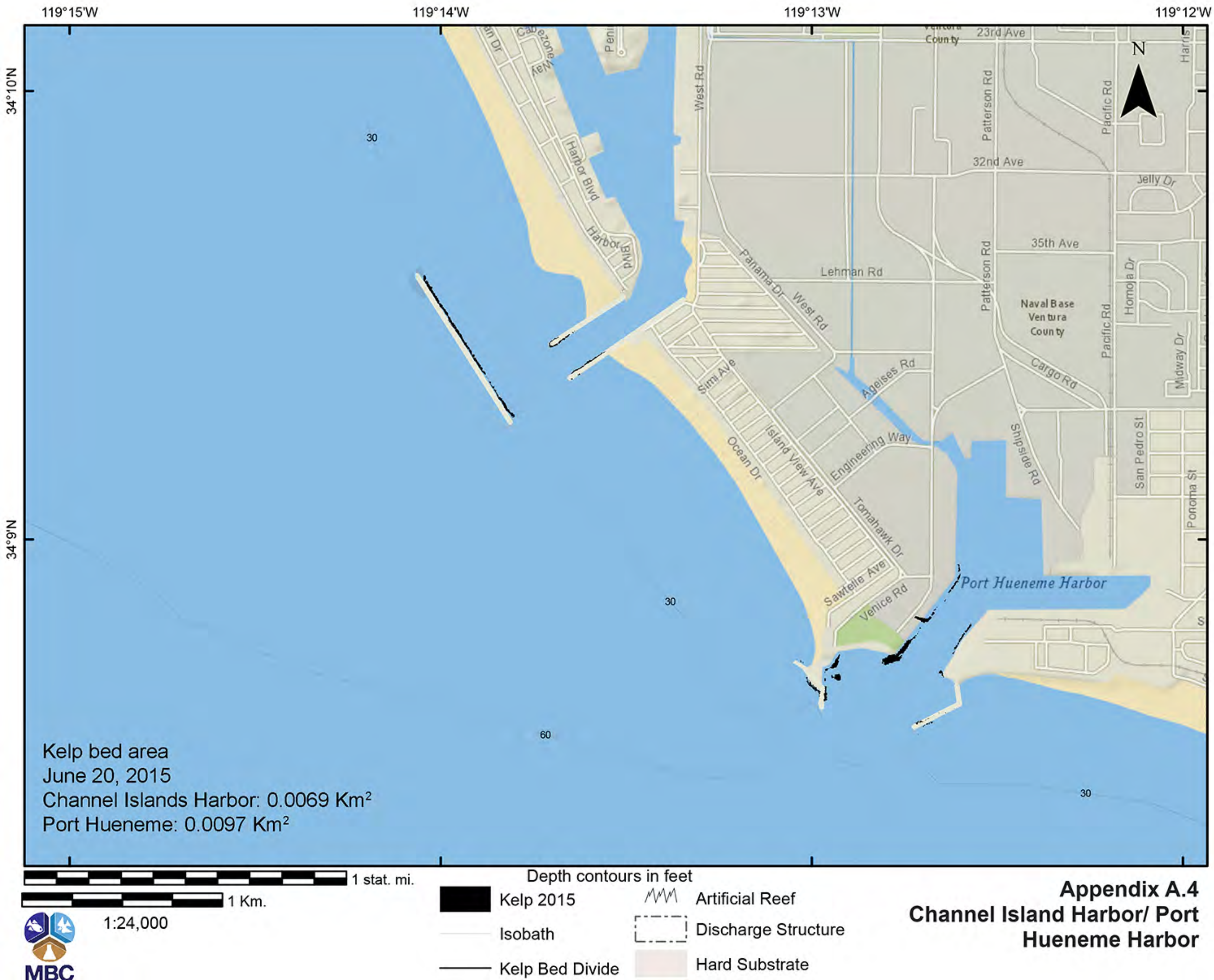
1:24,000

Depth contours in feet

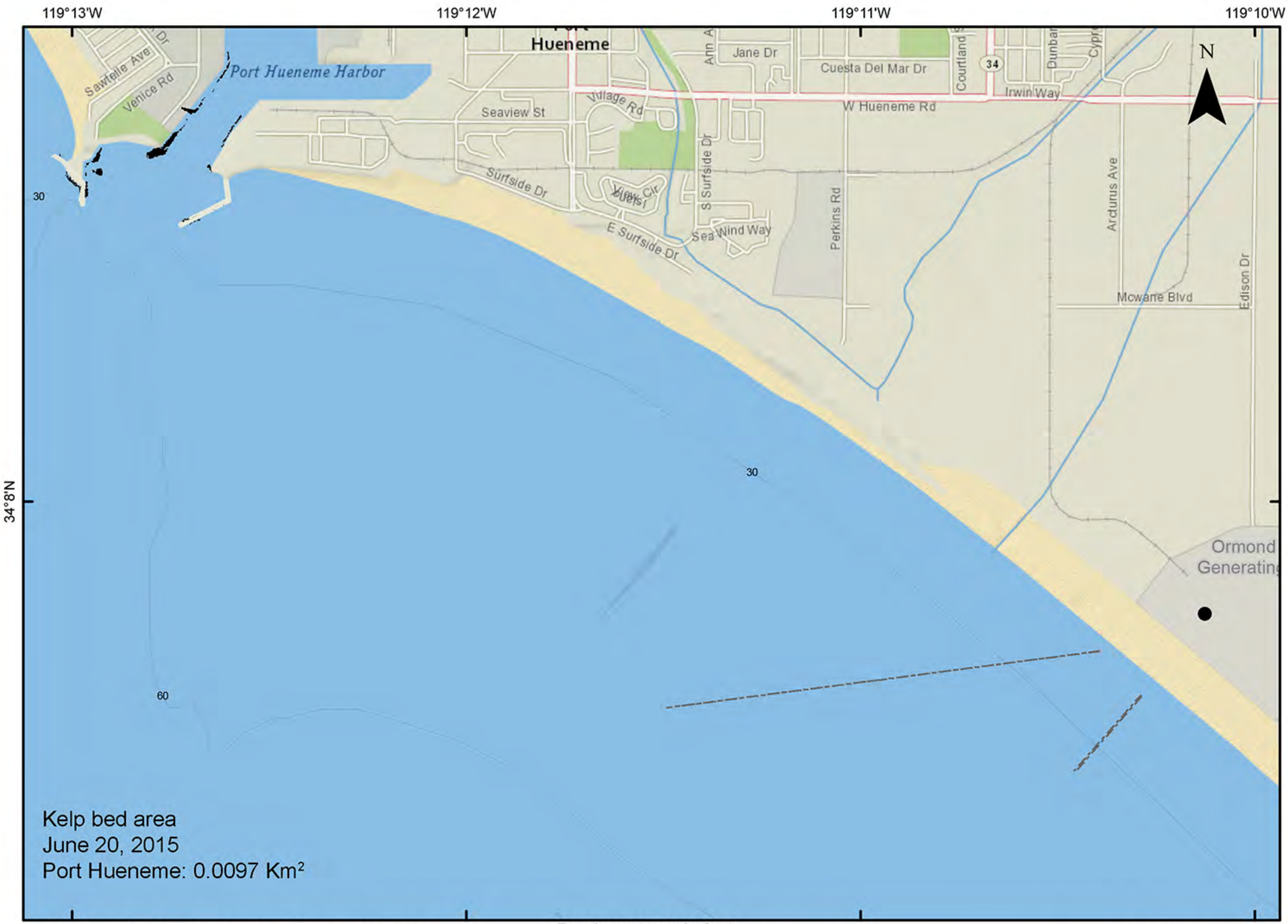
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

Appendix A.3
Oxnard (Silver Strand)



Appendix A.4
Channel Island Harbor/ Port Hueneme Harbor



1 stat. mi.

1 Km.

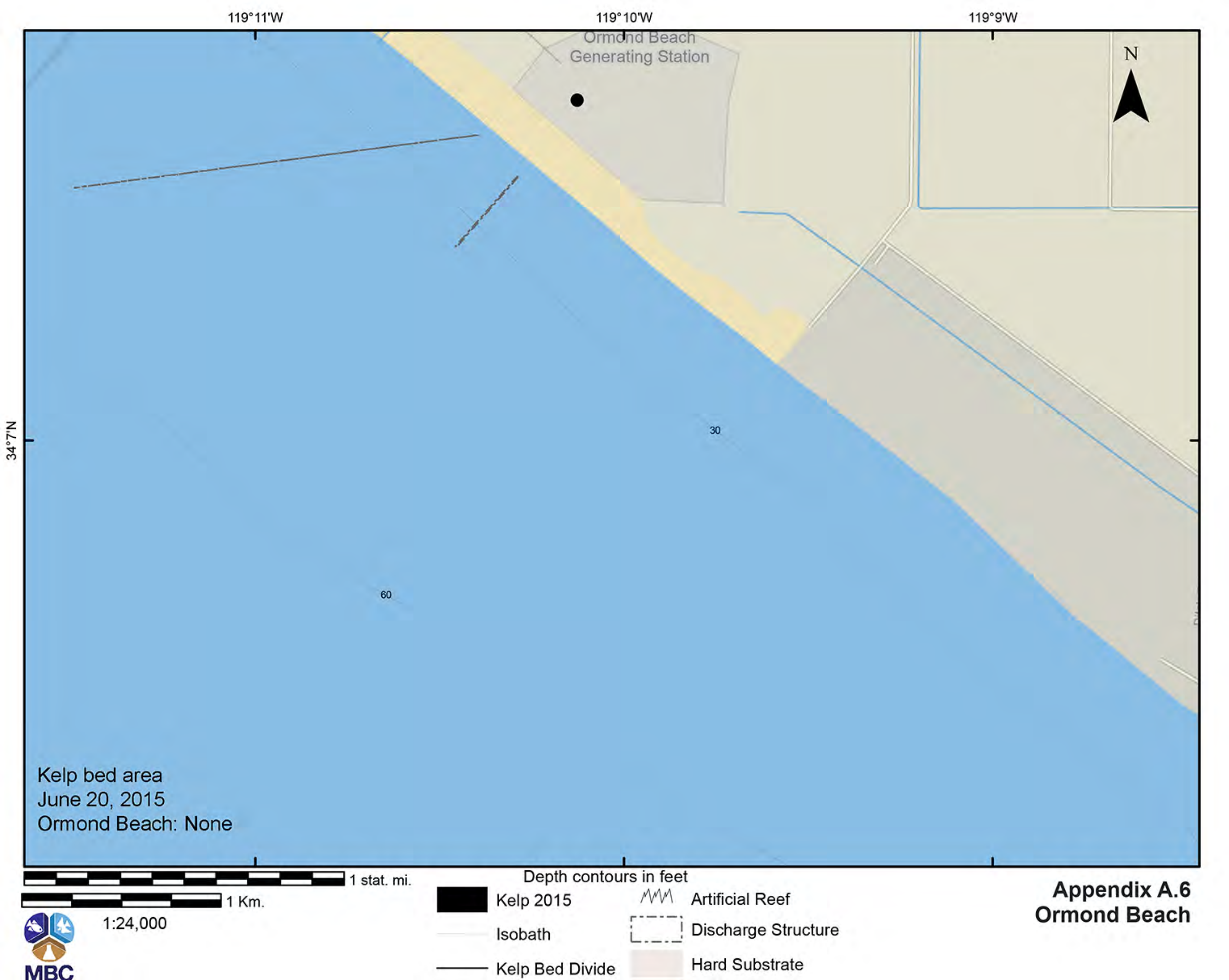
1:24,000

Depth contours in feet

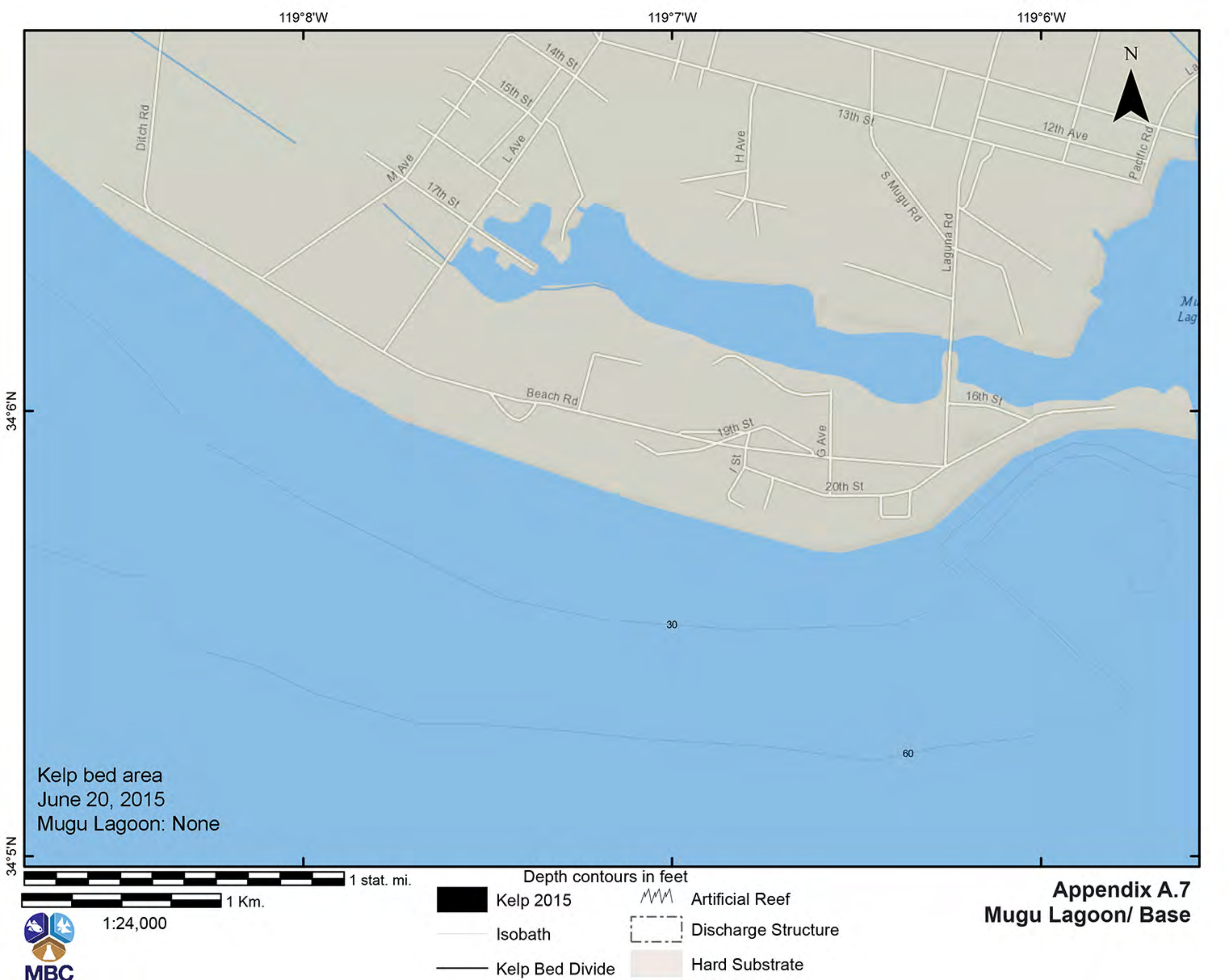
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

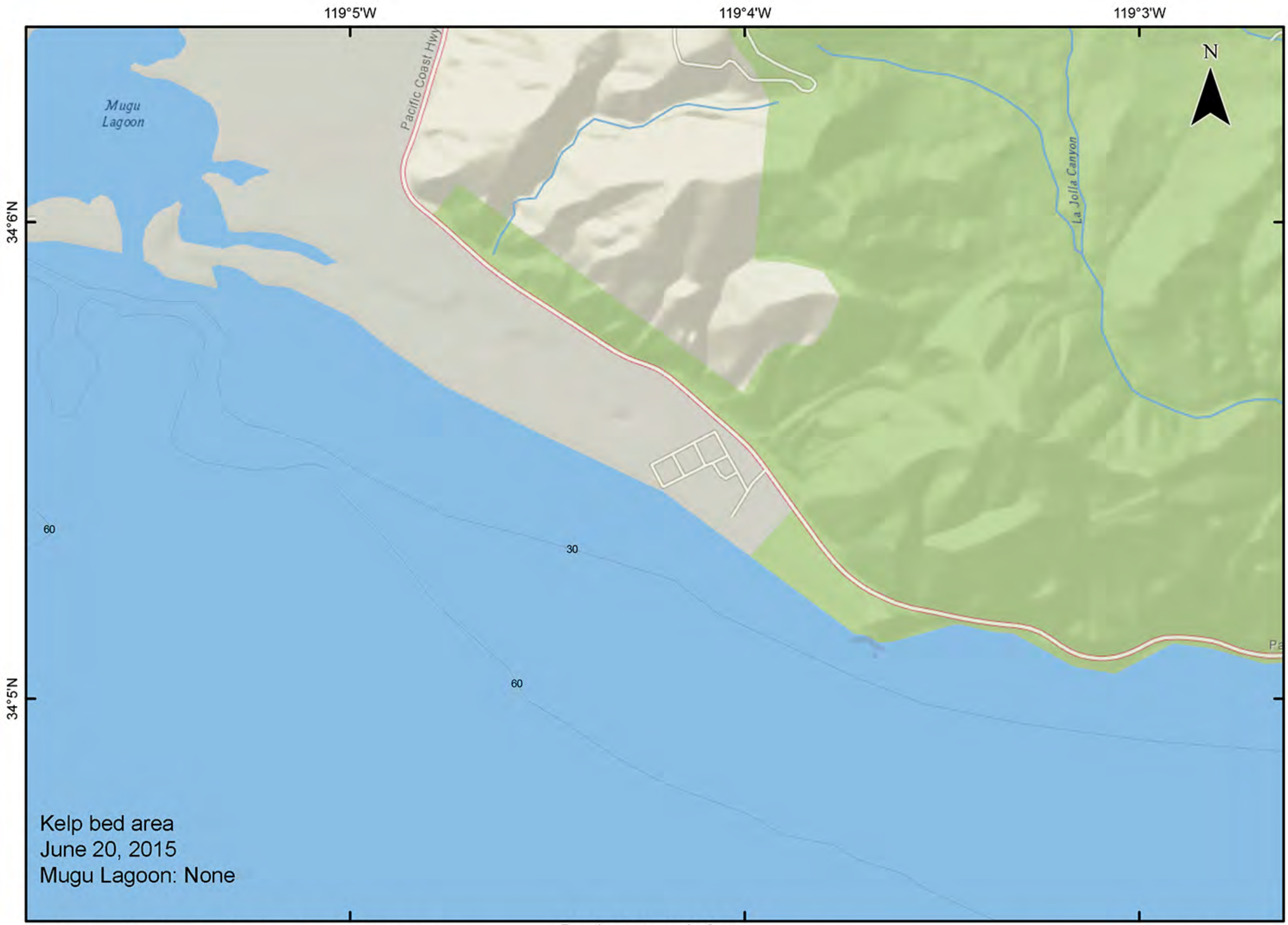
Appendix A.5
Port Hueneme Beach



Appendix A.6
Ormond Beach



Appendix A.7
Mugu Lagoon/ Base



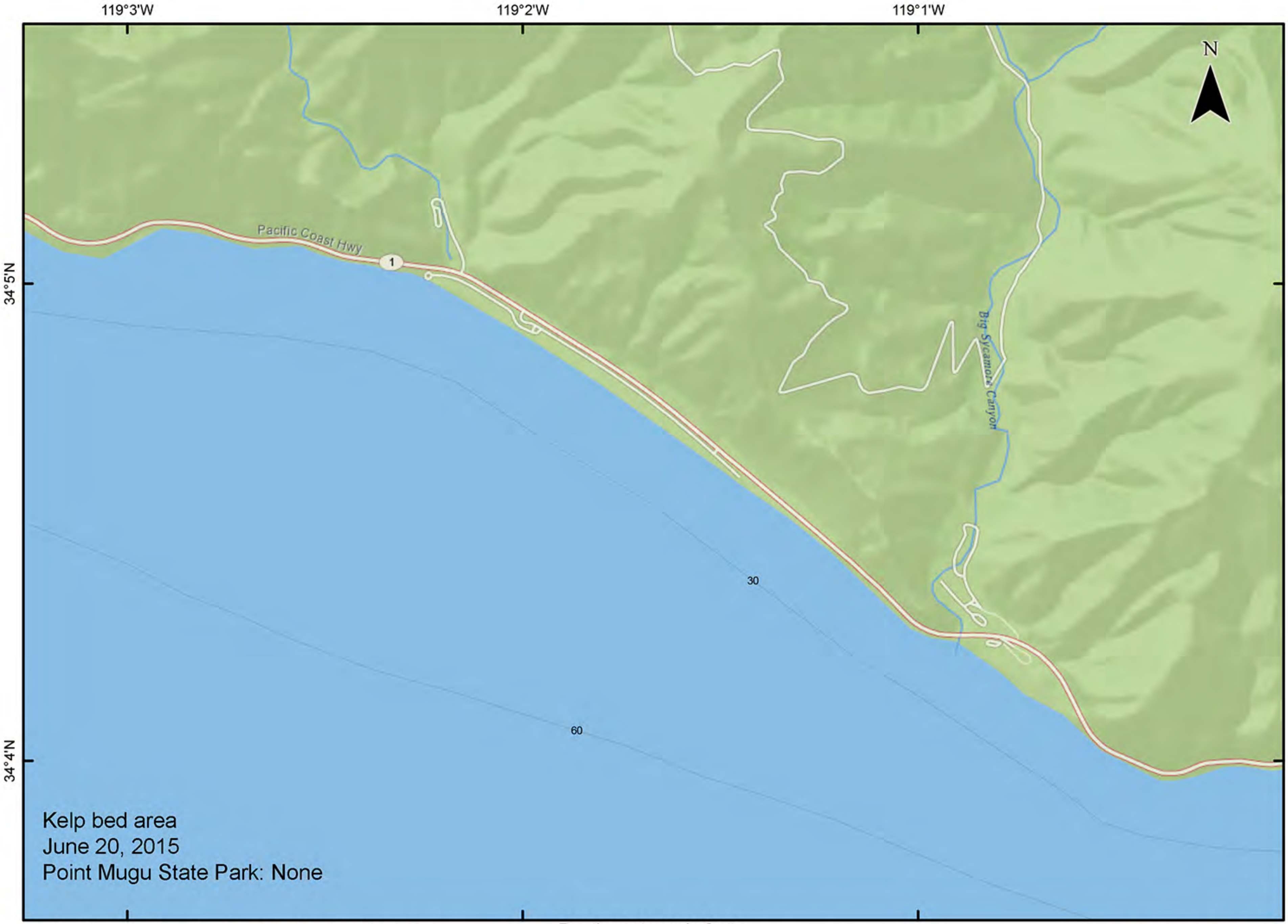
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

Kelp 2015
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

MBC

Appendix A.8
Mugu Coast and Point



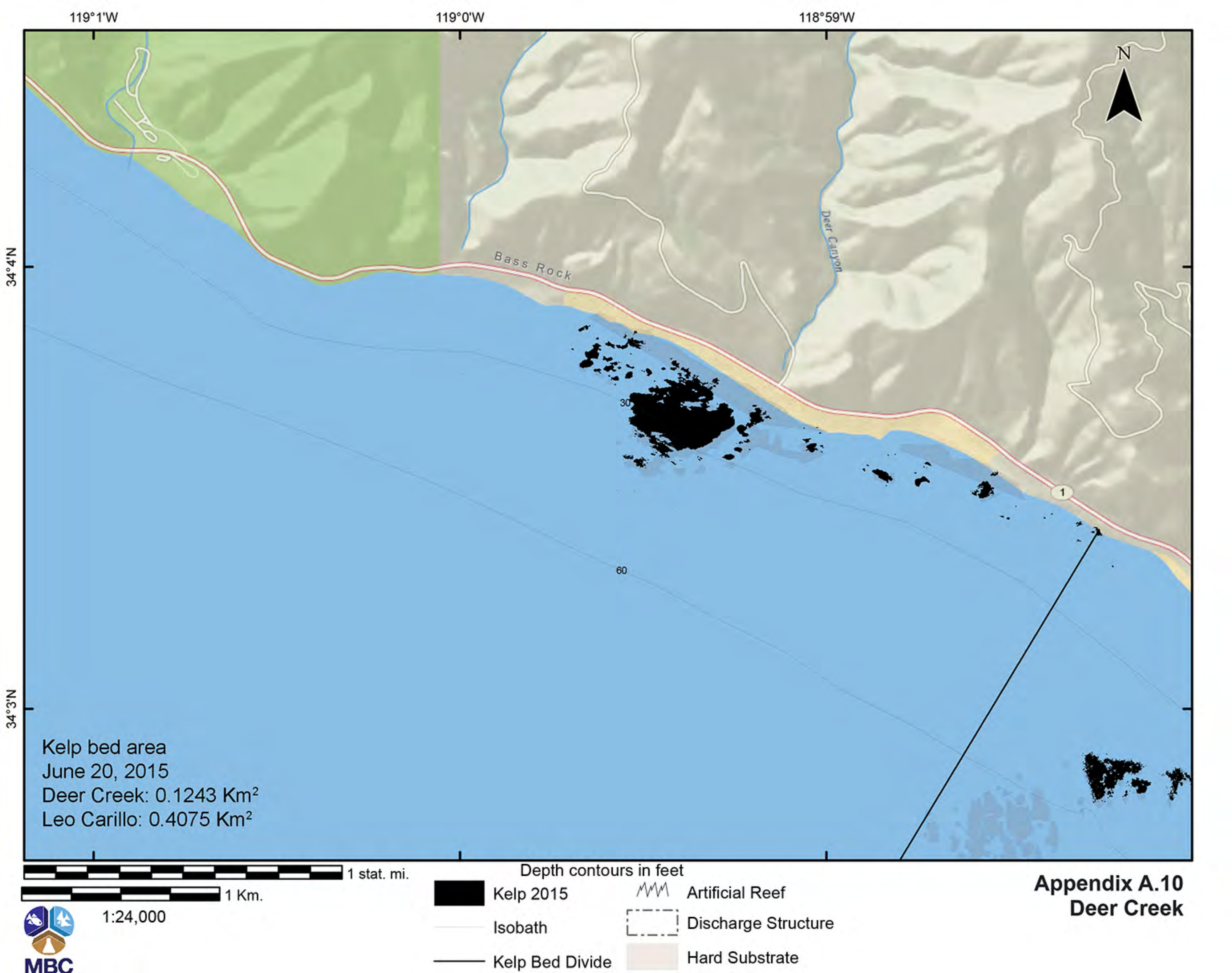
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

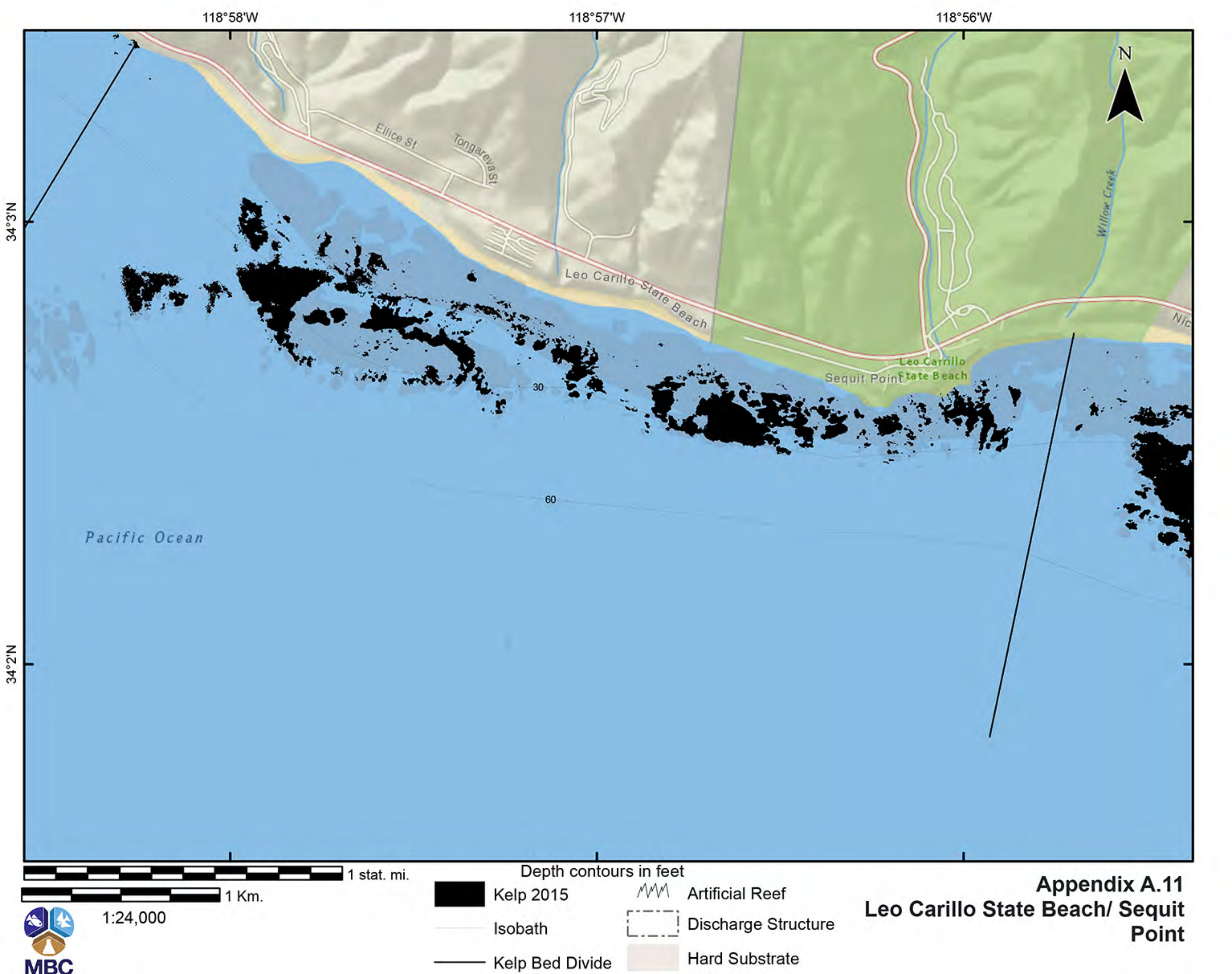
Kelp 2015
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

MBC

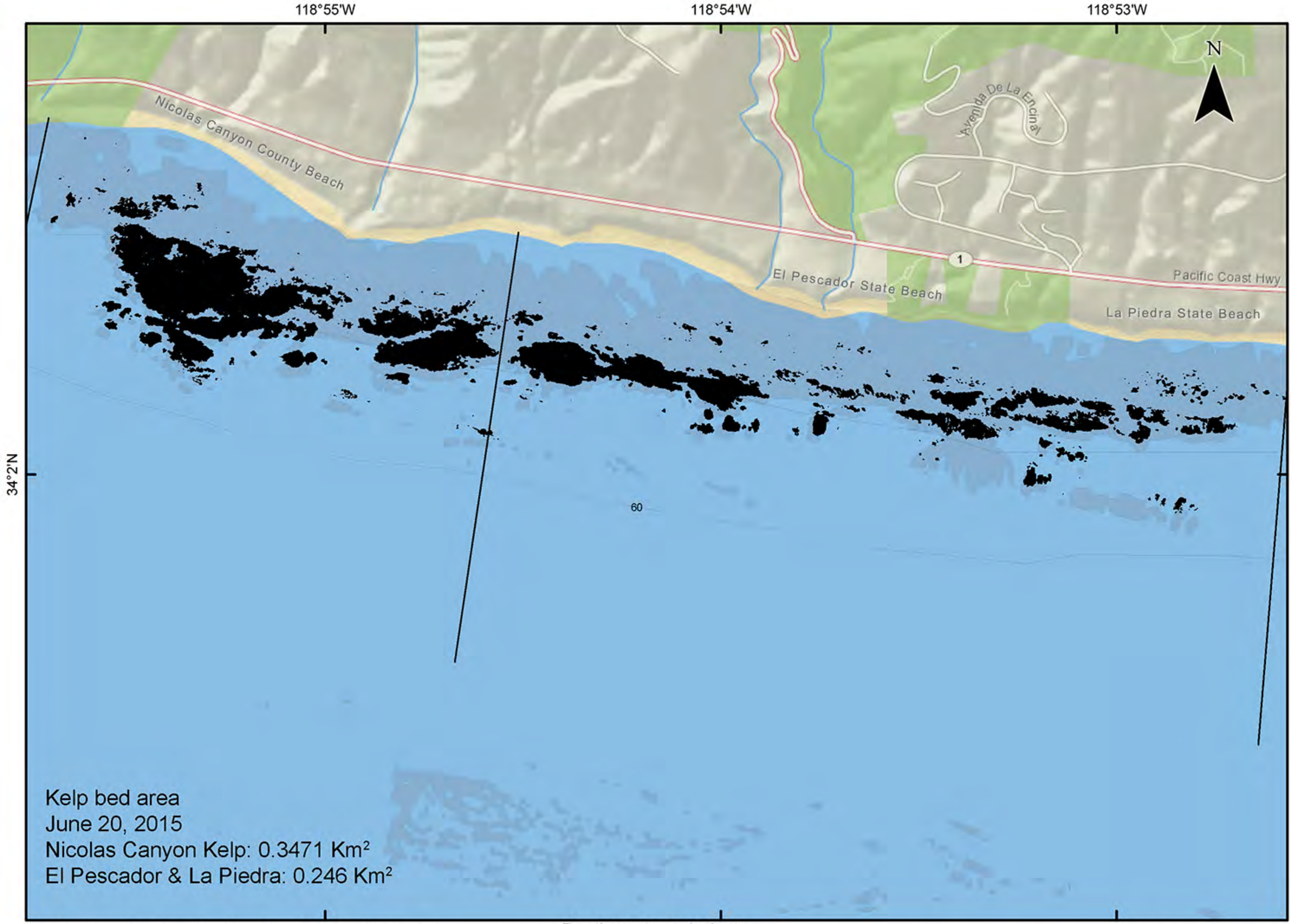
Appendix A.9
Mugu State Park



Appendix A.10
Deer Creek



Appendix A.11
Leo Carillo State Beach/ Sequit Point



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

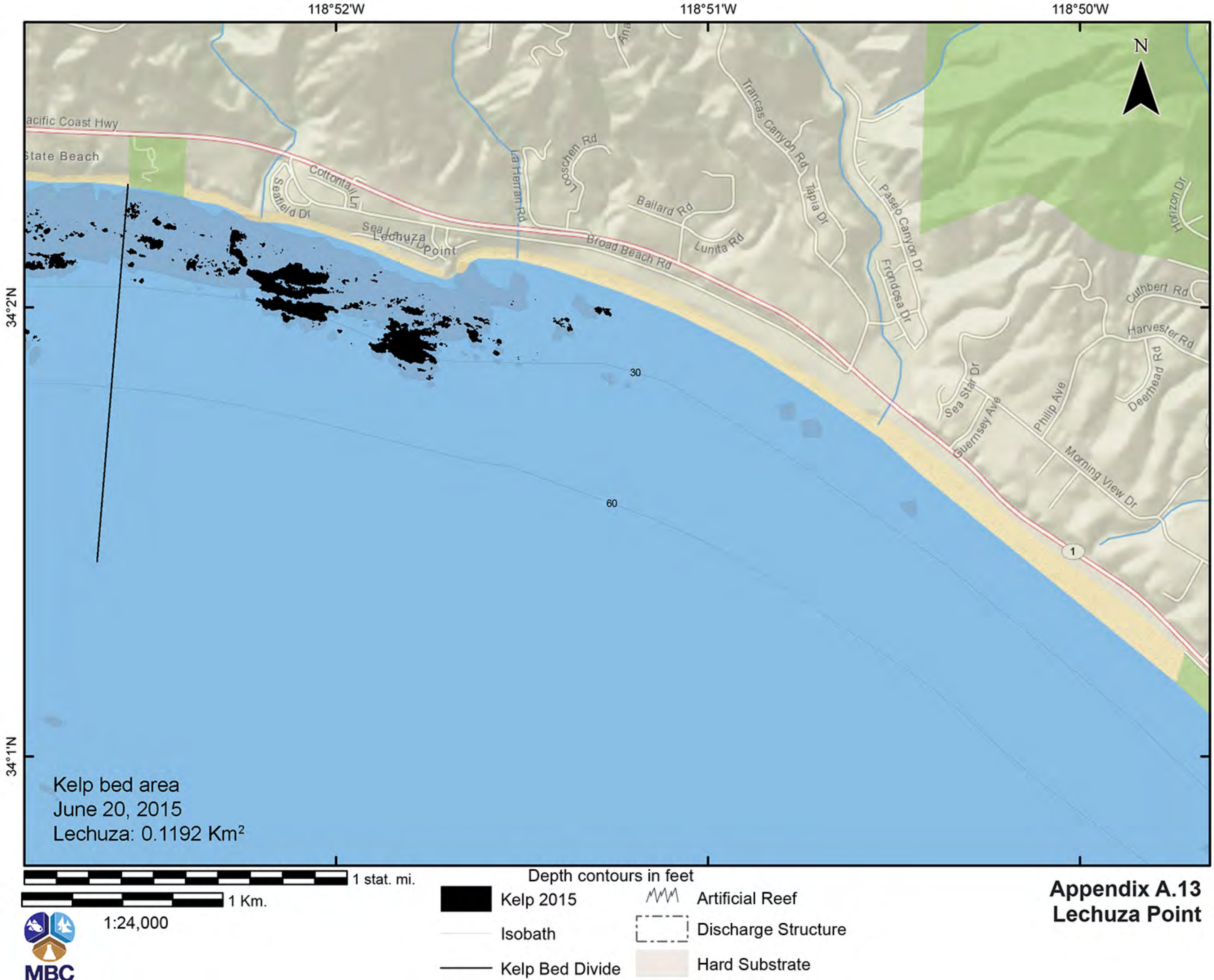
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

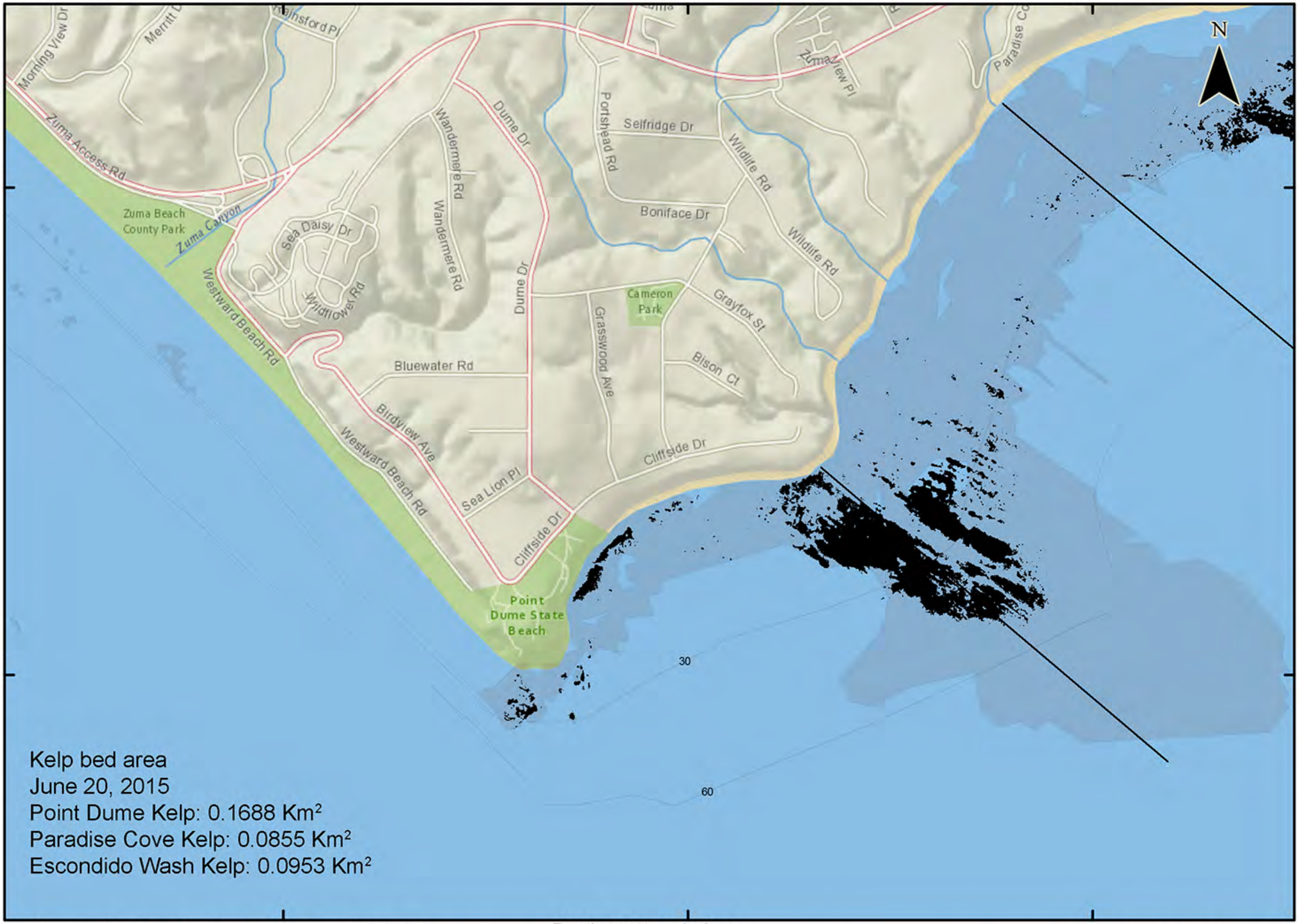
Appendix A.12
Nicolas Canyon/ El Pescador & La Piedra State Beach



Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.13
Lechuza Point



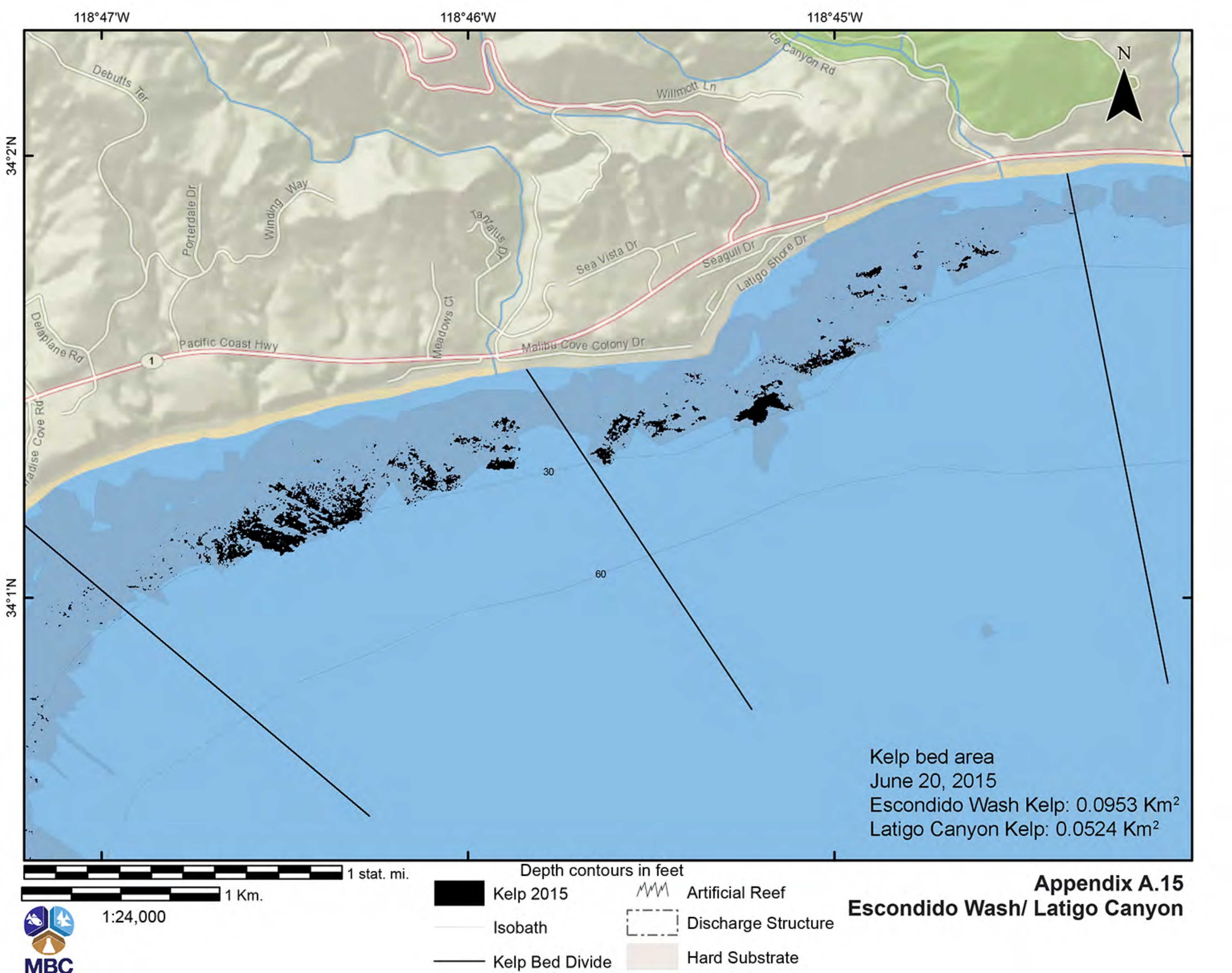
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

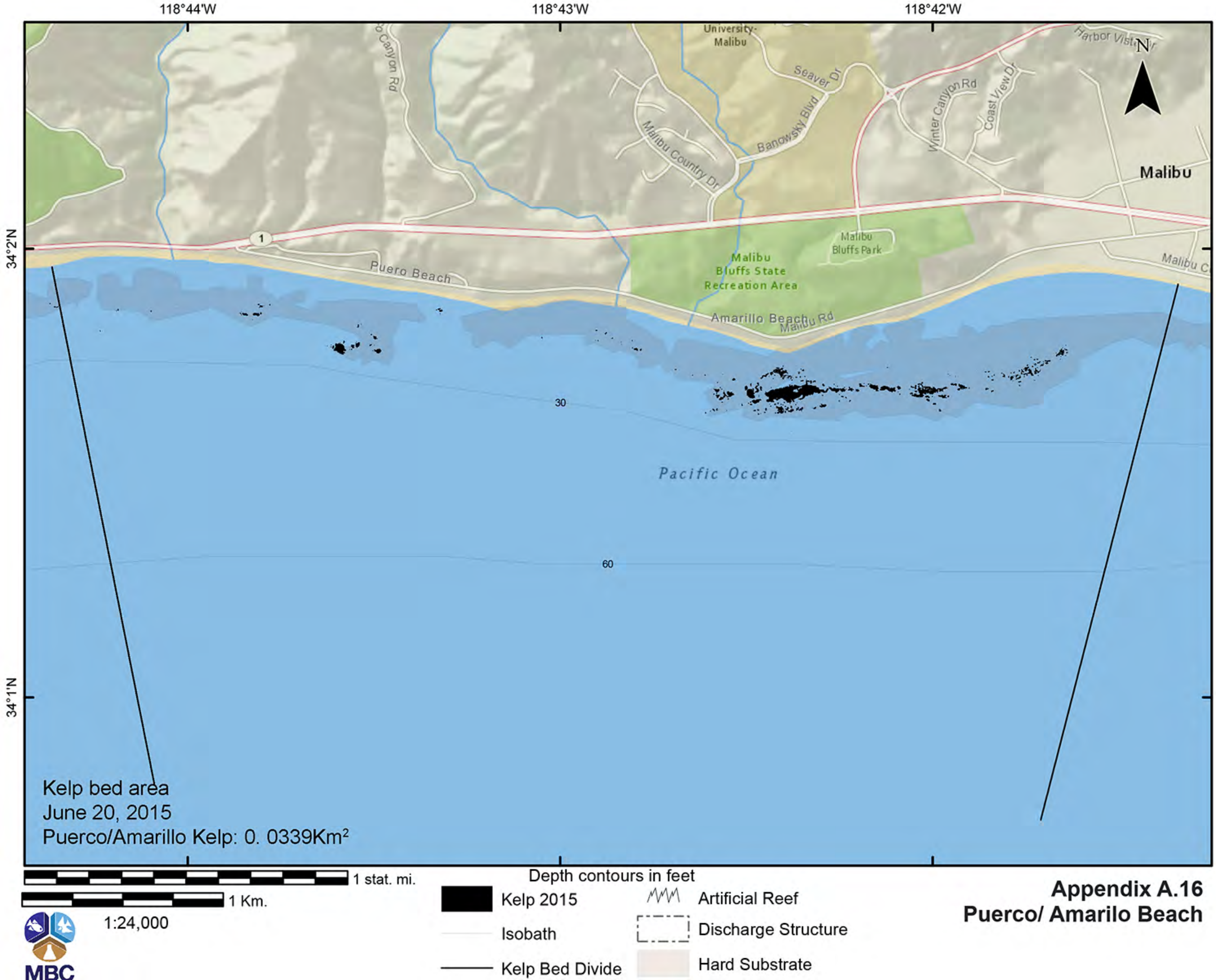
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

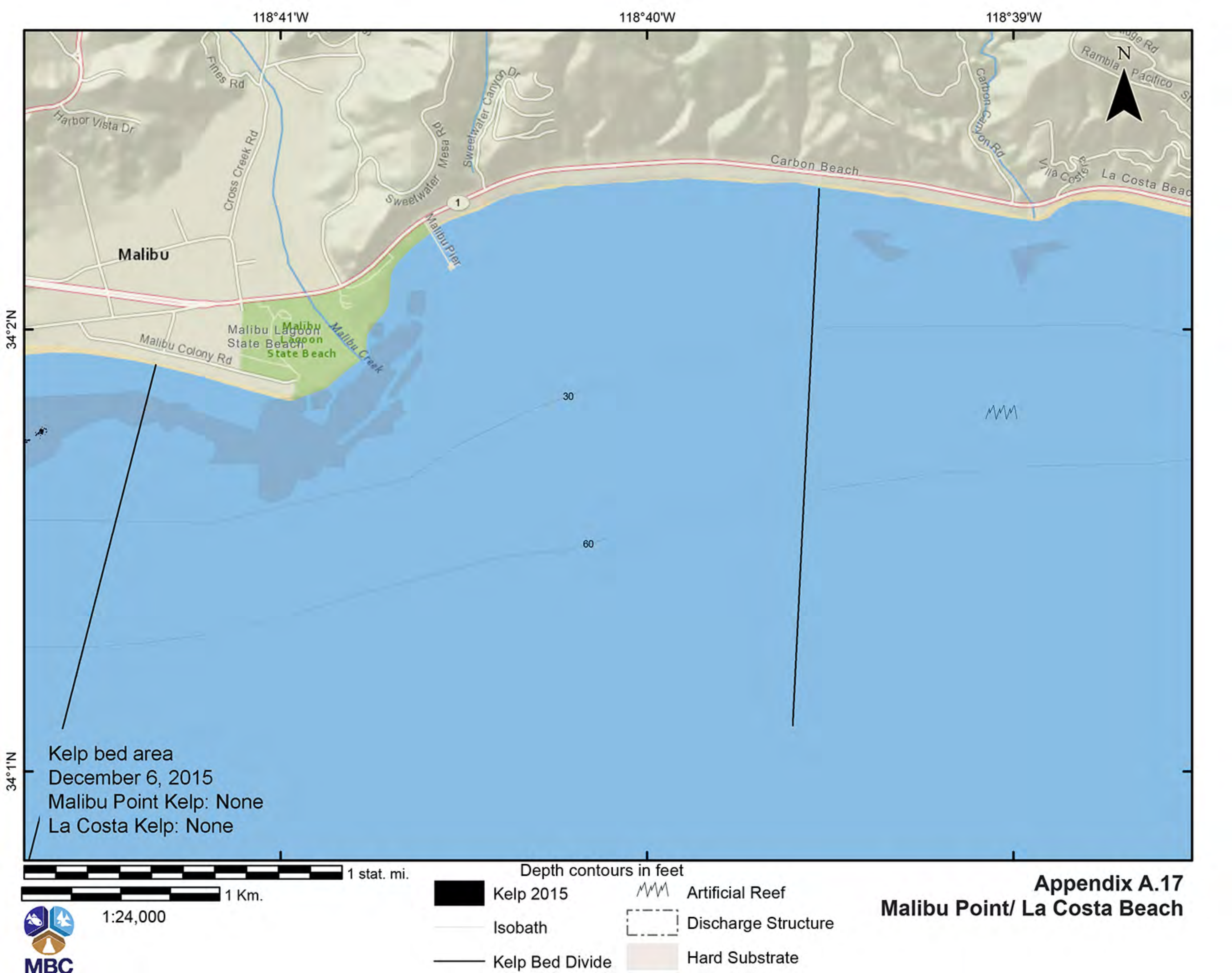
Appendix A.14
Point Dume/ Paradise Cove/ Escondido Wash



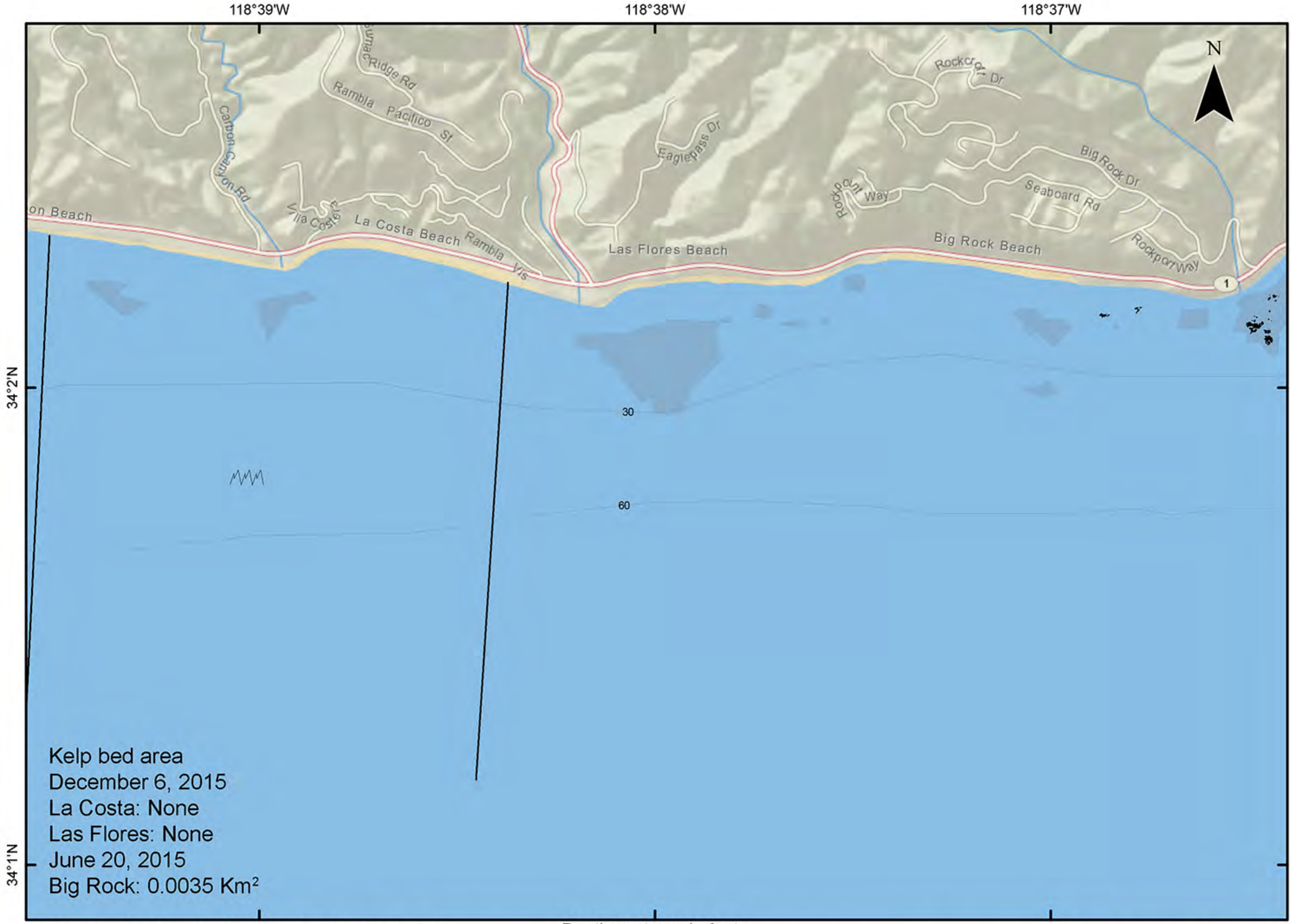
Appendix A.15
Escondido Wash/ Latigo Canyon



Appendix A.16
Puerco/ Amarilo Beach



Appendix A.17
Malibu Point/ La Costa Beach



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

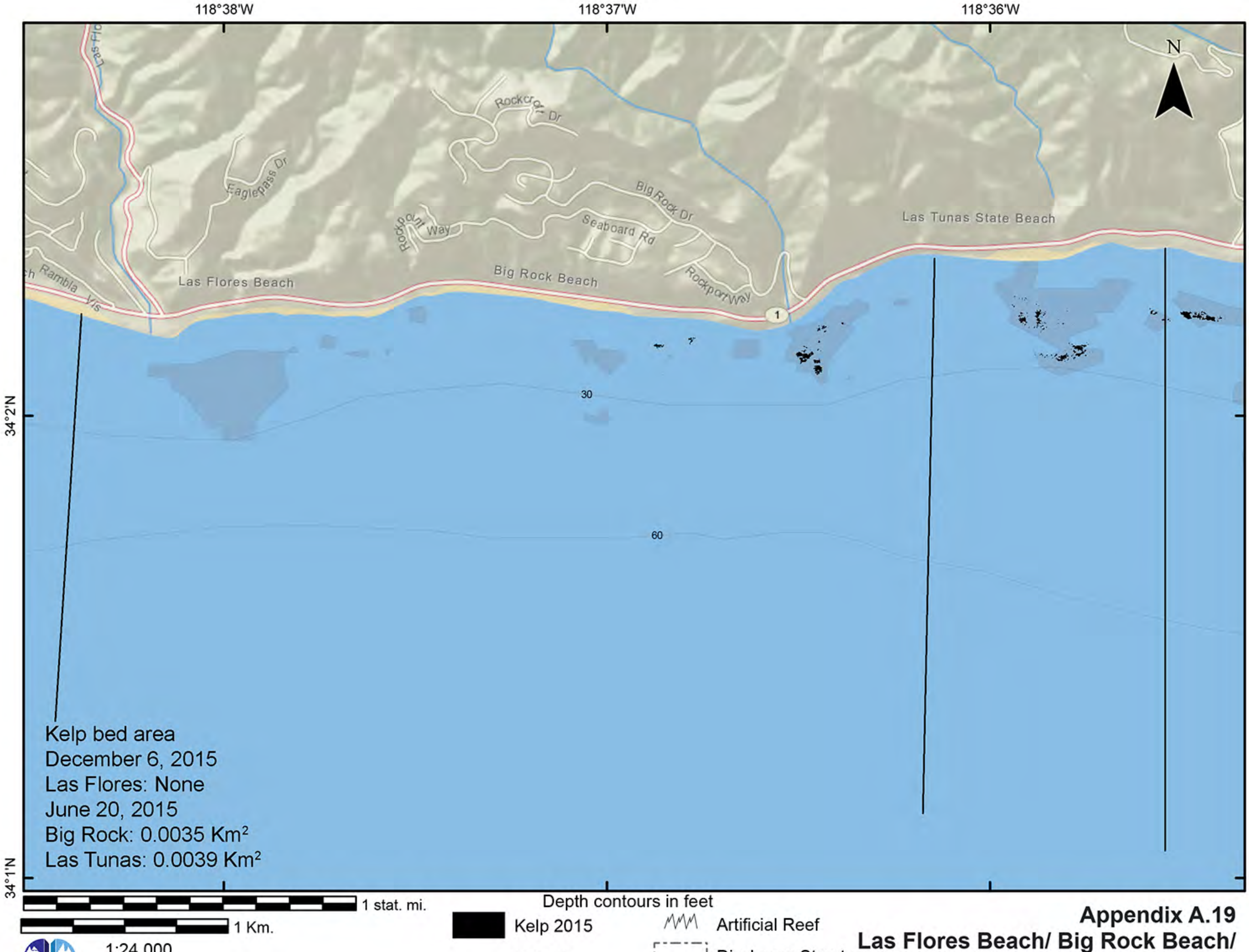
Artificial Reef

Discharge Structure

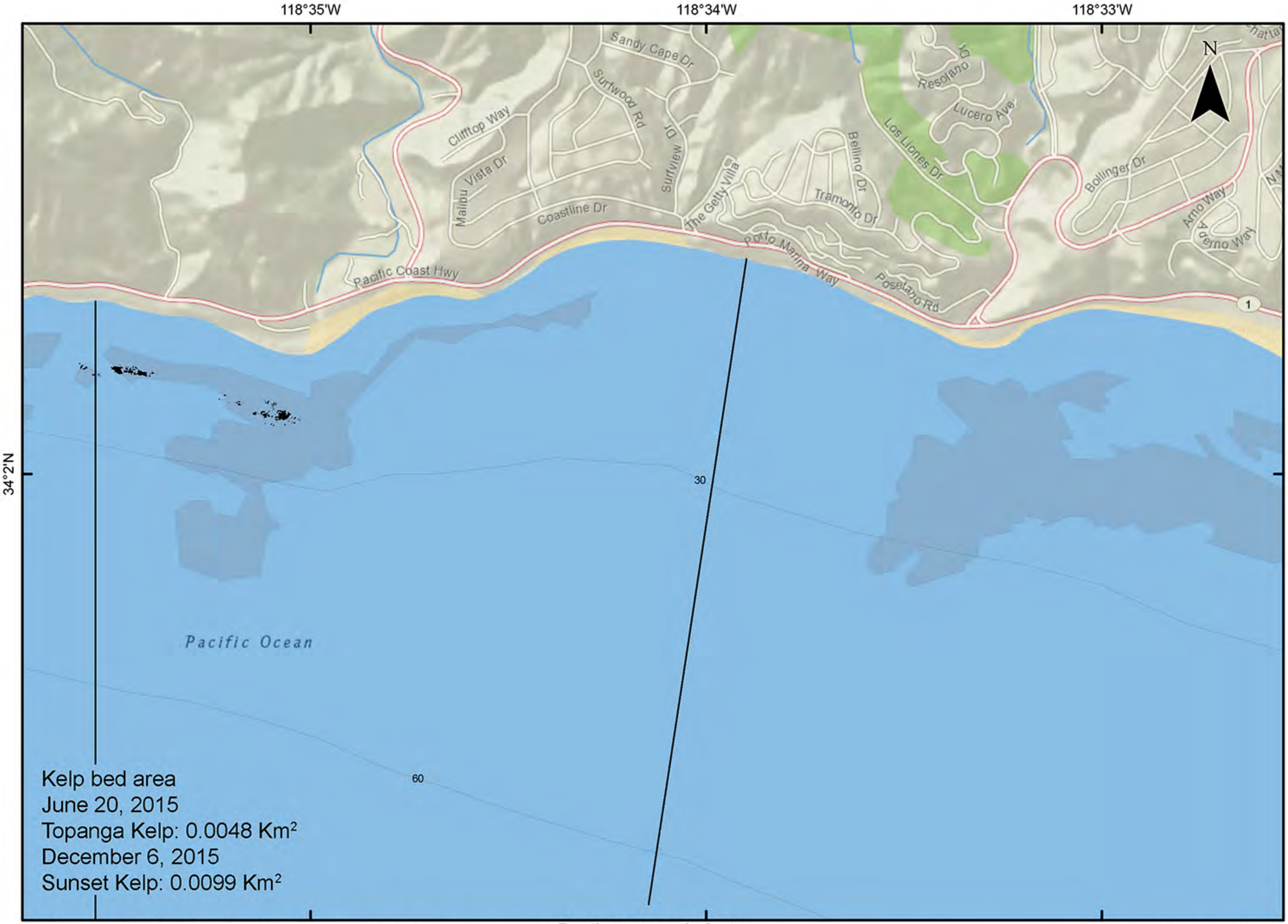
Hard Substrate

MBC

Appendix A.18
La Costa Beach/ Las Flores Beach/ Big Rock



Appendix A.19
Las Flores Beach/ Big Rock Beach/ Las Tunas State Beach



1 stat. mi.

1 Km.

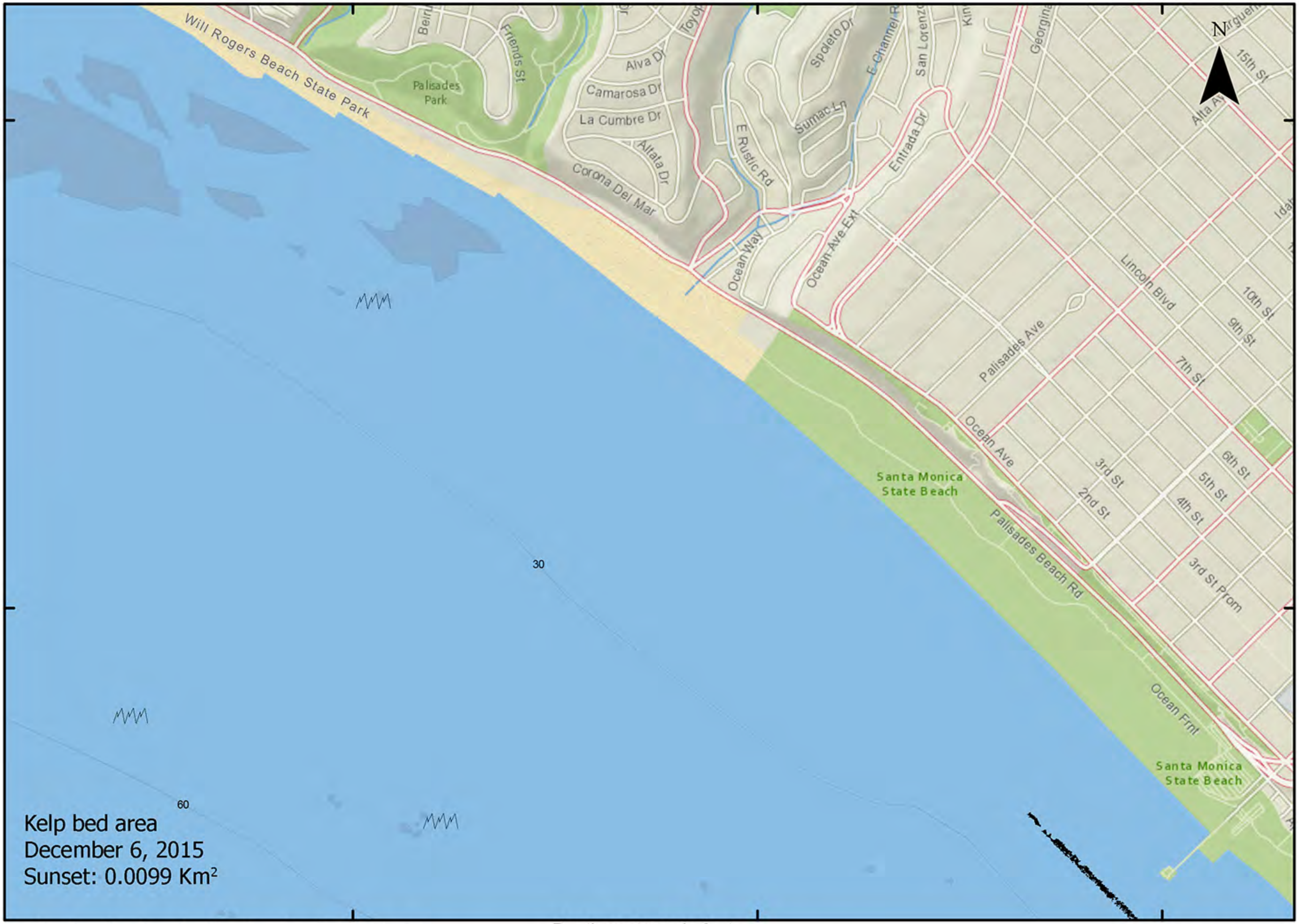
1:24,000

MBC

Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.20
Topanga Canyon Rd/ Sunset Blvd

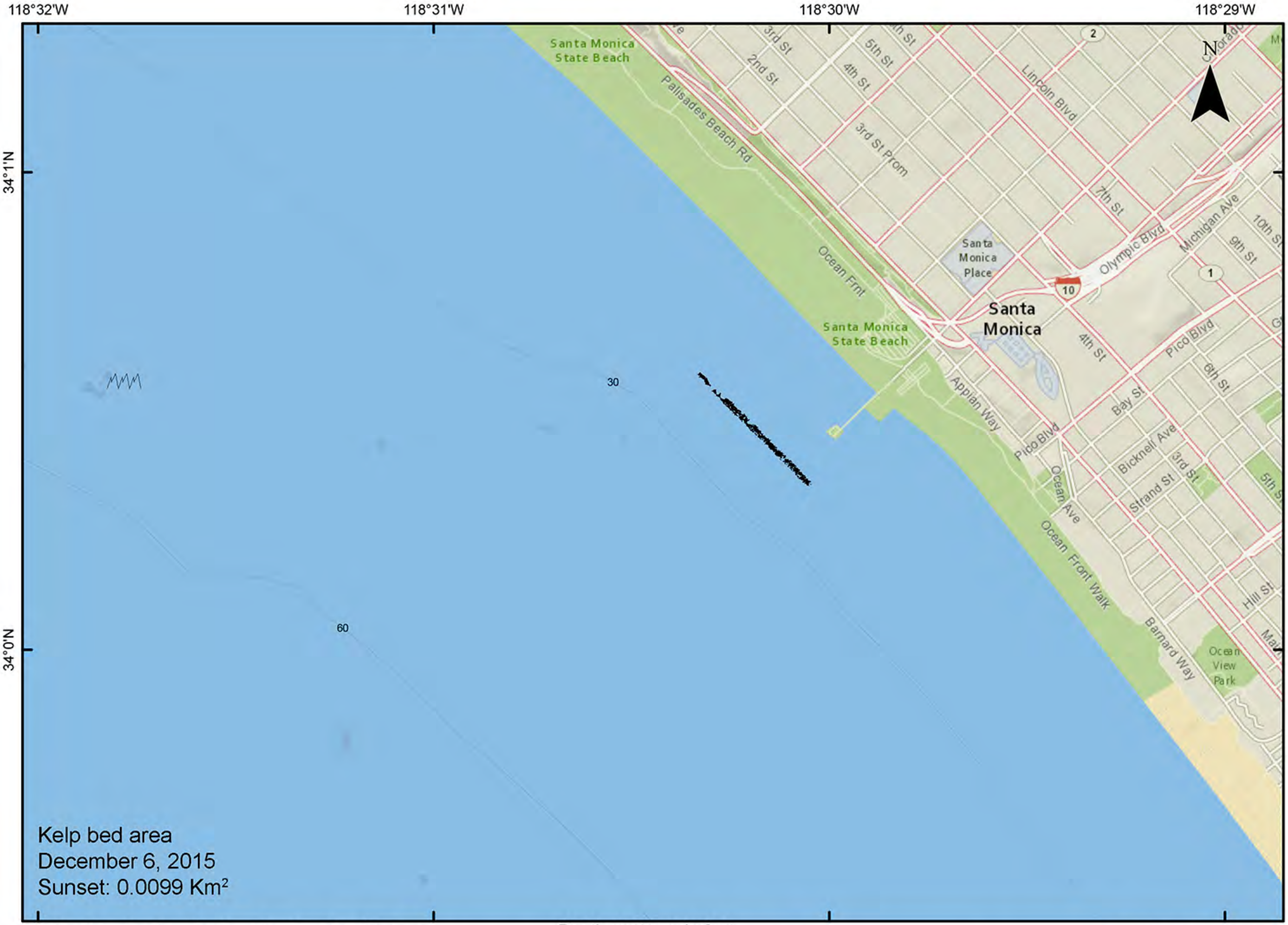


1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.21
Sunset



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.22
Sunset/ Santa Monica Pier/ Santa Monica State Beach

MBC

1 stat. mi.

1 Km.

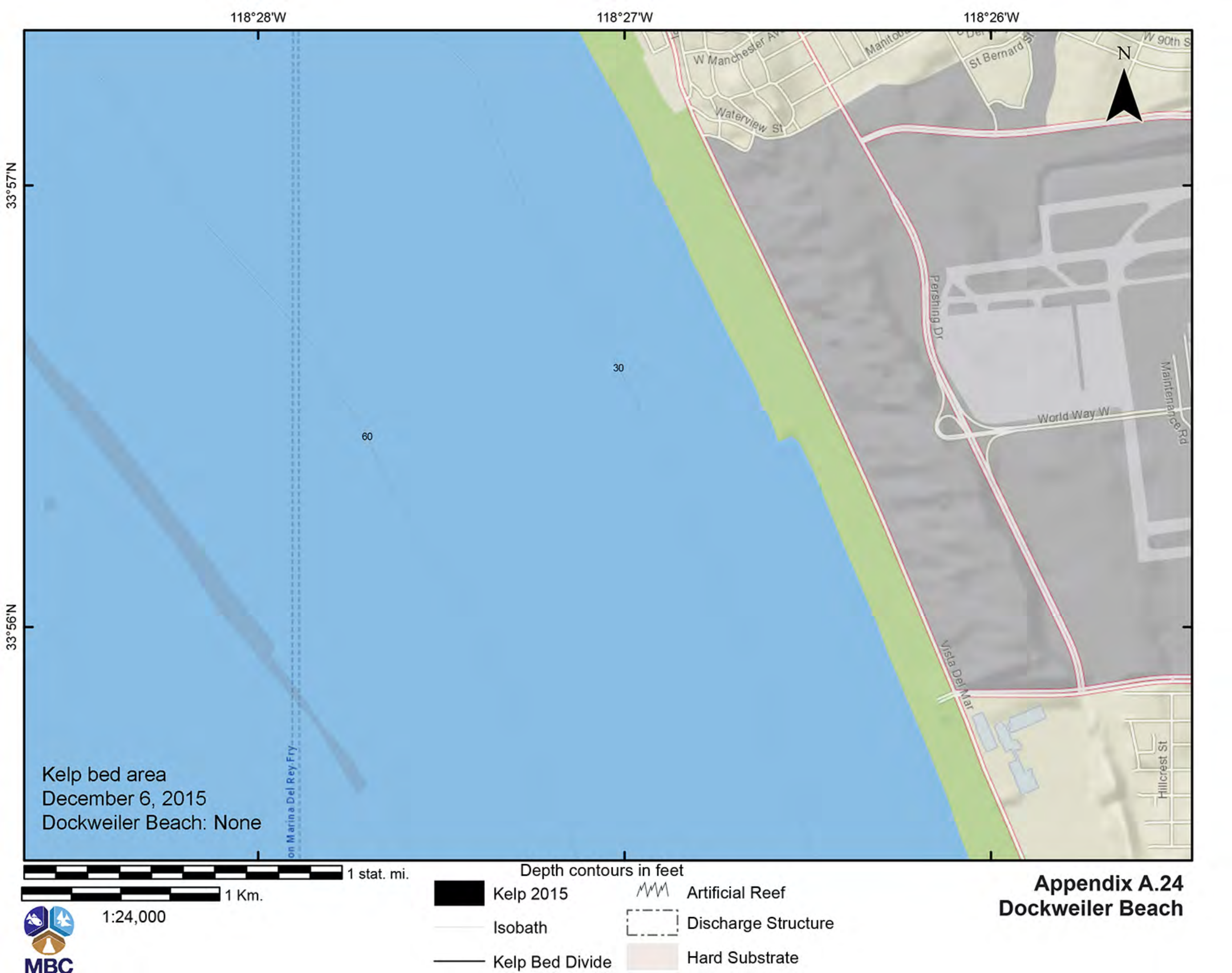
1:24,000

Depth contours in feet

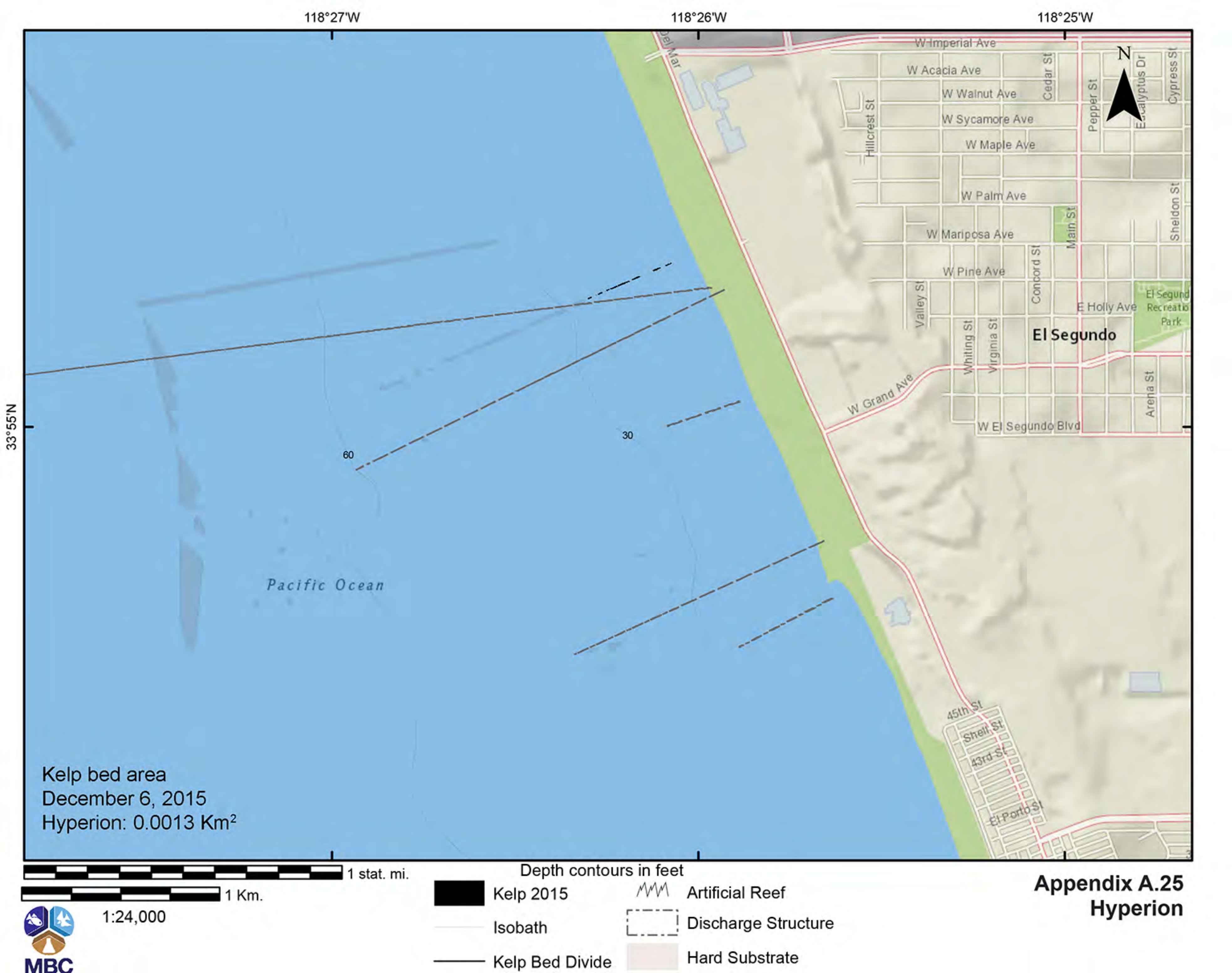
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

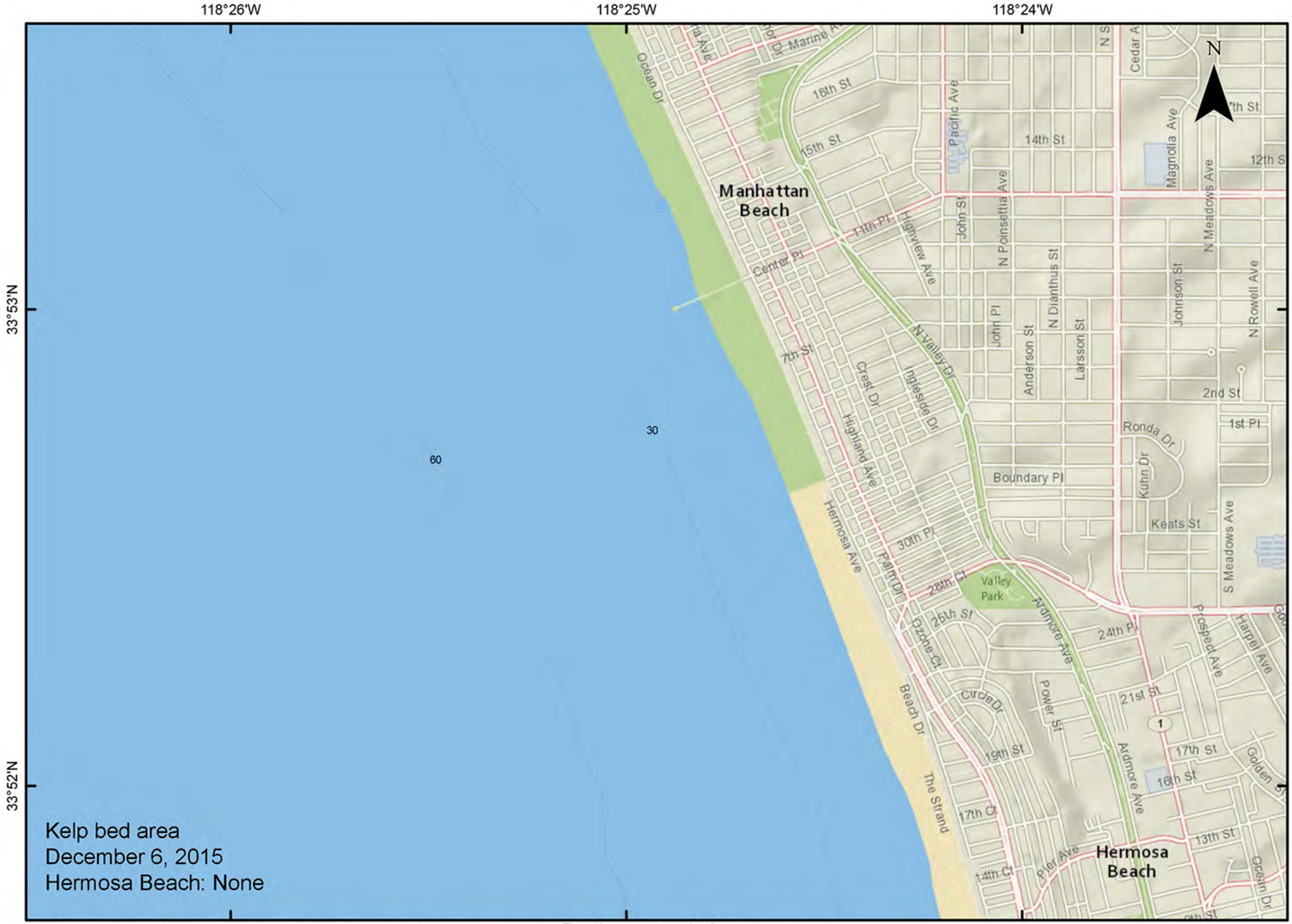
Appendix A.23
Marina del Rey



Appendix A.24
Dockweiler Beach



Appendix A.25
Hyperion



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

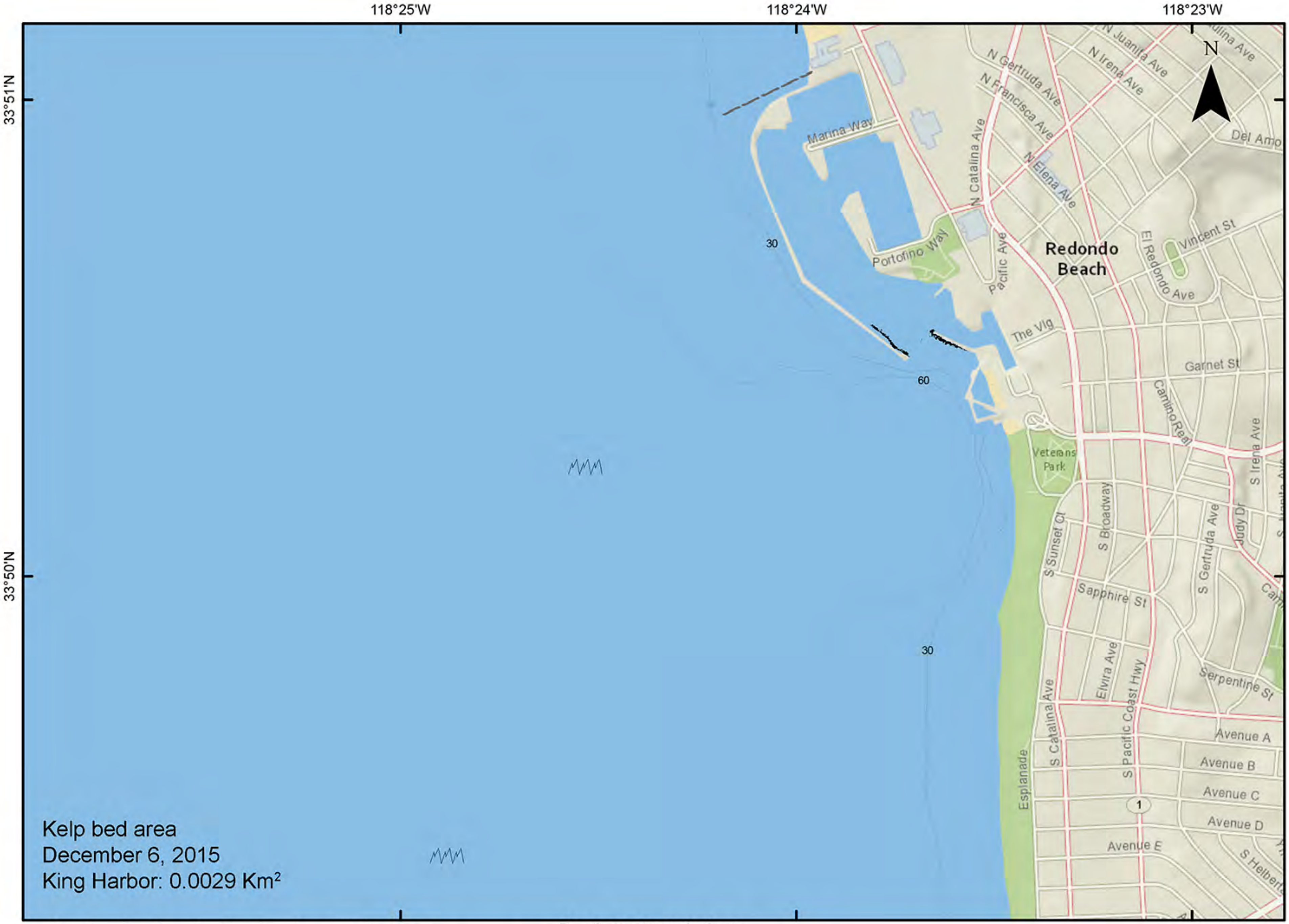
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.26
Hermosa Beach



1 stat. mi.

1 Km.

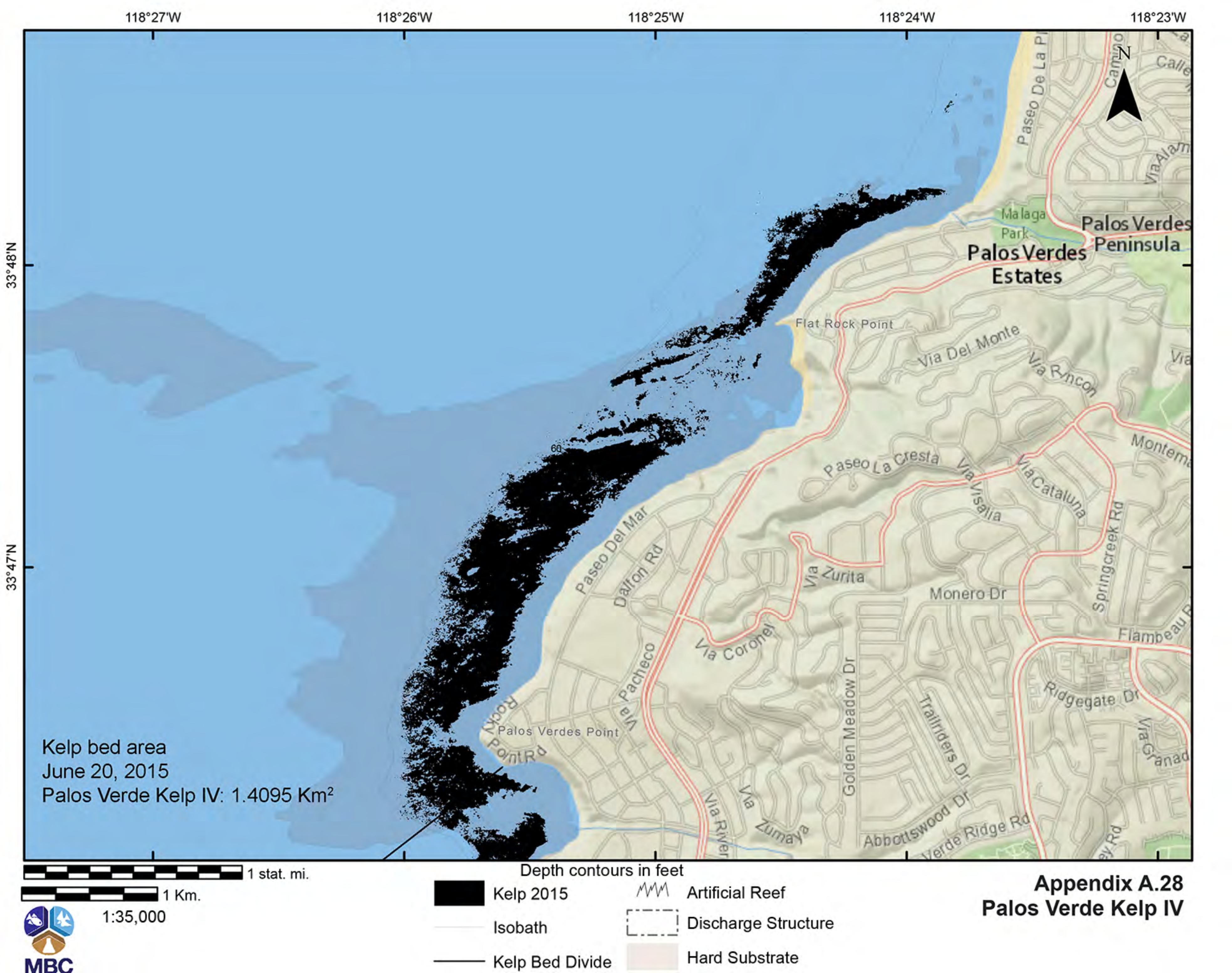
1:24,000

Depth contours in feet

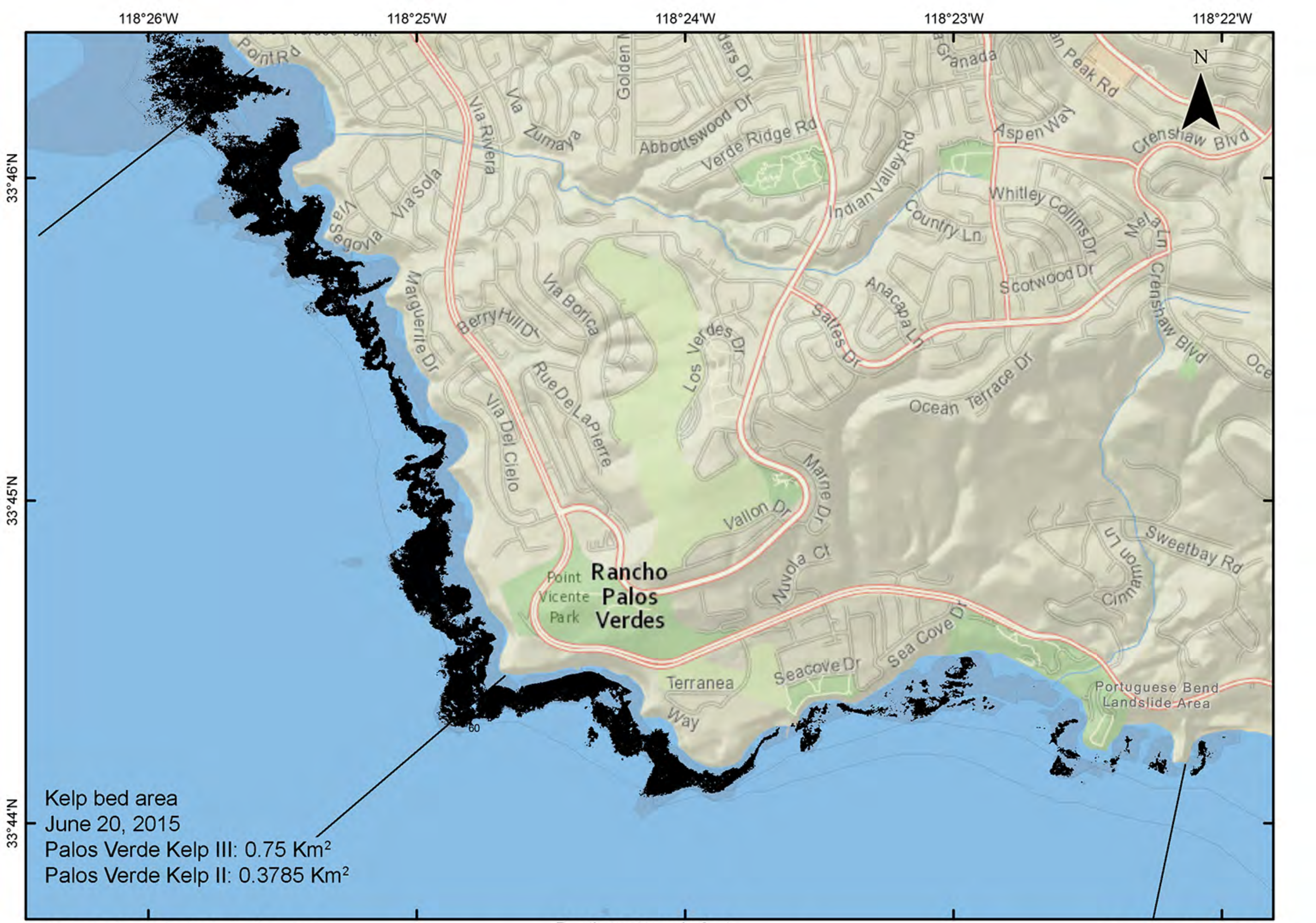
Kelp 2015	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

MBC

Appendix A.27
King Harbor



Appendix A.28
Palos Verde Kelp IV



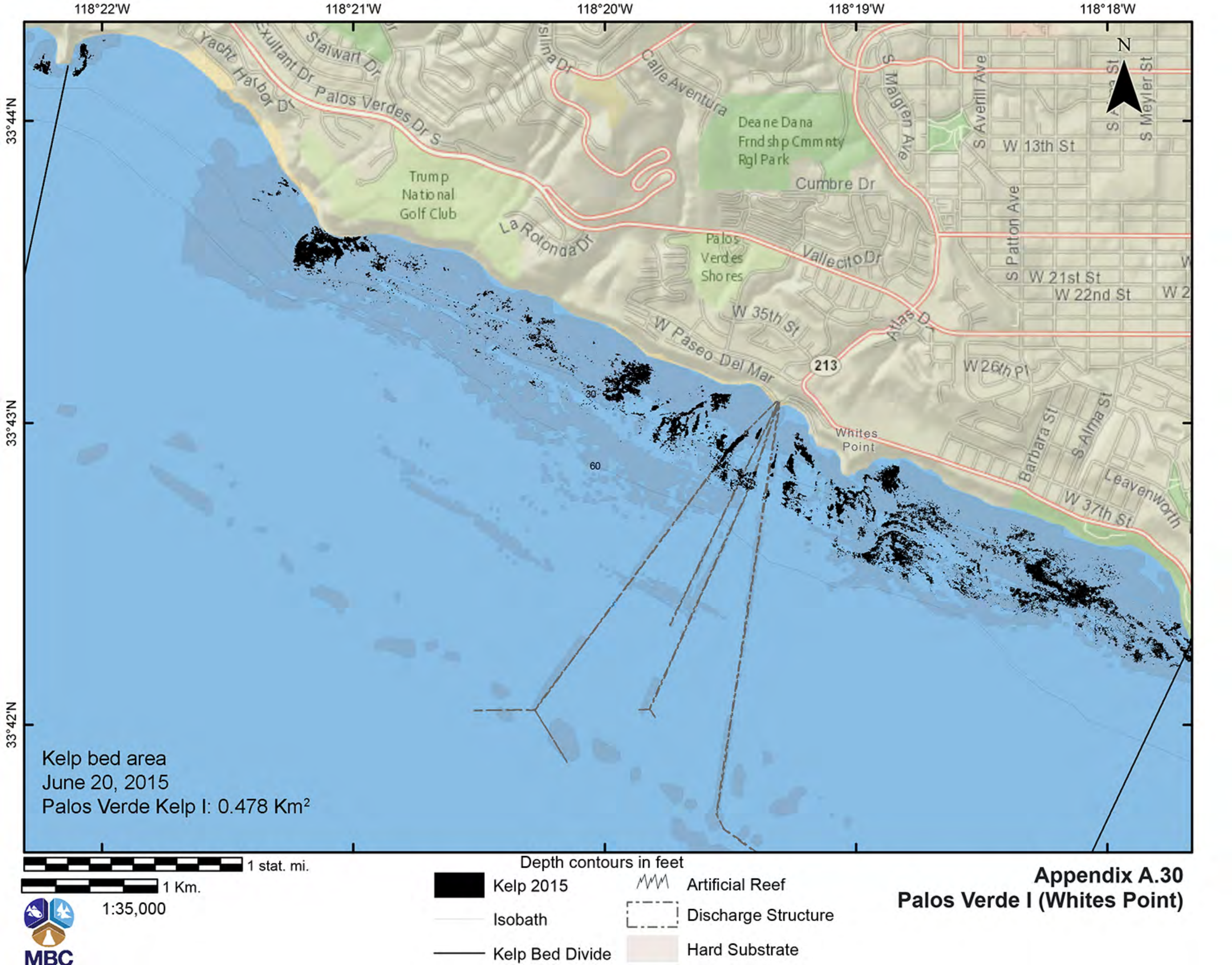
1 stat. mi.
1 Km.
1:35,000

Depth contours in feet

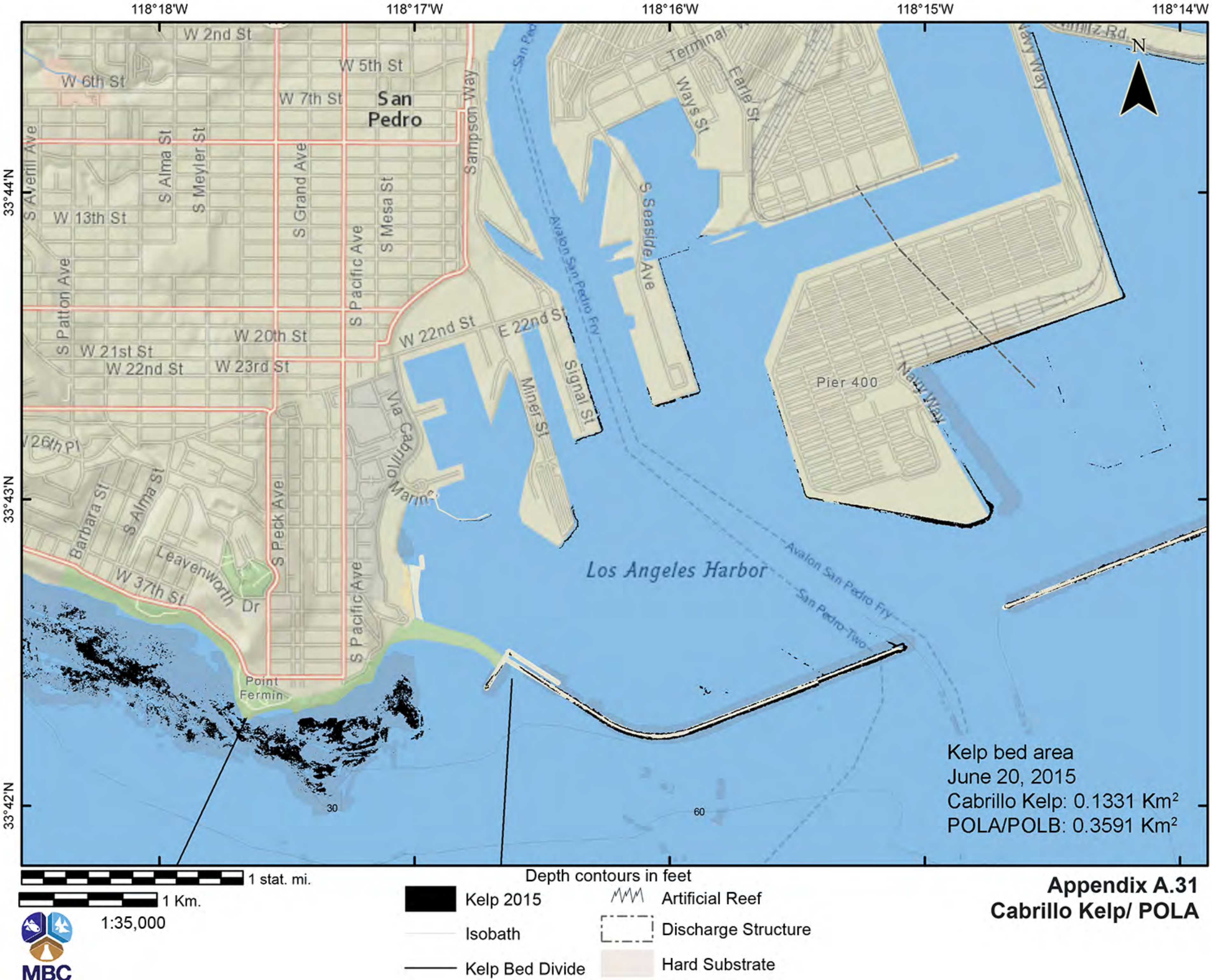
Kelp 2015	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

MBC

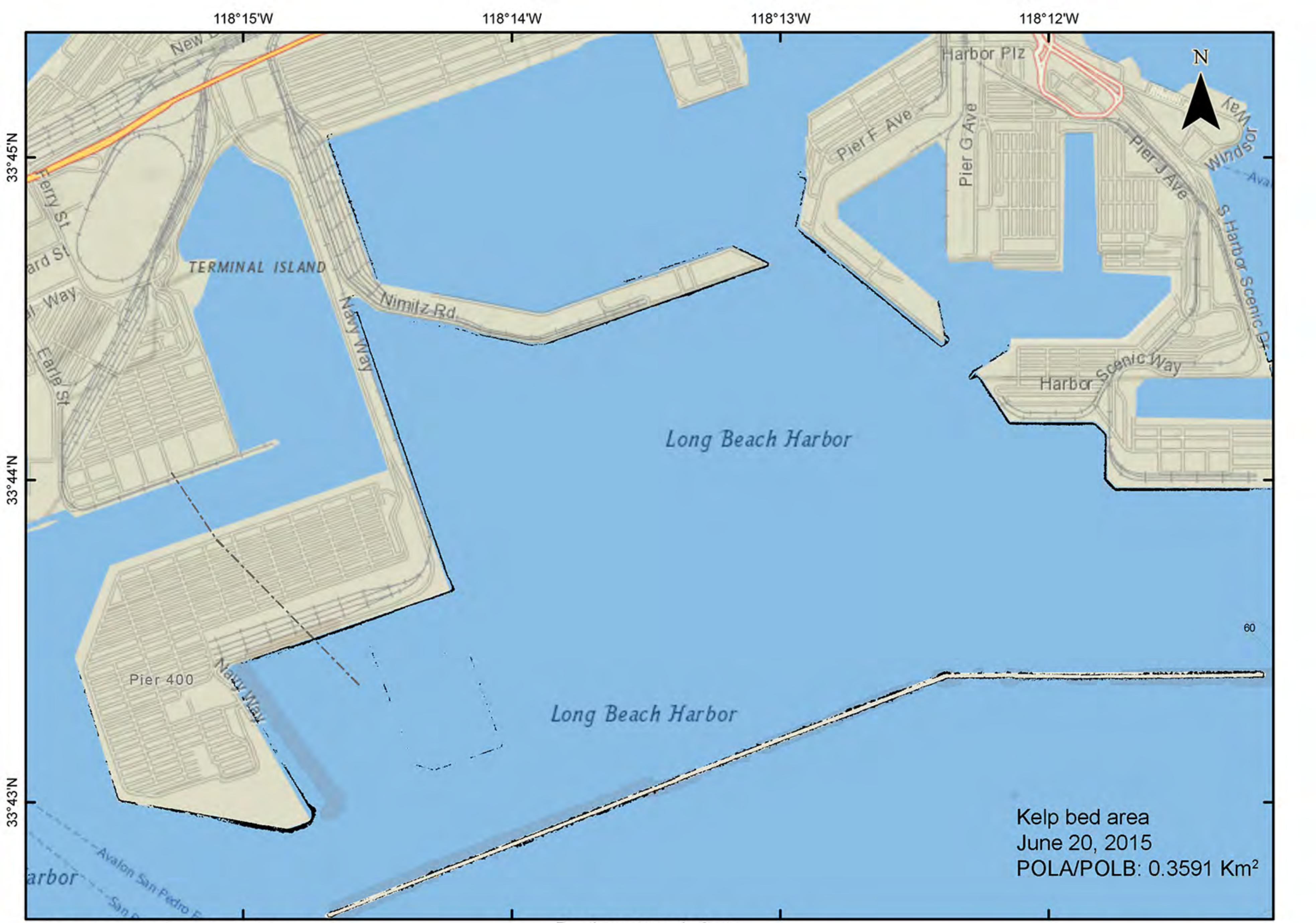
Appendix A.29
Palos Verde III and II (Point Vicente)



Appendix A.30
Palos Verde I (Whites Point)



Appendix A.31
Cabrillo Kelp/ POLA



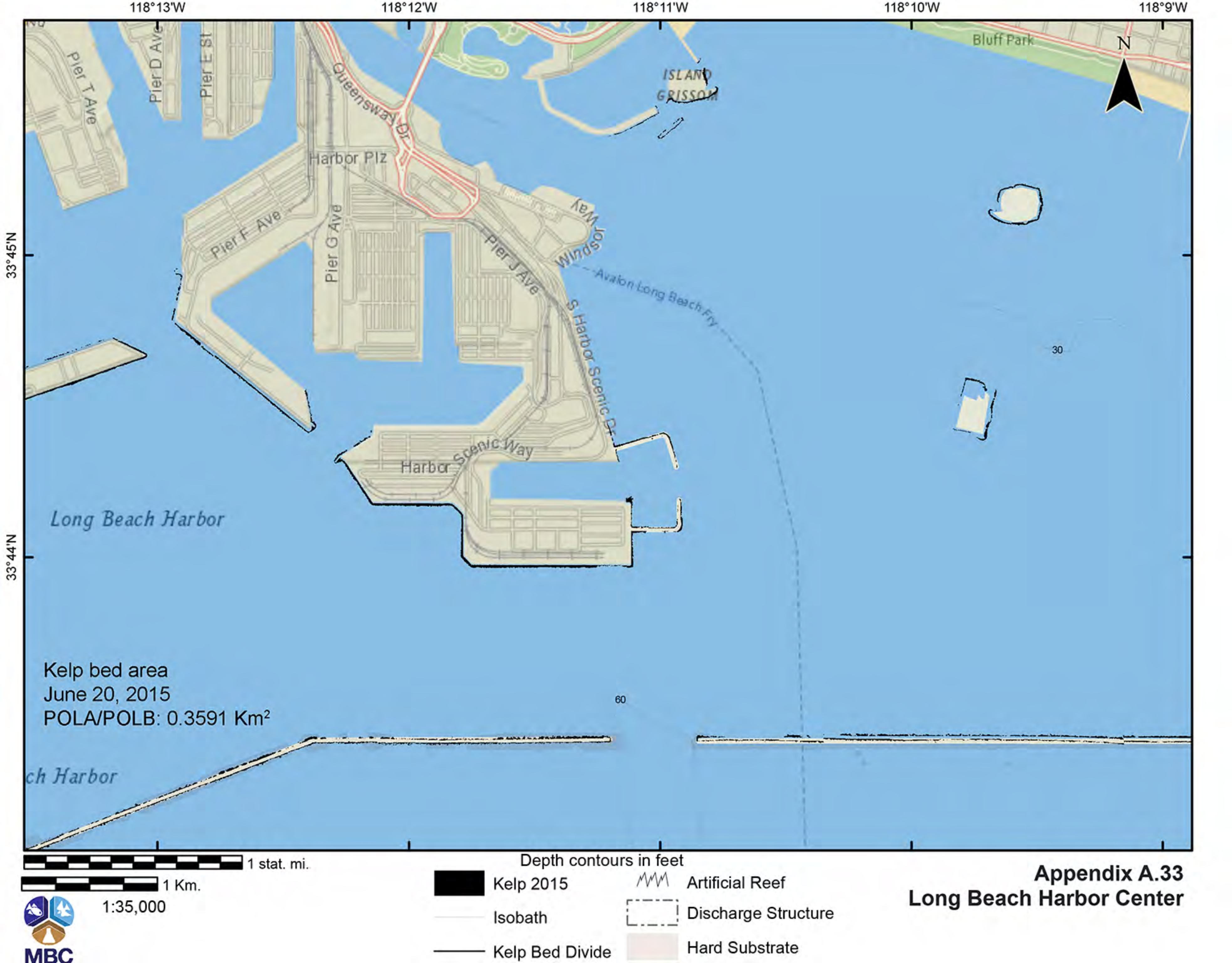
1 stat. mi.
1 Km.
1:35,000

Depth contours in feet

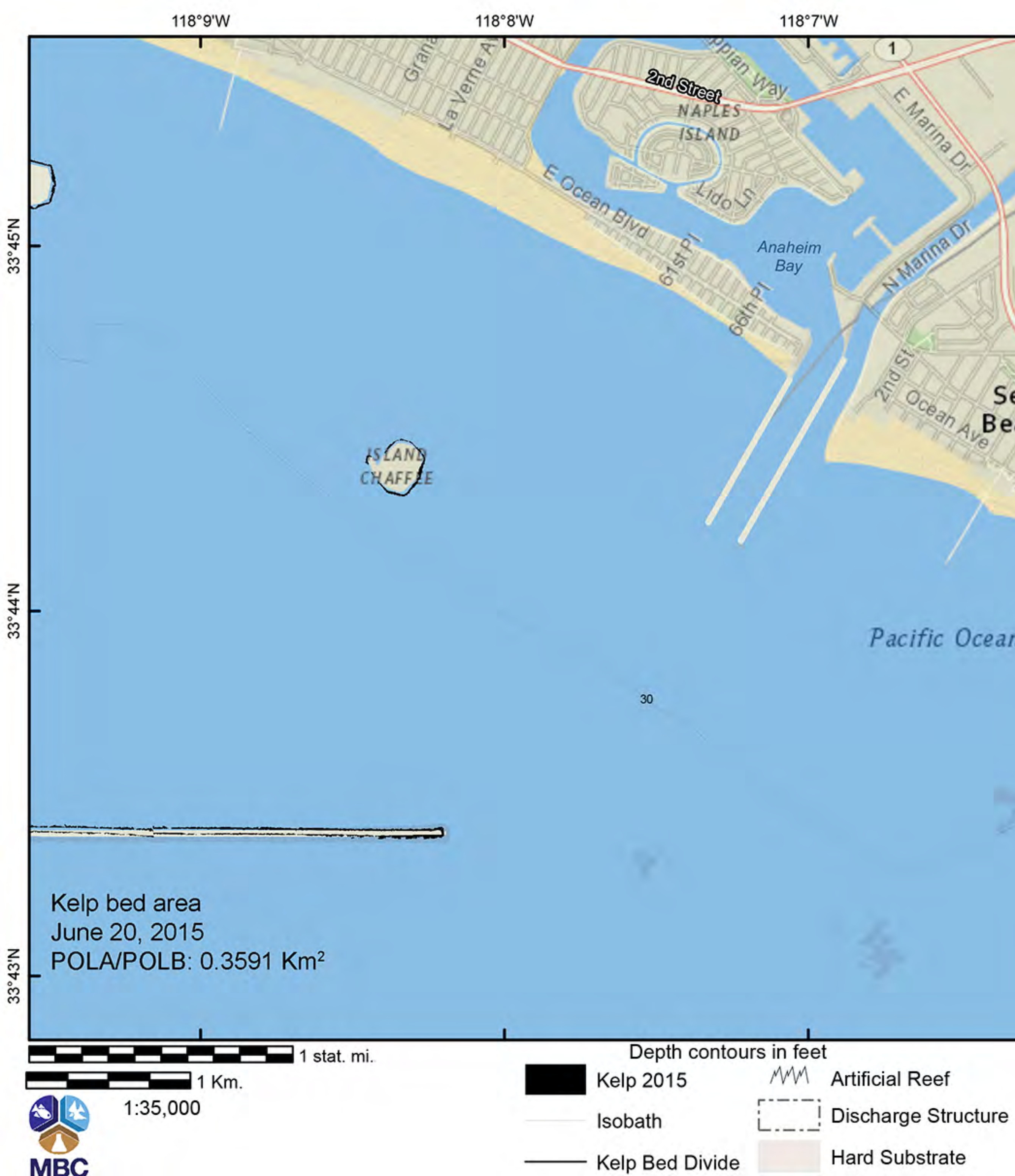
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.32
Long Beach Harbor North

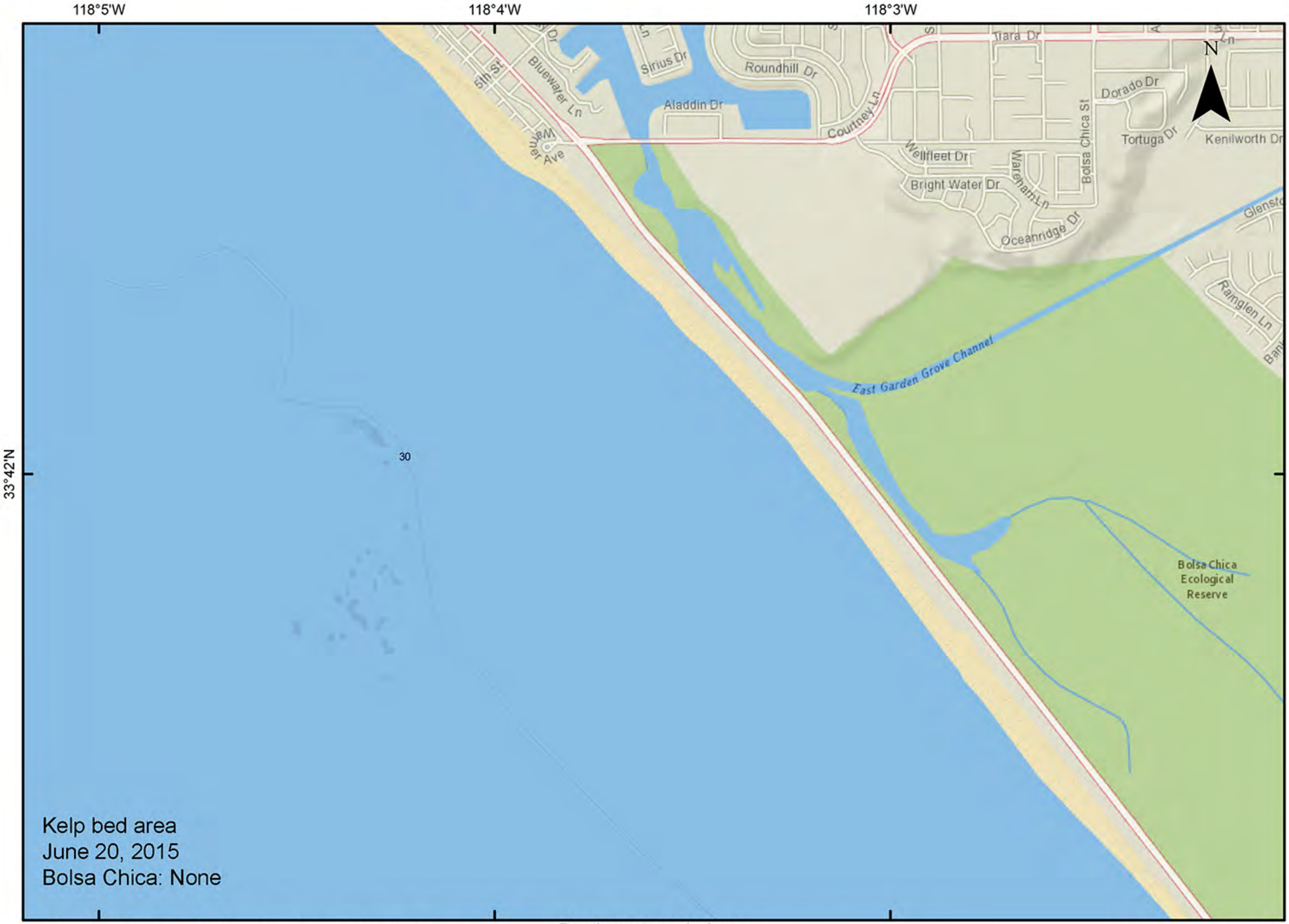
MBC



Appendix A.33
Long Beach Harbor Center



Appendix A.34
Long Beach Harbor South



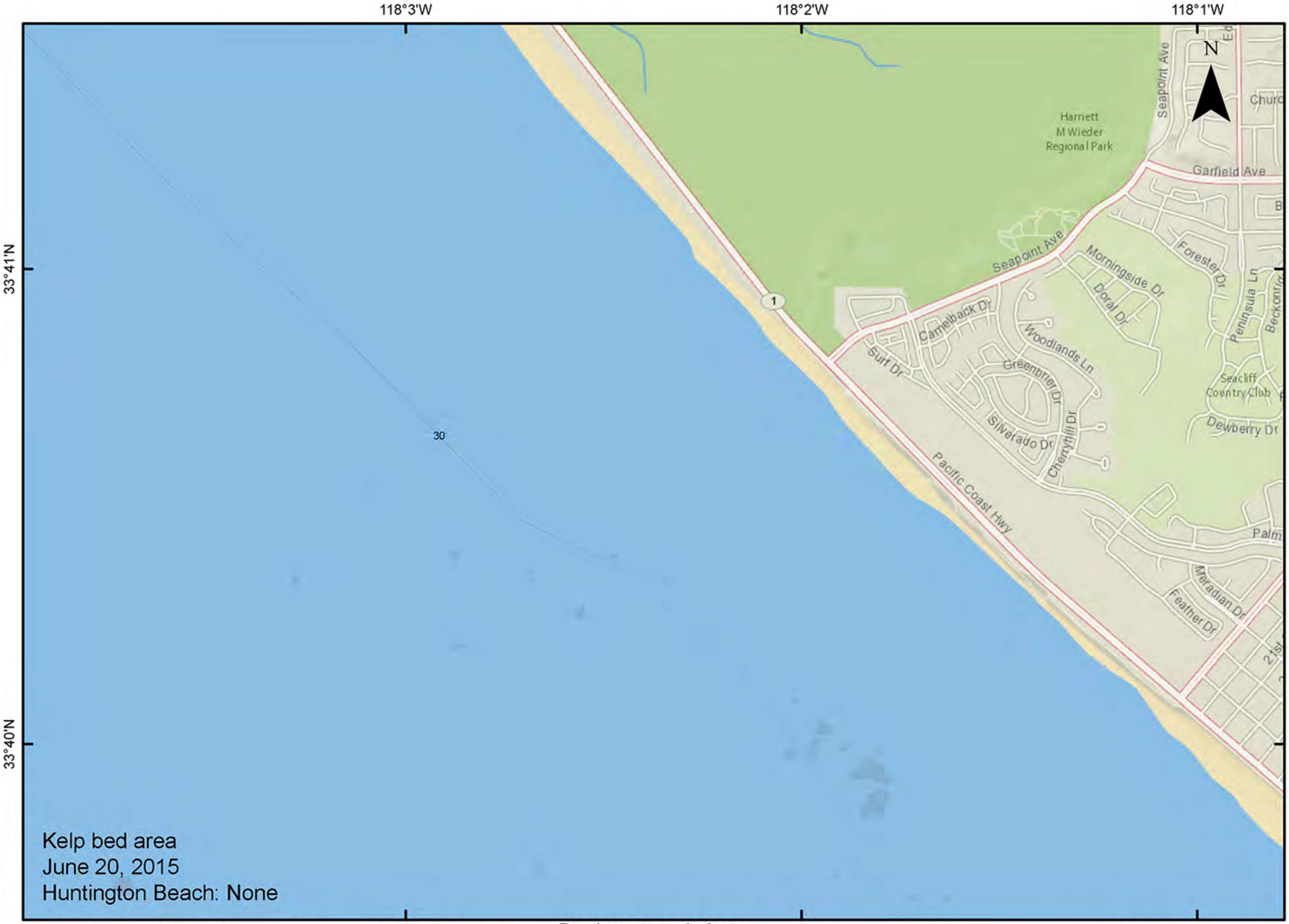
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

Appendix A.35
Bolsa Chica



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

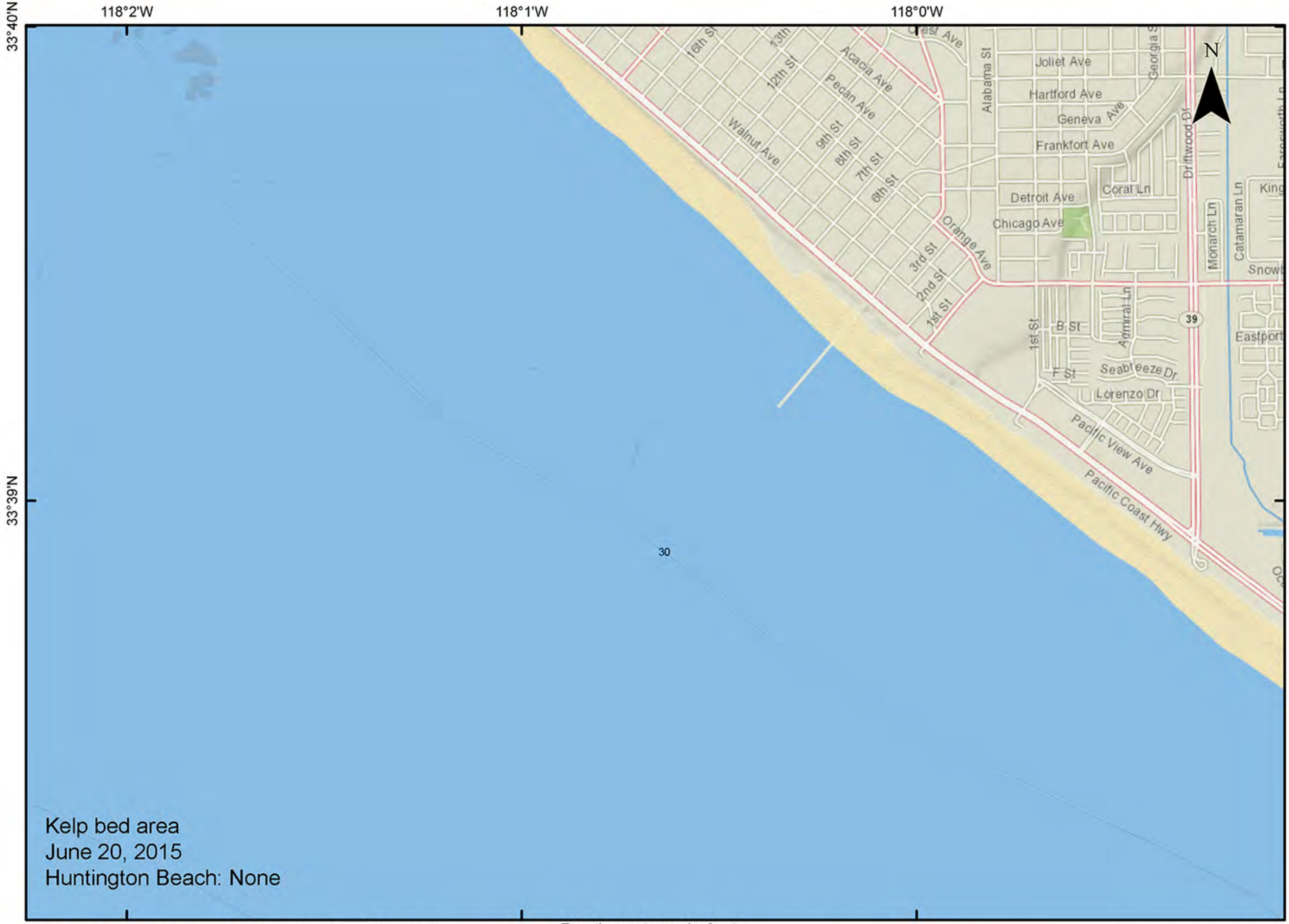
Artificial Reef

Discharge Structure

Hard Substrate

MBC

Appendix A.36
Huntington Beach



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

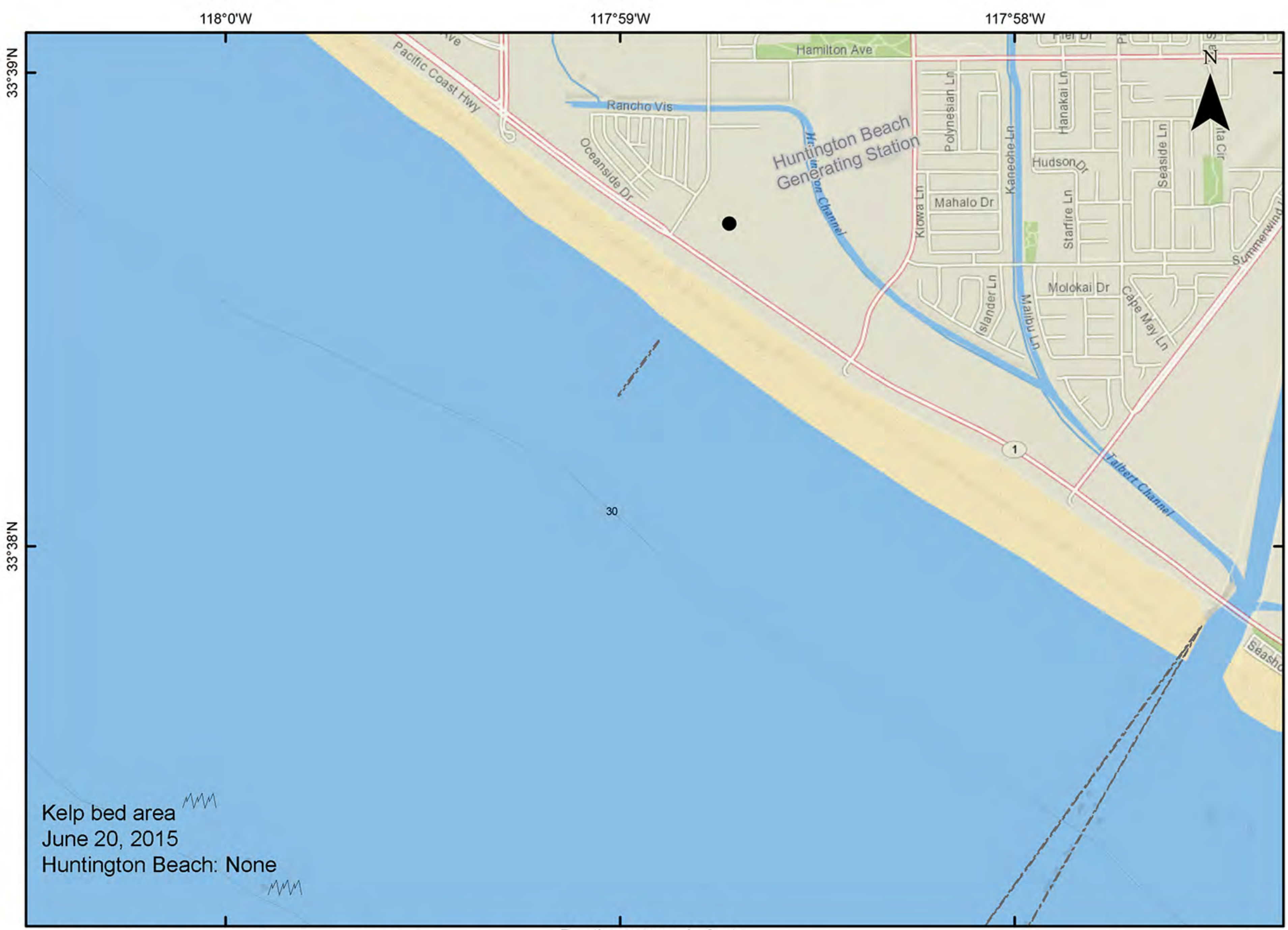
Artificial Reef

Discharge Structure

Hard Substrate

MBC

Appendix A.37
Huntington Beach Pier



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

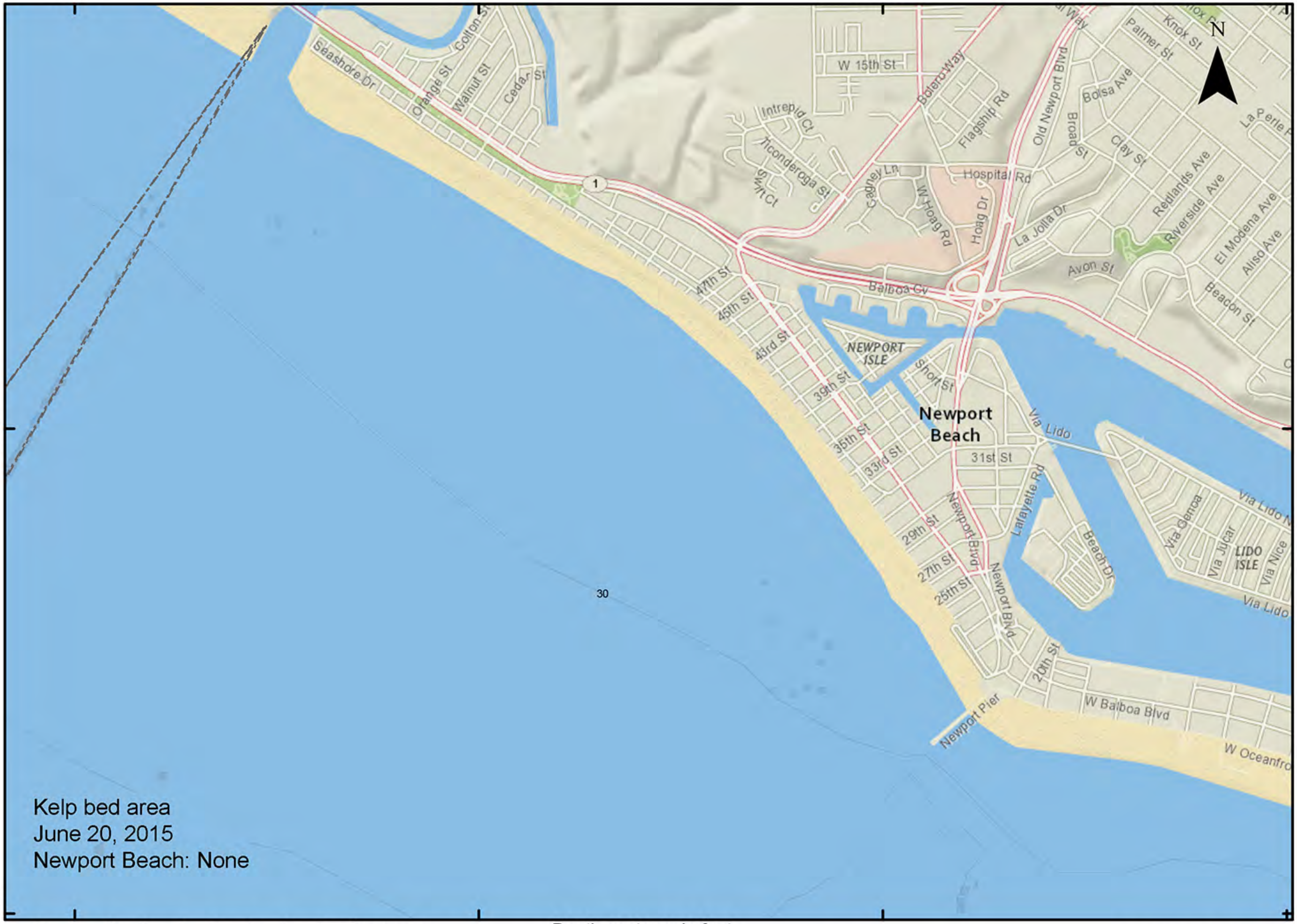
Artificial Reef

Discharge Structure

Hard Substrate

MBC

Appendix A.38
Huntington Beach Generating Station



1 stat. mi.

1 Km.

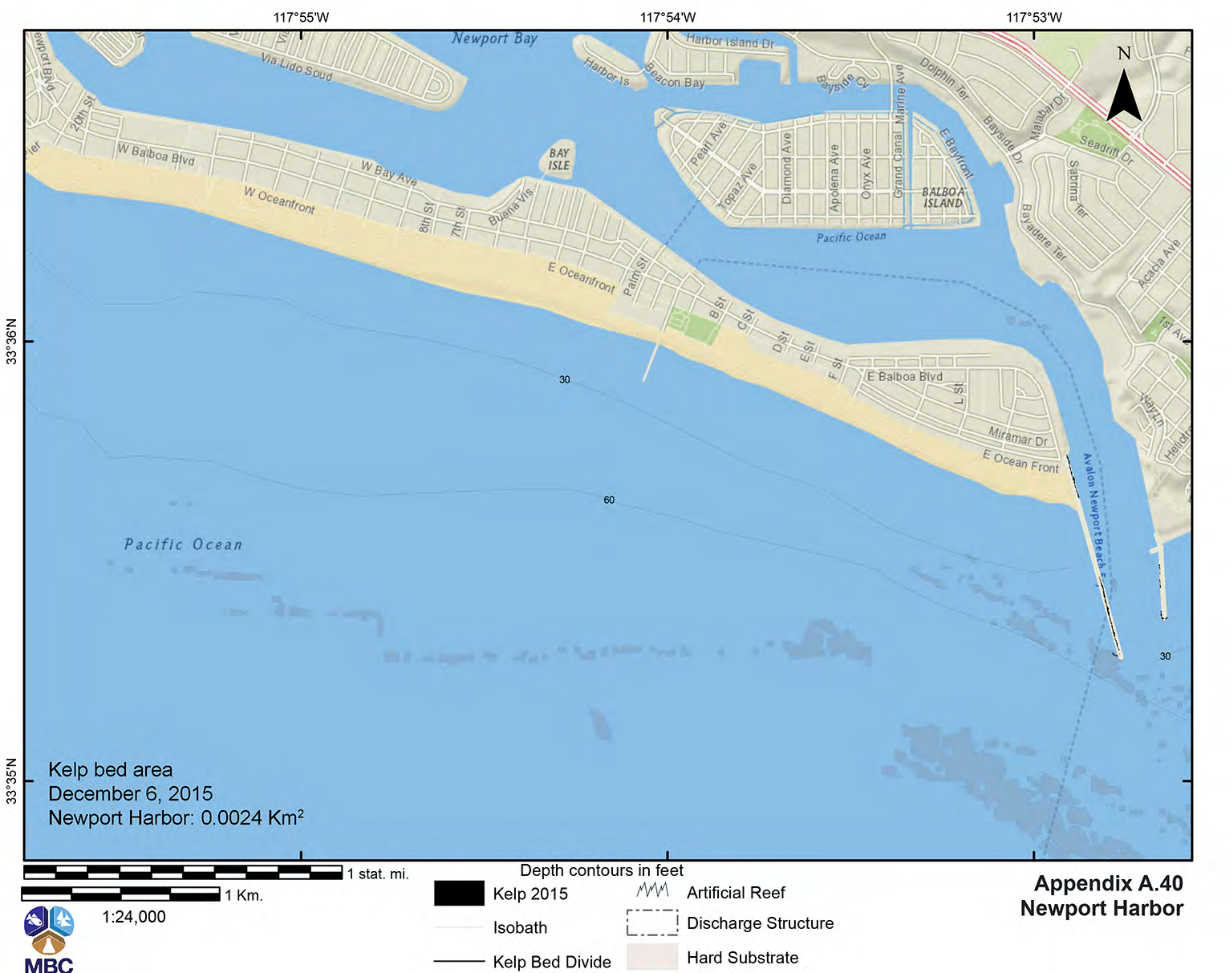
1:24,000

Depth contours in feet

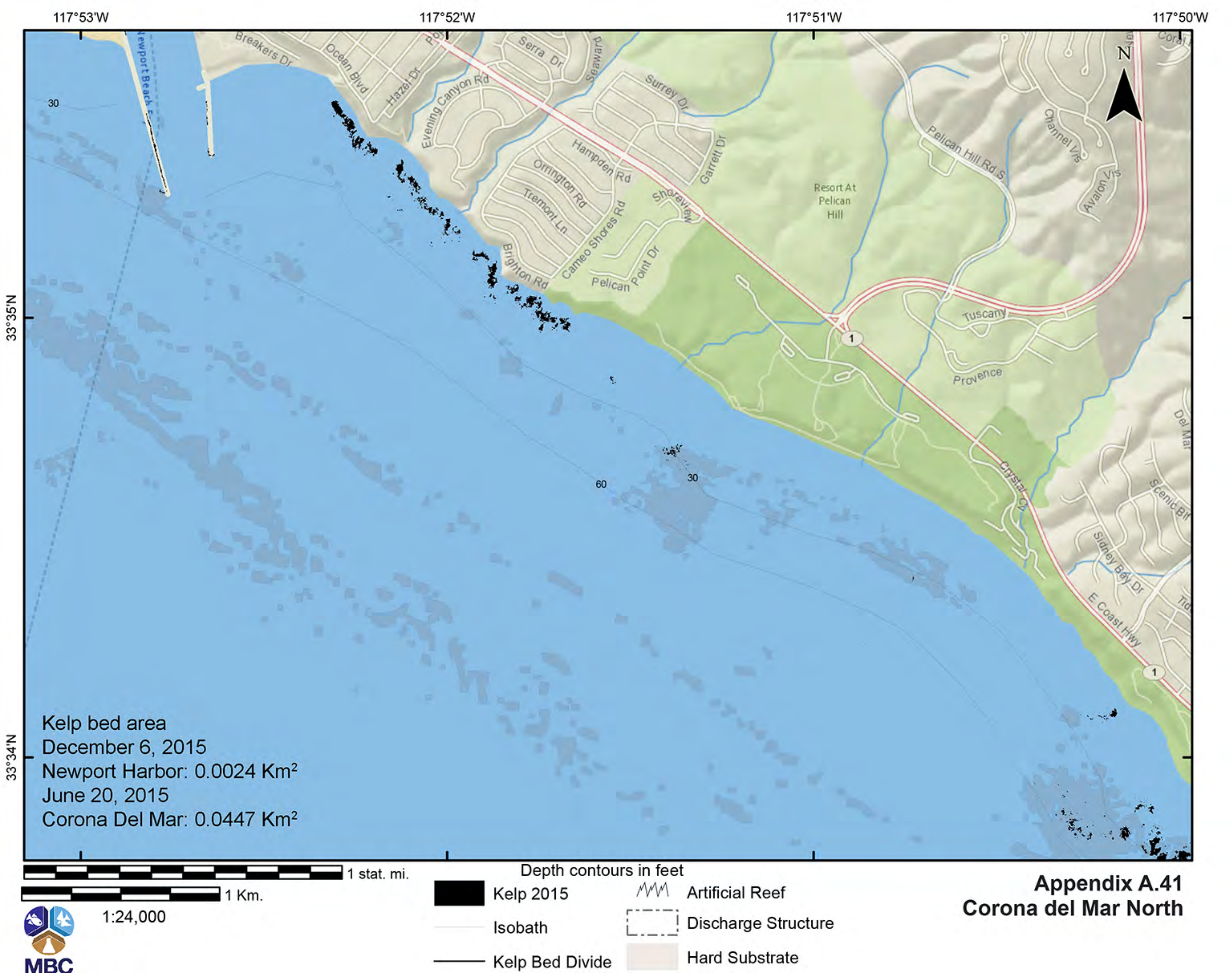
Kelp 2015	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

MBC

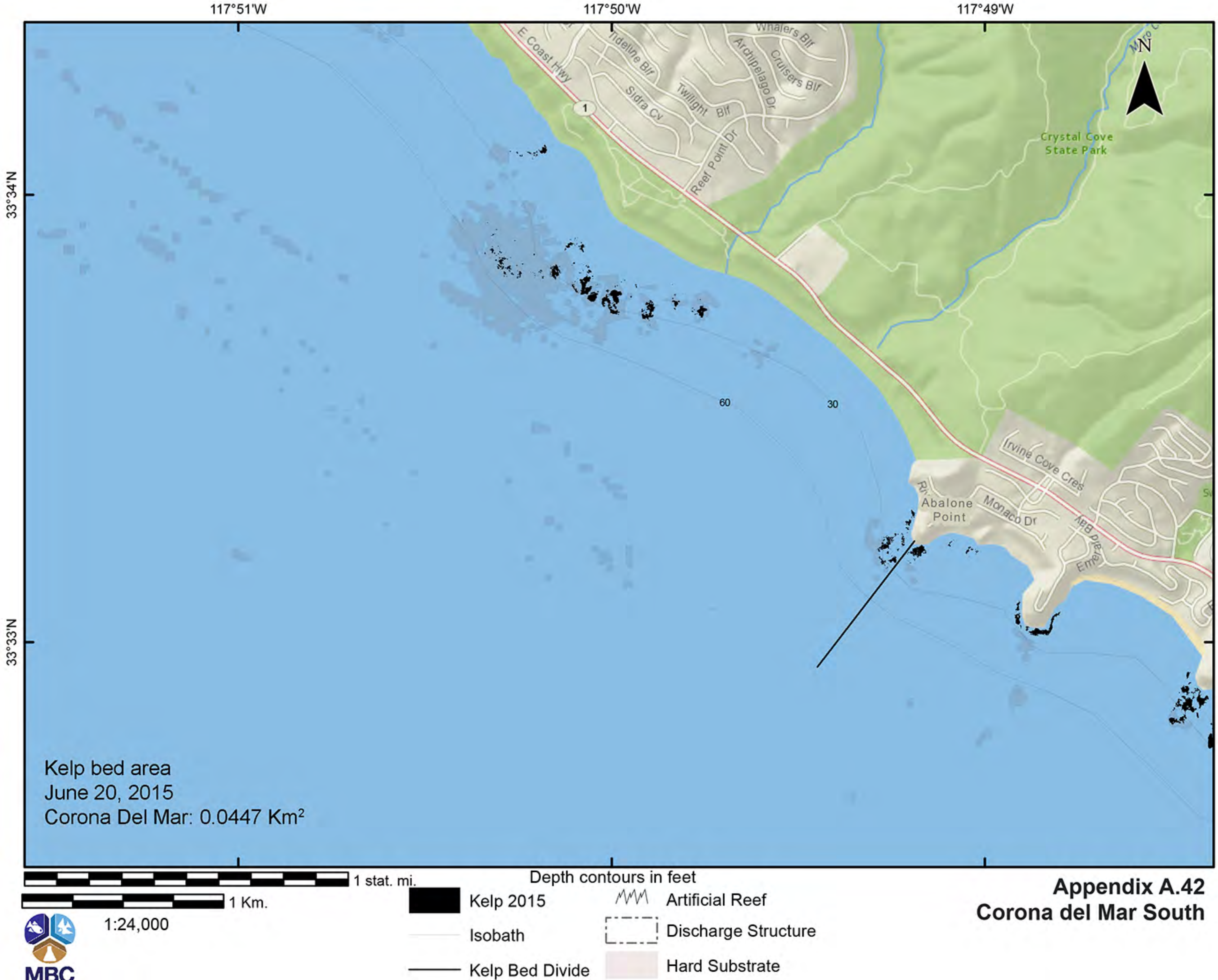
Appendix A.39
Newport Beach



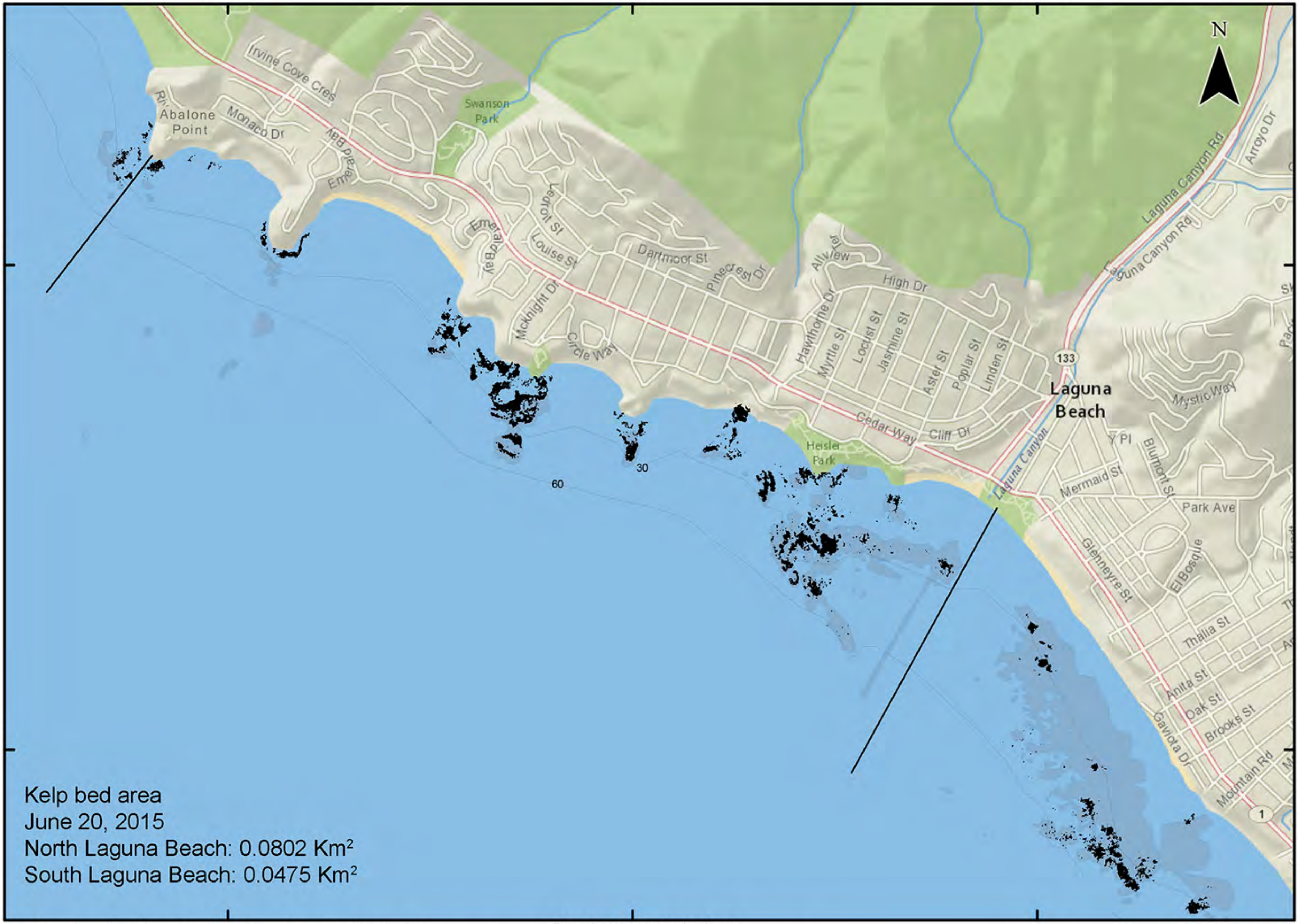
Appendix A.40
Newport Harbor



Appendix A.41
Corona del Mar North



Appendix A.42
Corona del Mar South



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

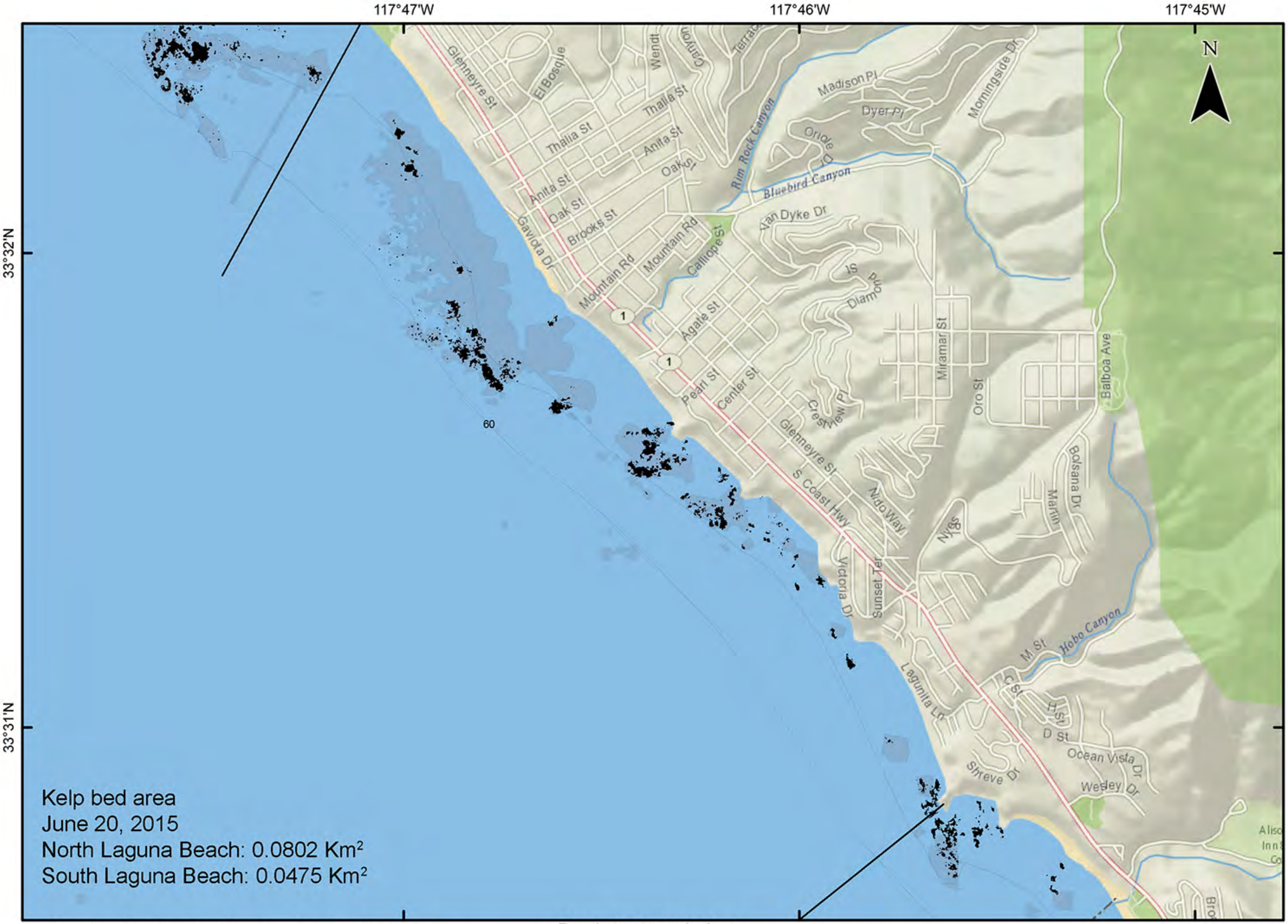
Artificial Reef

Discharge Structure

Hard Substrate

MBC

Appendix A.43
Laguna North



1 stat. mi.

1 Km.

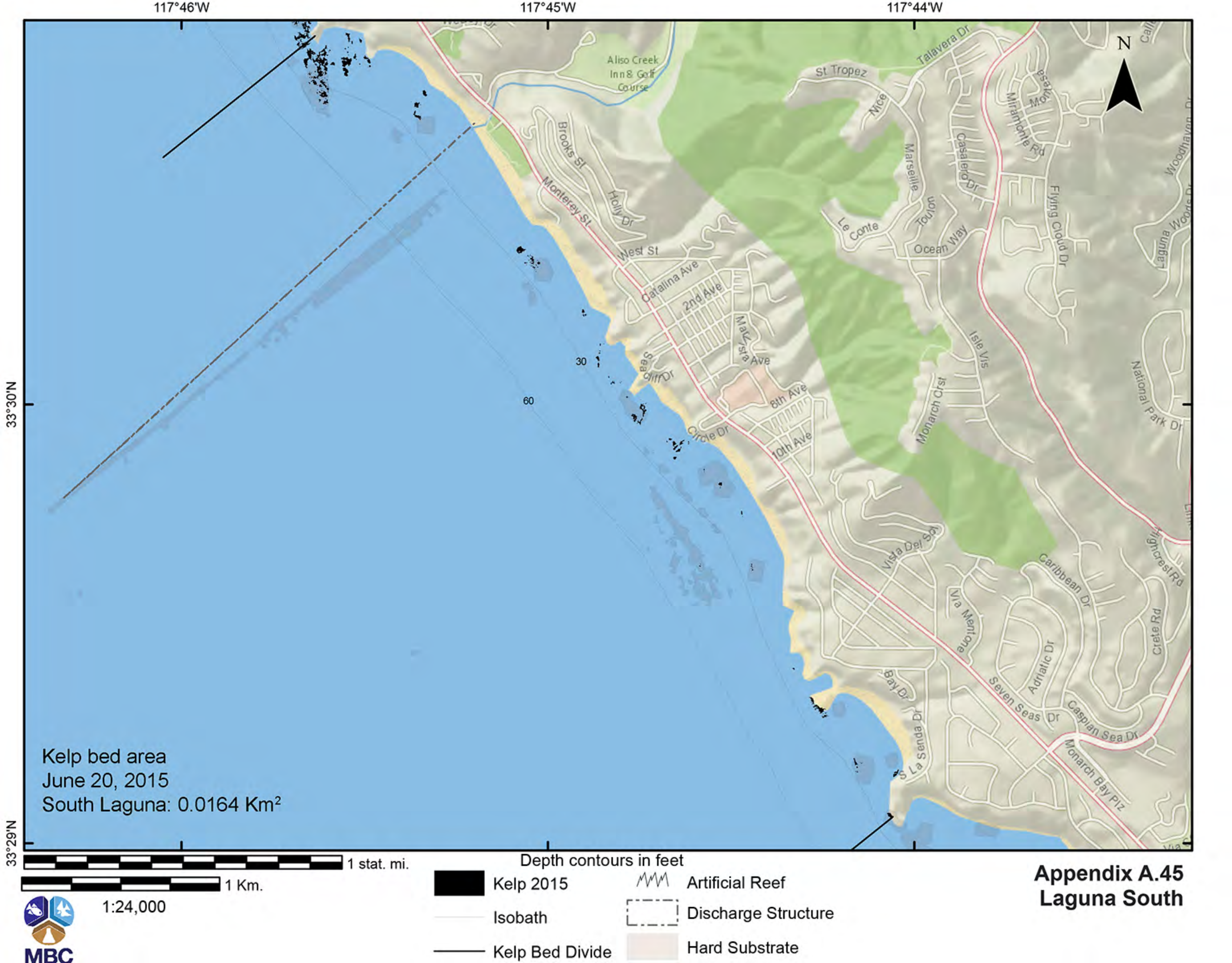
1:24,000

Depth contours in feet

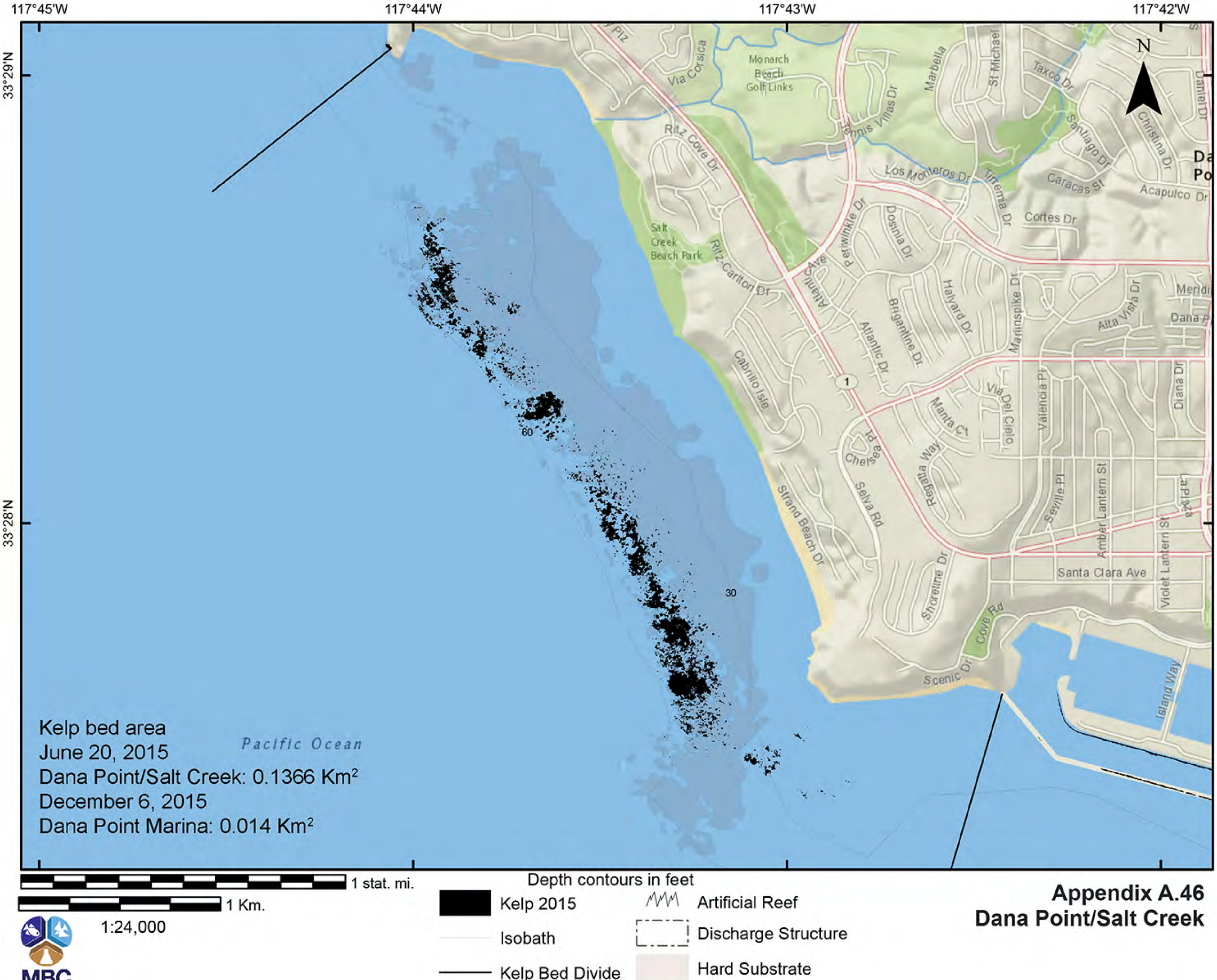
- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.44
Laguna South

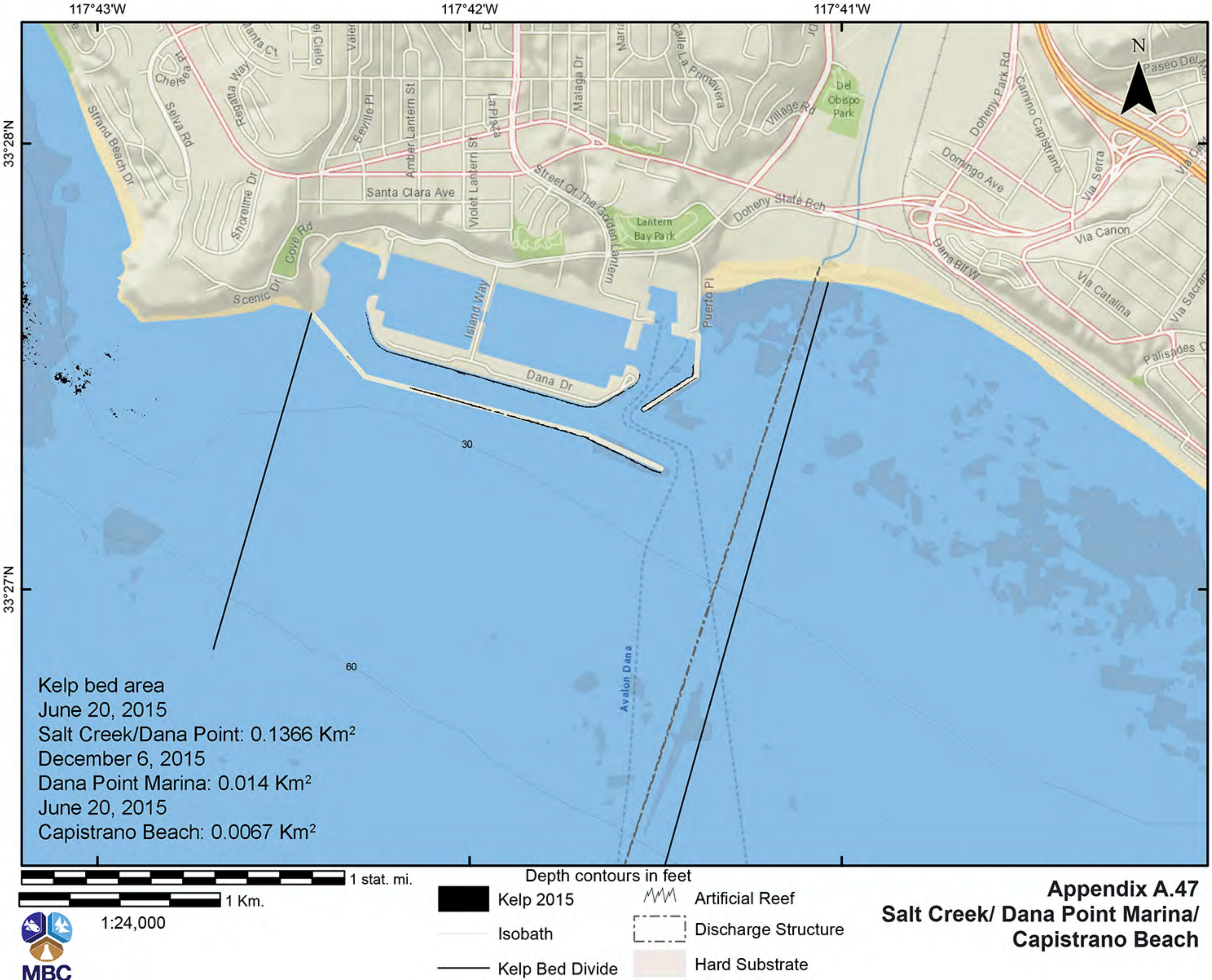
MBC



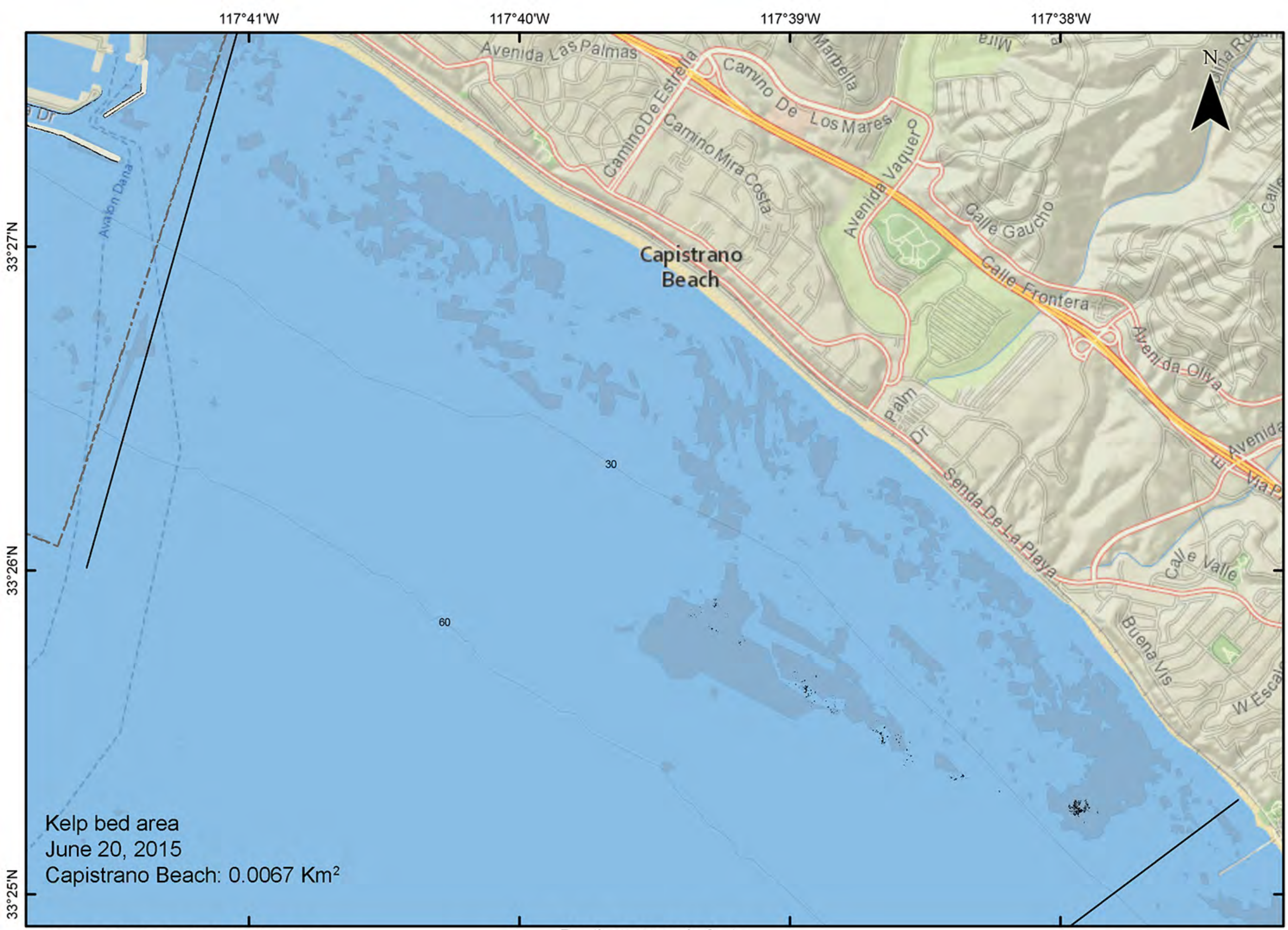
Appendix A.45
Laguna South



Appendix A.46
Dana Point/Salt Creek



Appendix A.47
Salt Creek/ Dana Point Marina/ Capistrano Beach



1 stat. mi.

1 Km.

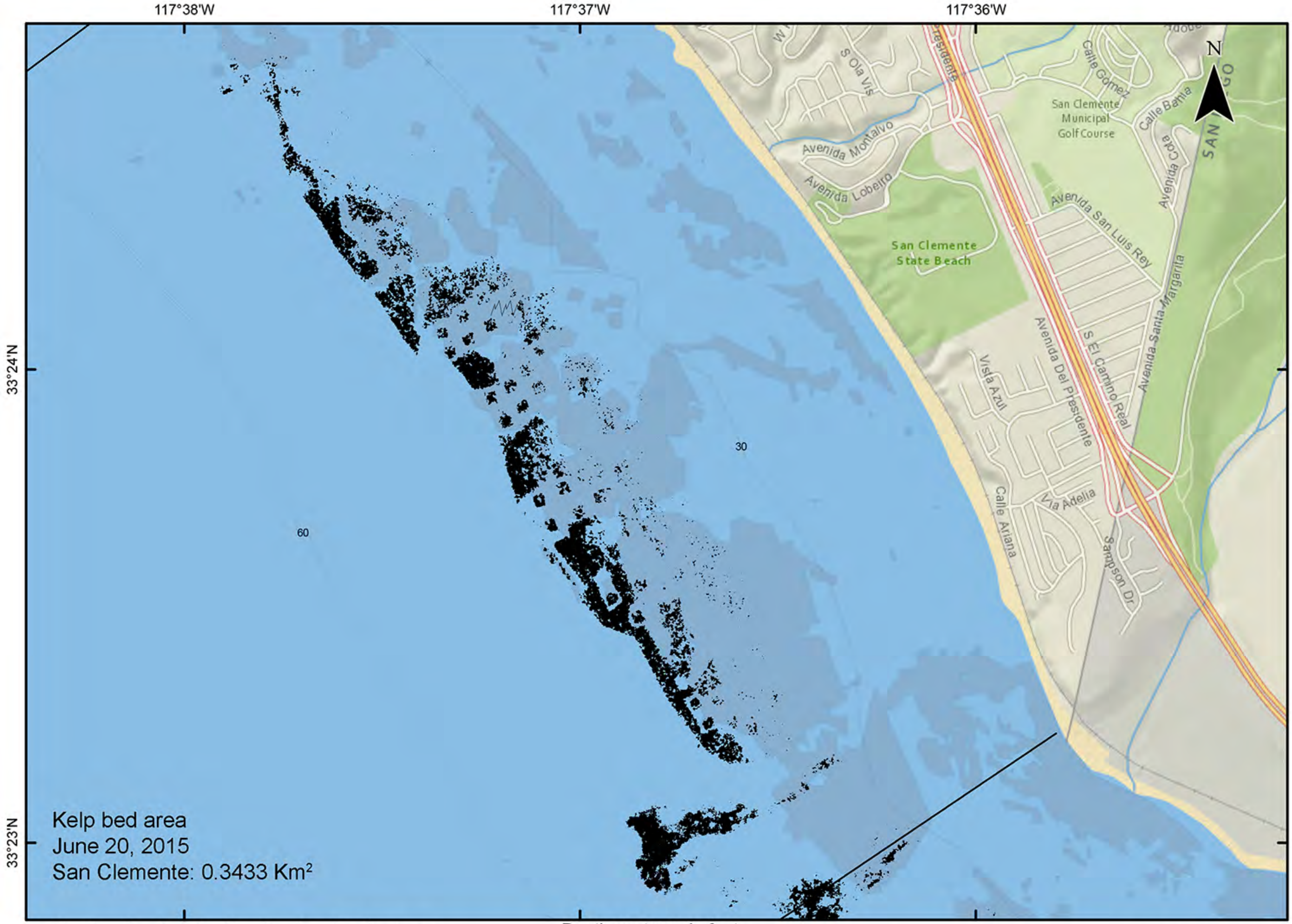
1:35,000

Depth contours in feet

- Kelp 2015
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

MBC

Appendix A.48
Capistrano Beach



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

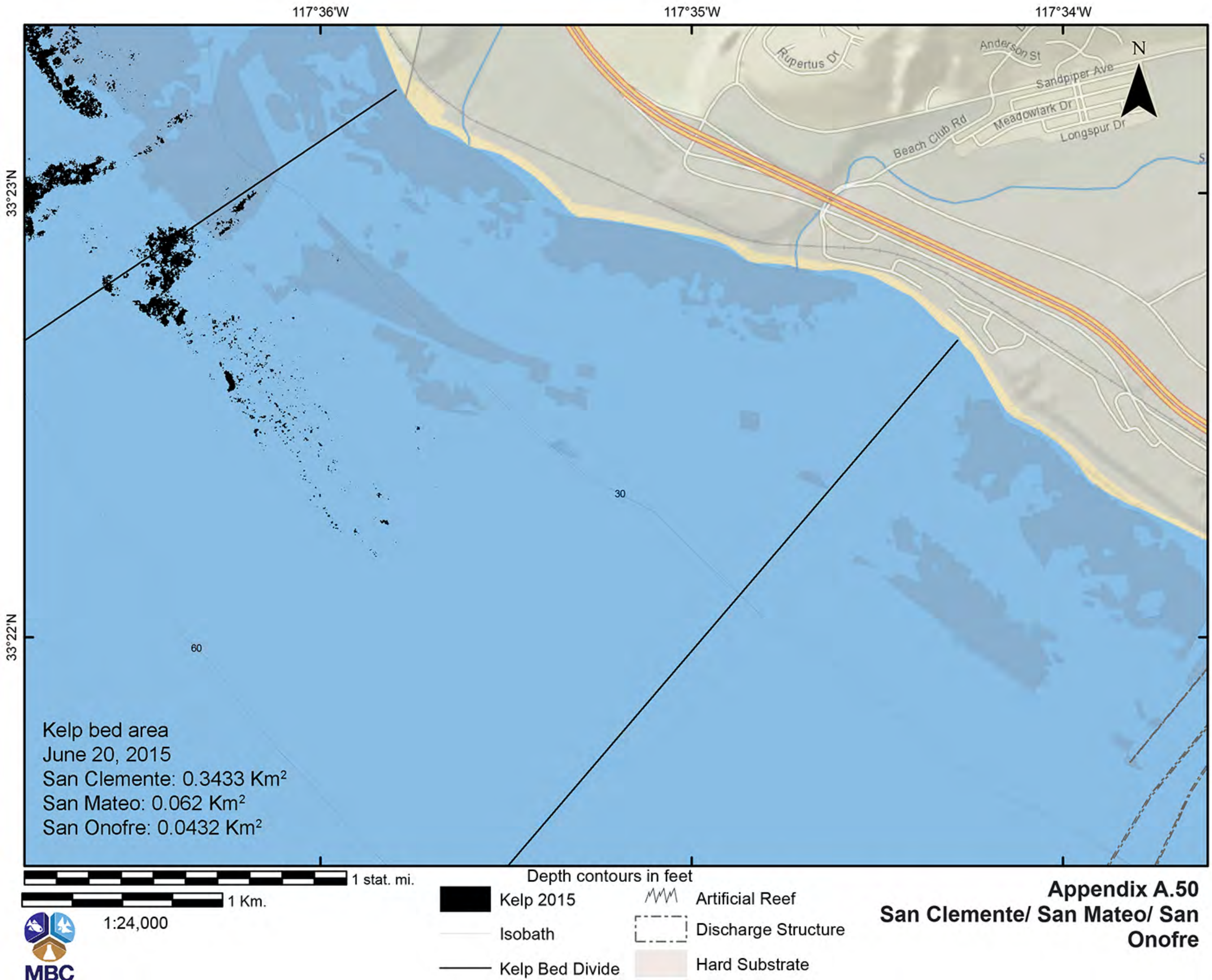
Artificial Reef

Discharge Structure

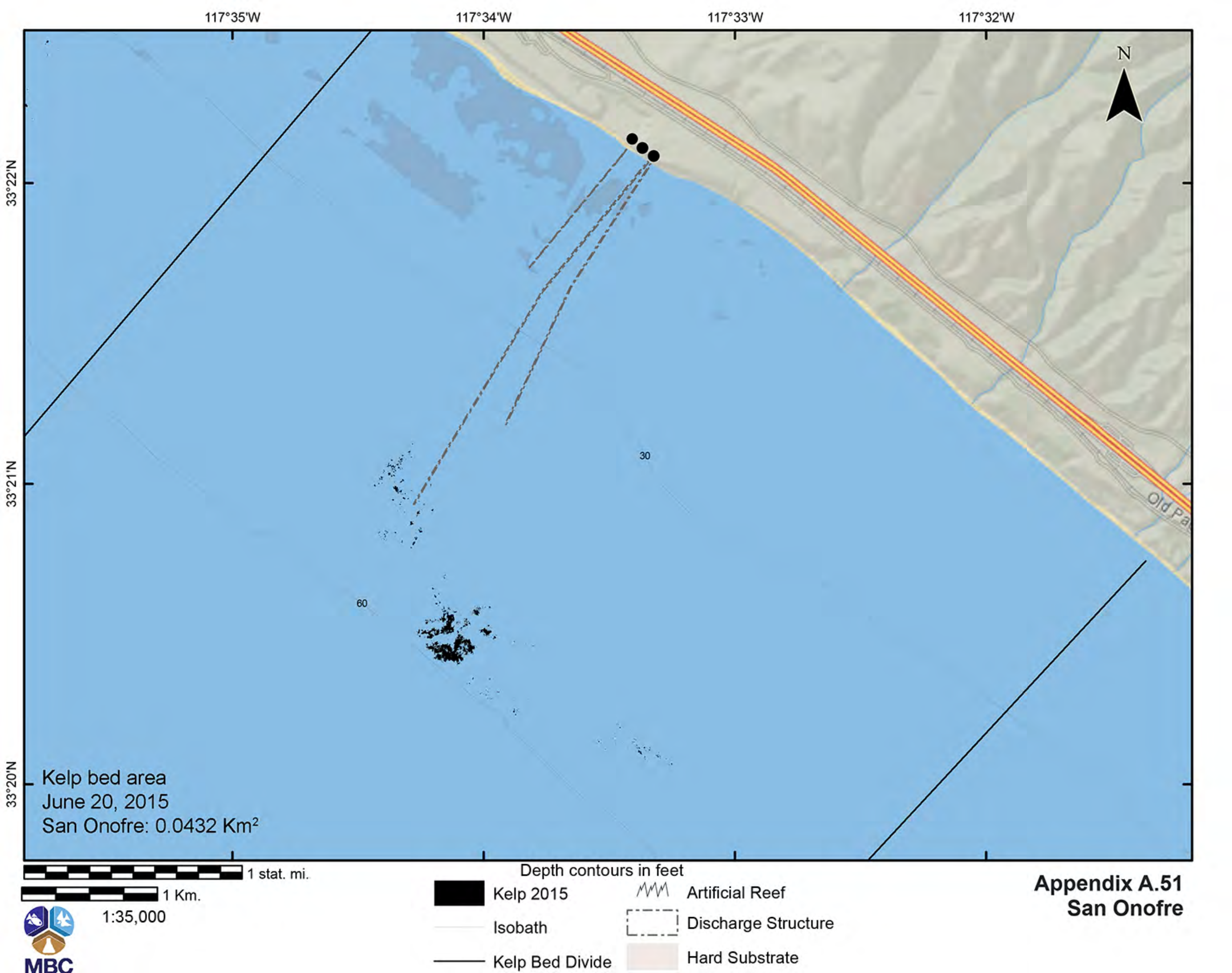
Hard Substrate

MBC

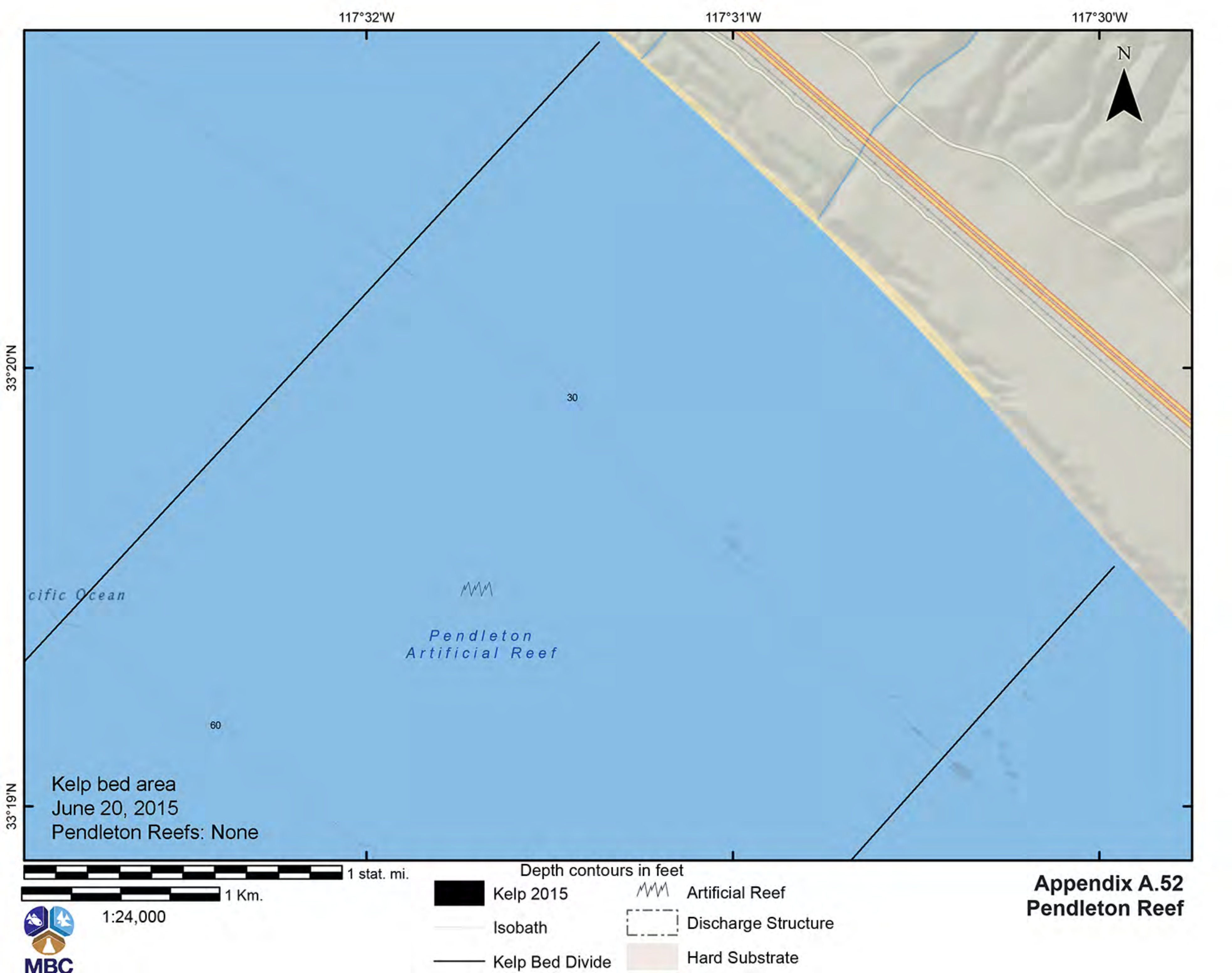
Appendix A.49
San Clemente



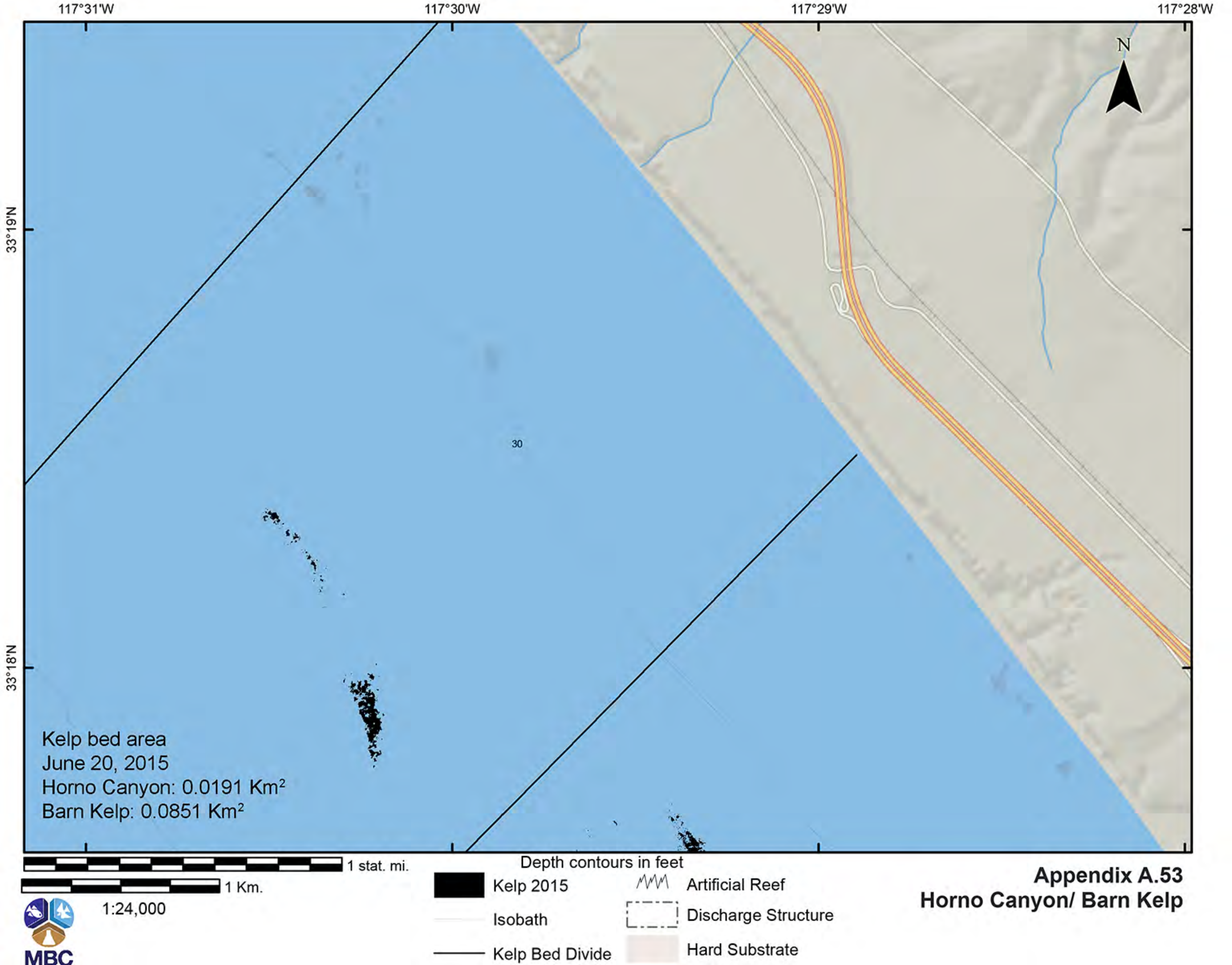
Appendix A.50
San Clemente/ San Mateo/ San Onofre



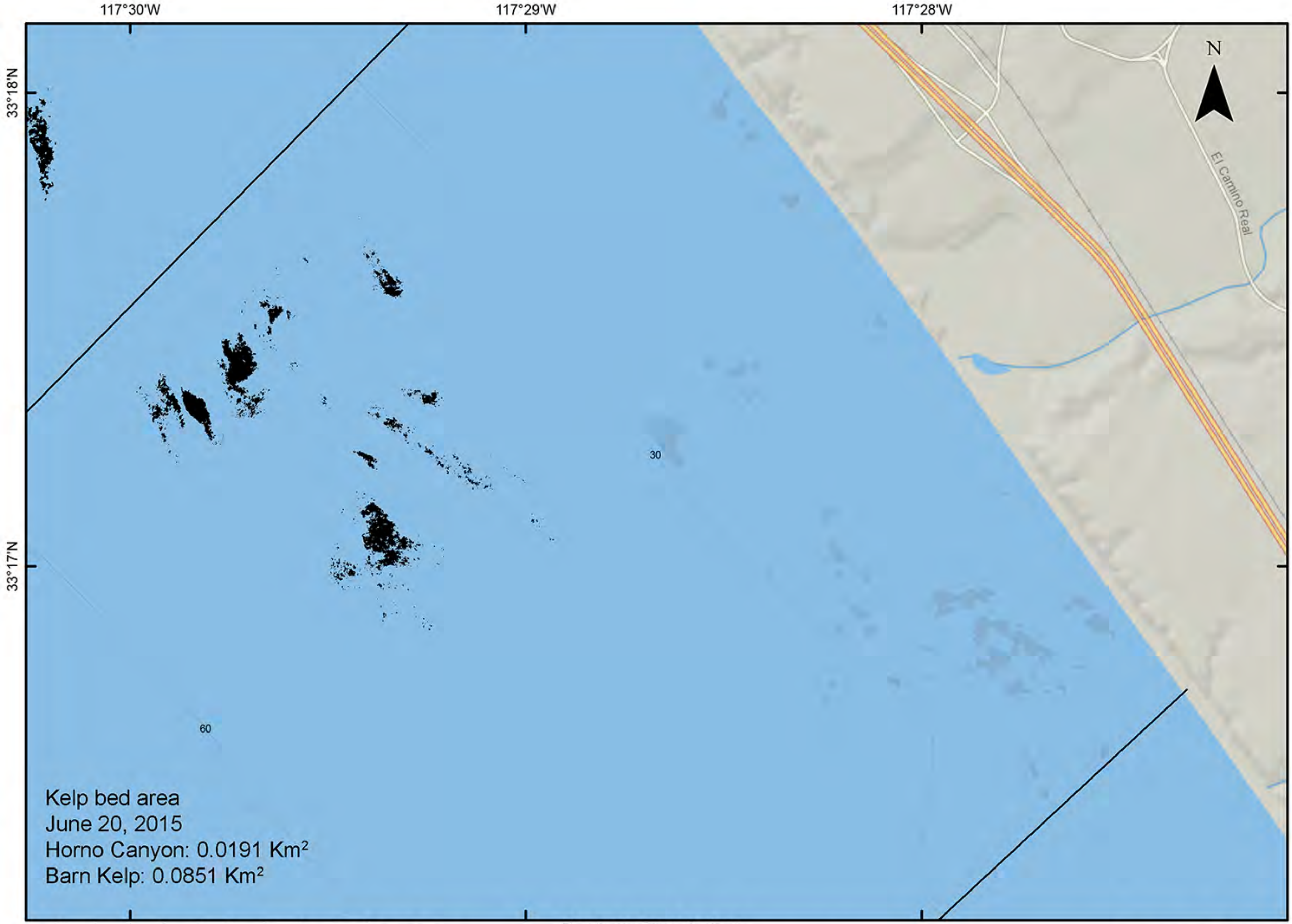
Appendix A.51
San Onofre



Appendix A.52
Pendleton Reef



Appendix A.53
Horno Canyon/ Barn Kelp



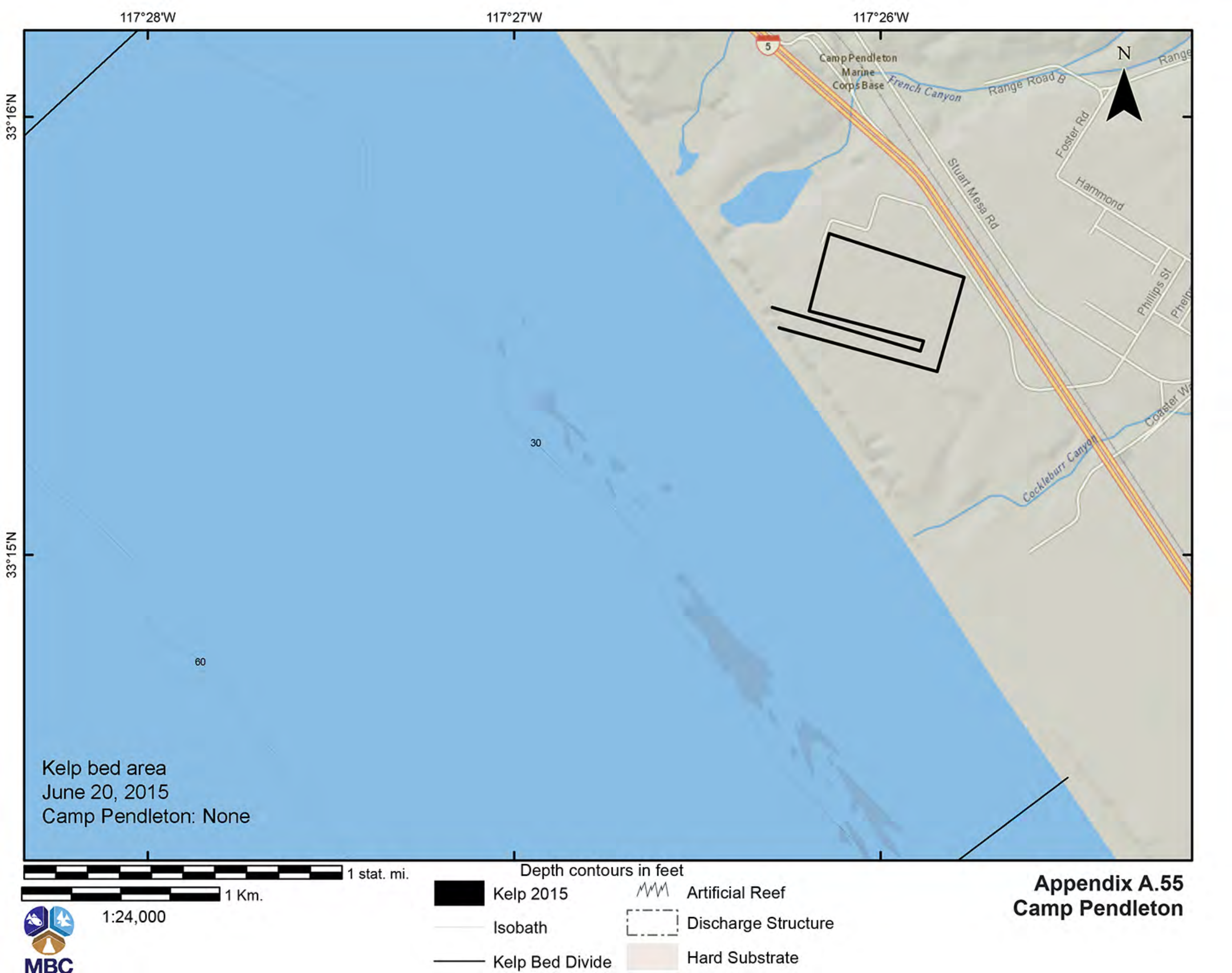
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

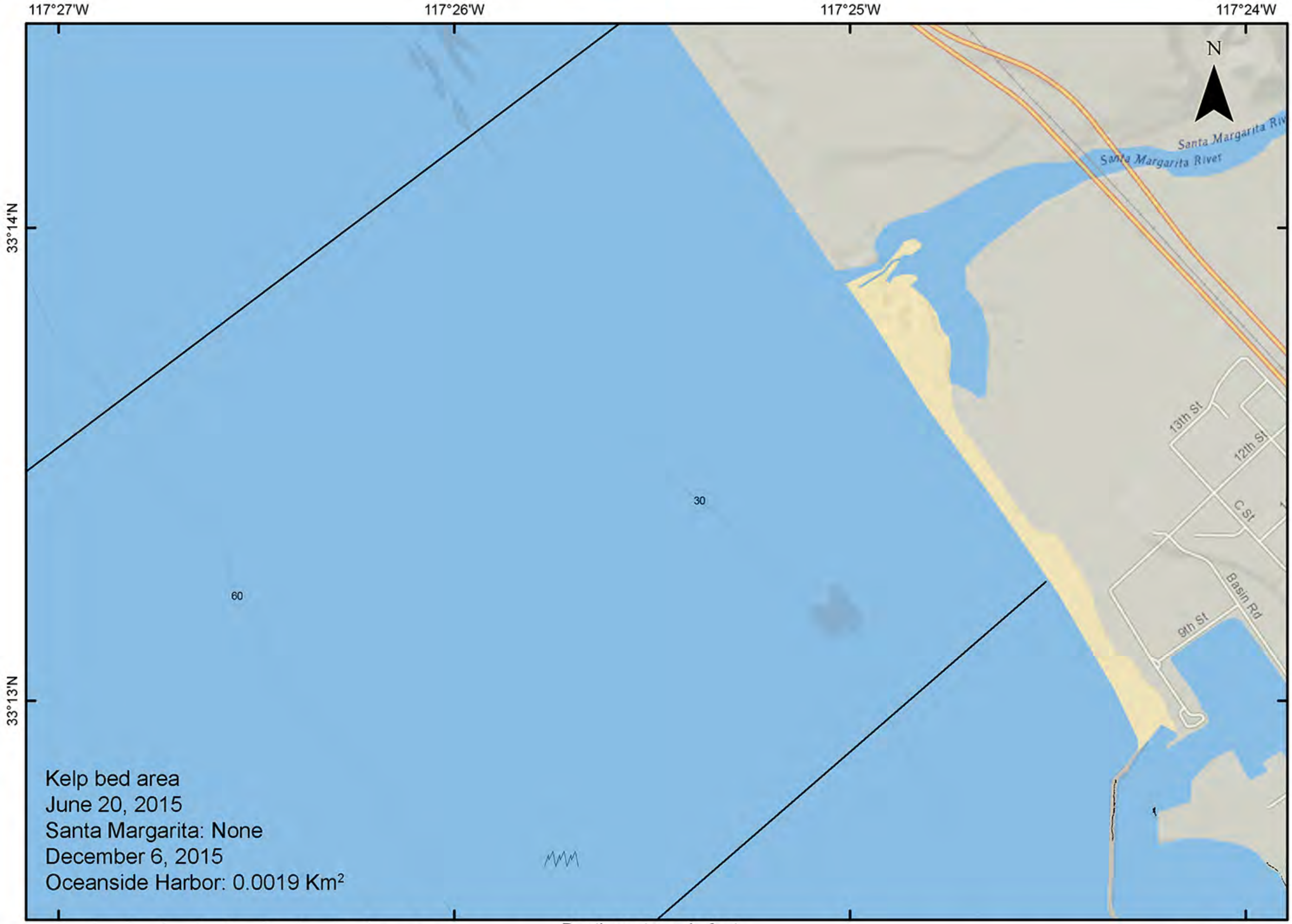
Kelp 2015
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

MBC

Appendix A.54
Horno Canyon/ Barn Kelp



Appendix A.55
Camp Pendleton



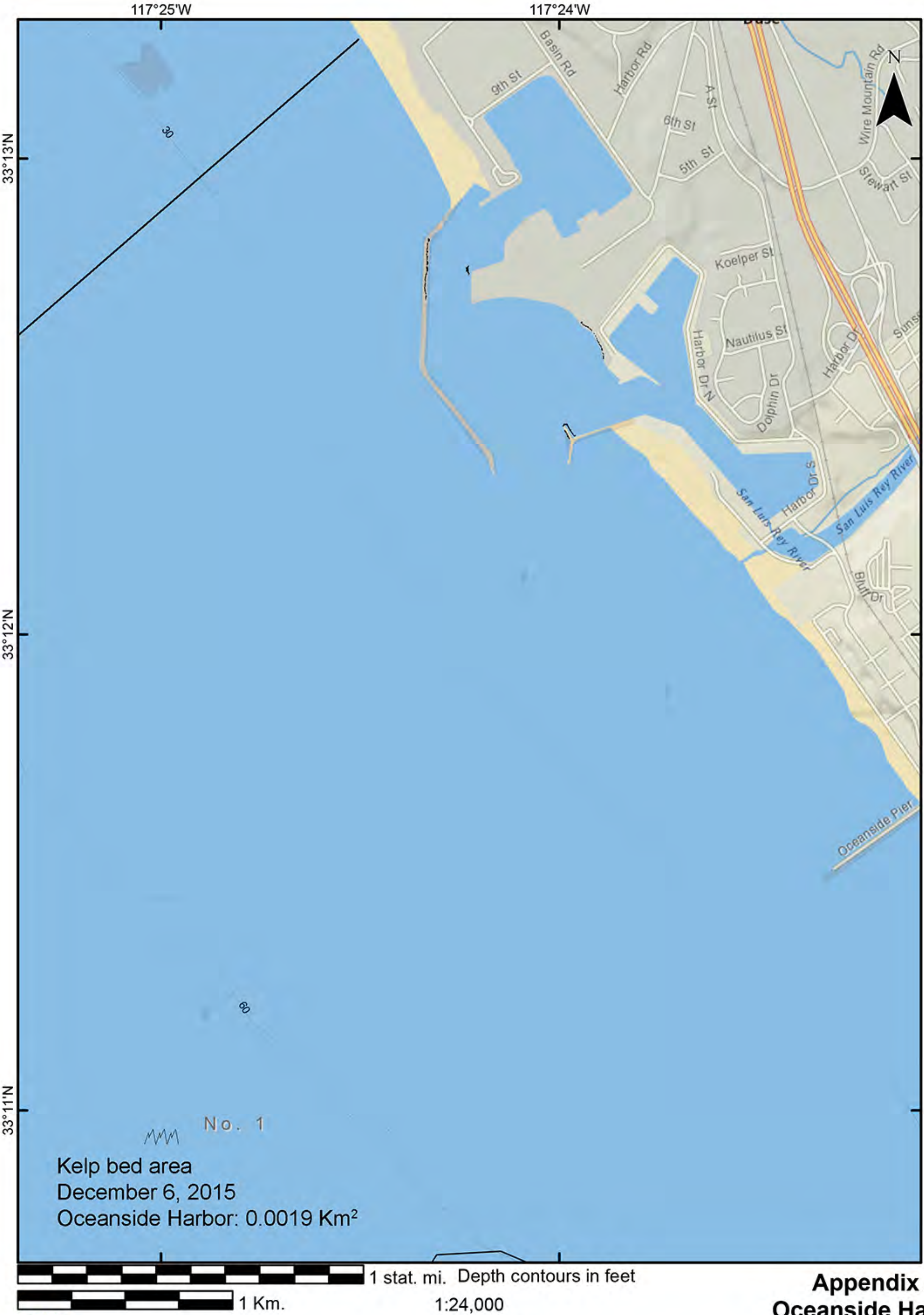
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

Kelp 2015
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.56
Santa Margarita/ Oceanside Harbor

MBC



Appendix A.57
Oceanside Harbor
and Pier

Kelp 2015 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate

MBC

1 stat. mi. Depth contours in feet

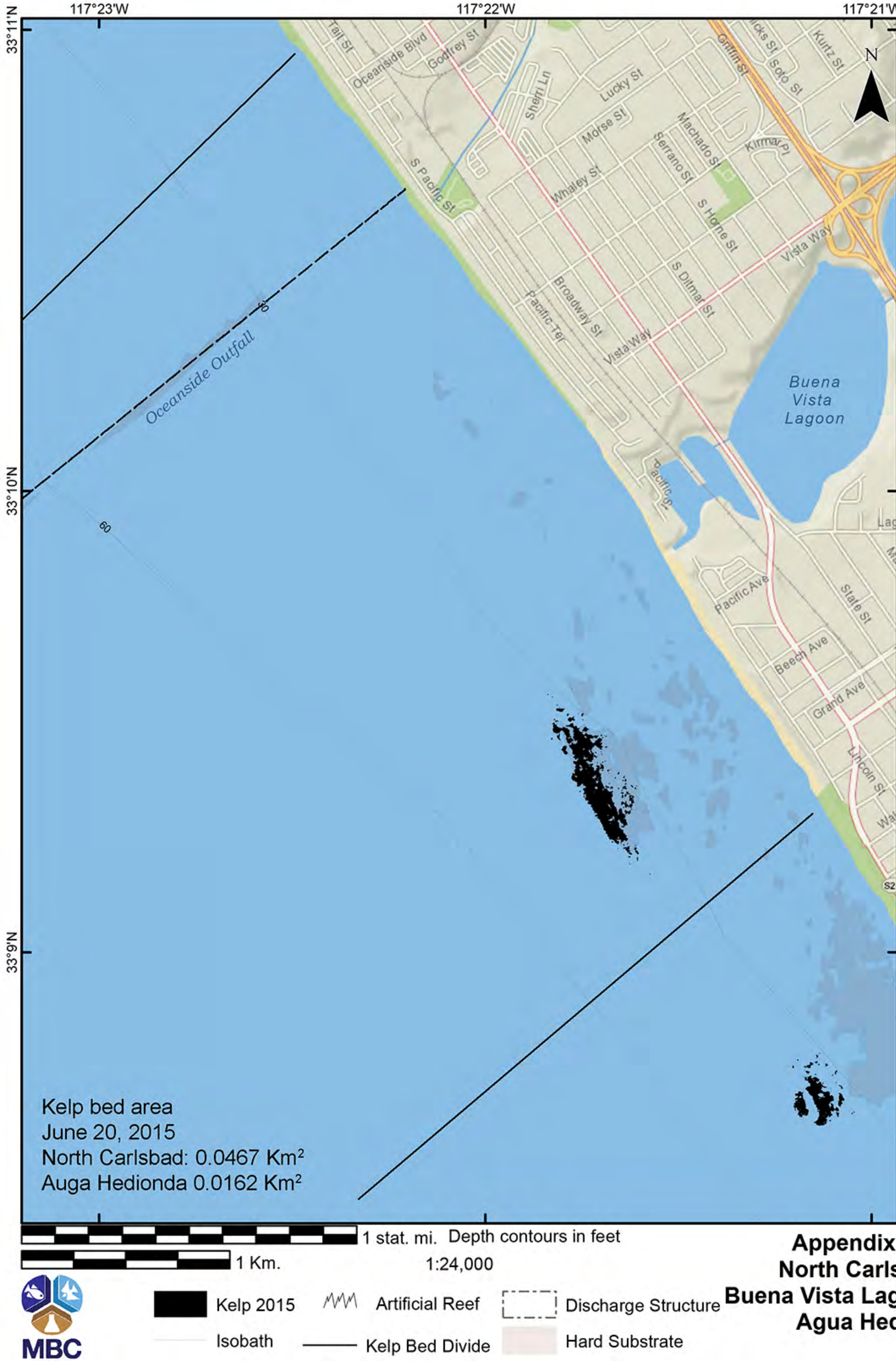
1 Km. 1:24,000

Kelp 2015 | Artificial Reef | Discharge Structure

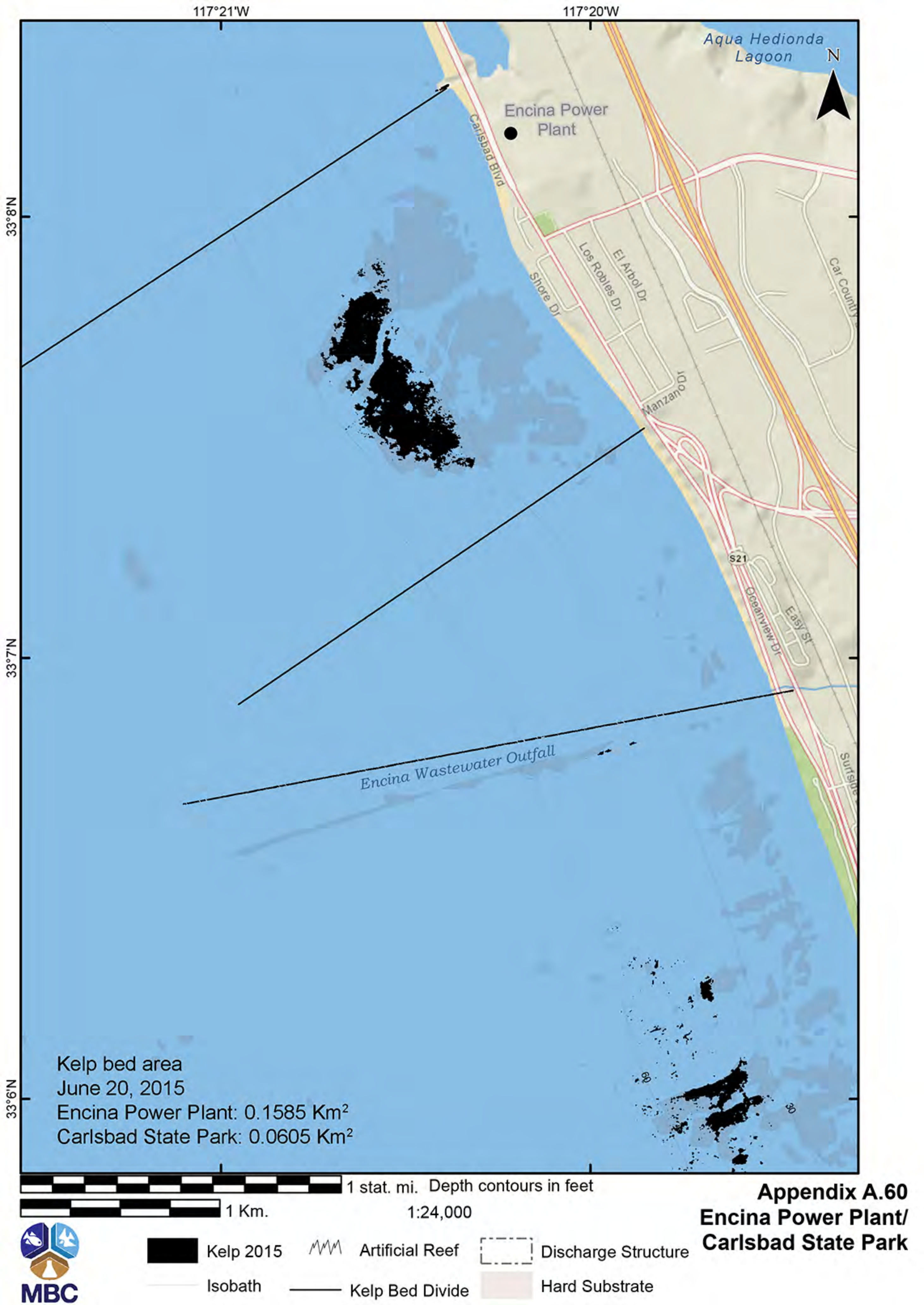
Isobath | Kelp Bed Divide | Hard Substrate

MBC

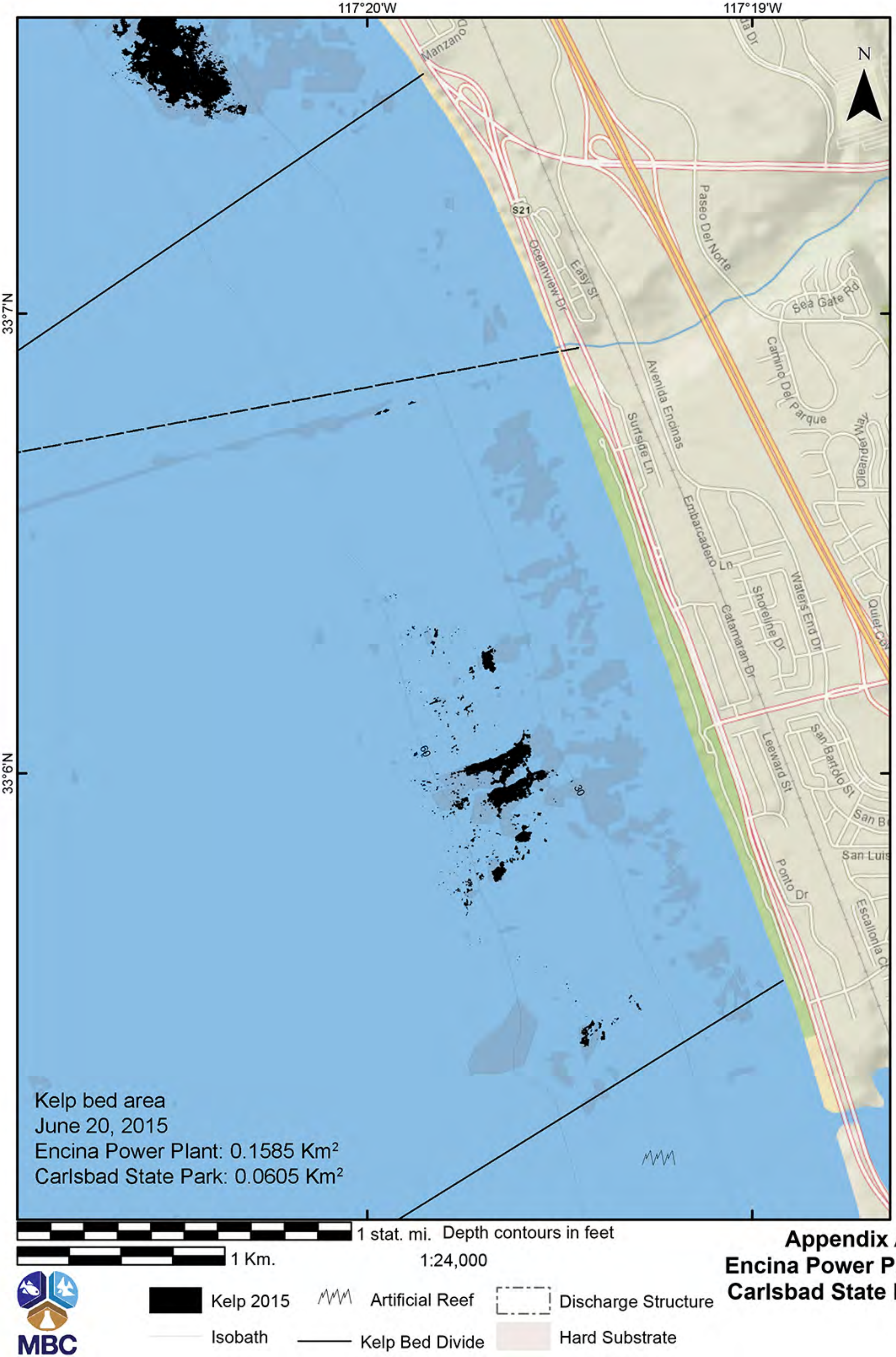
Appendix A.58 Oceanside Harbor/ Pier/ North Carlsbad



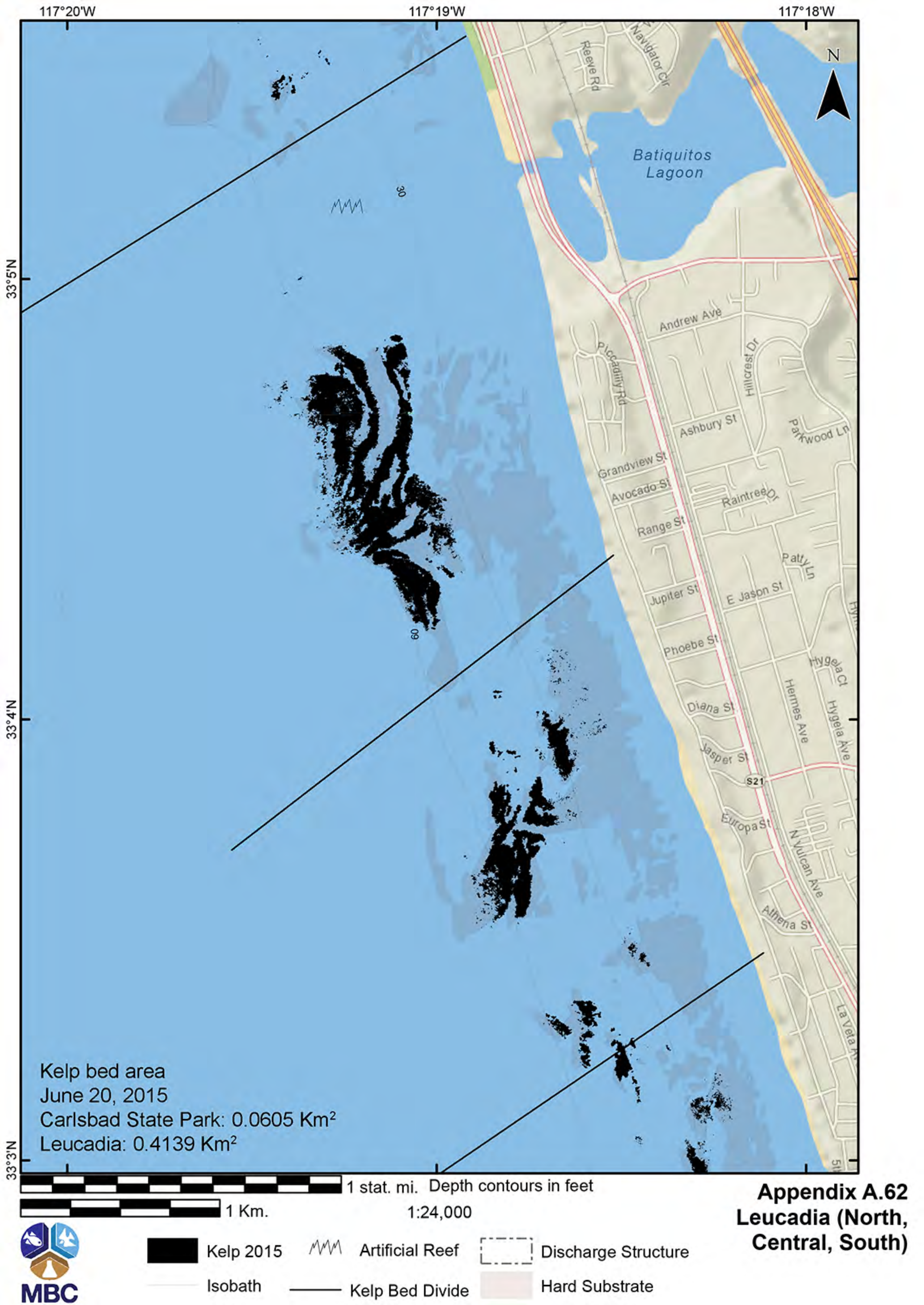
Appendix A.59
North Carlsbad/ Buena Vista Lagoon/ Agua Hediona



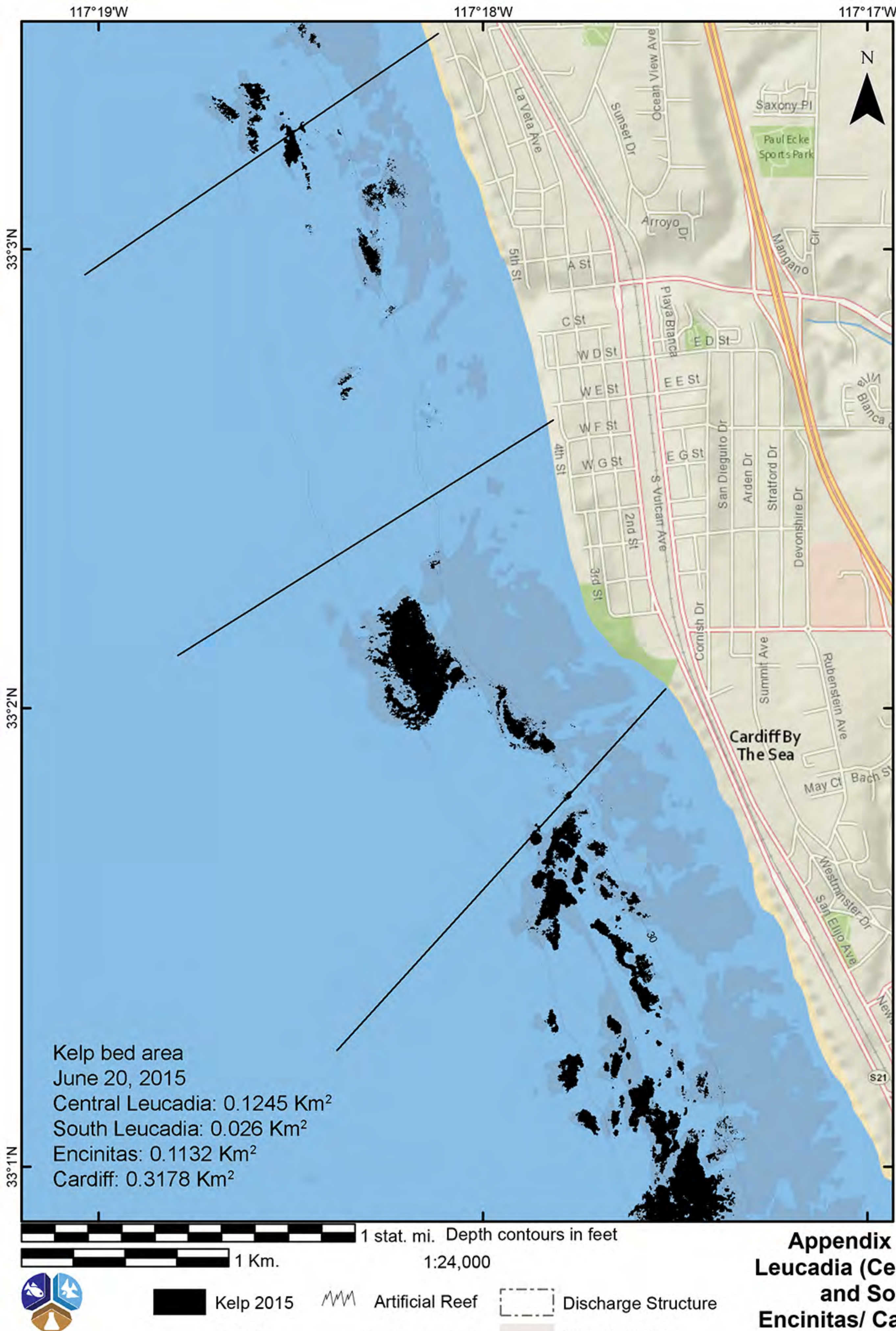
Appendix A.60
Encina Power Plant/
Carlsbad State Park



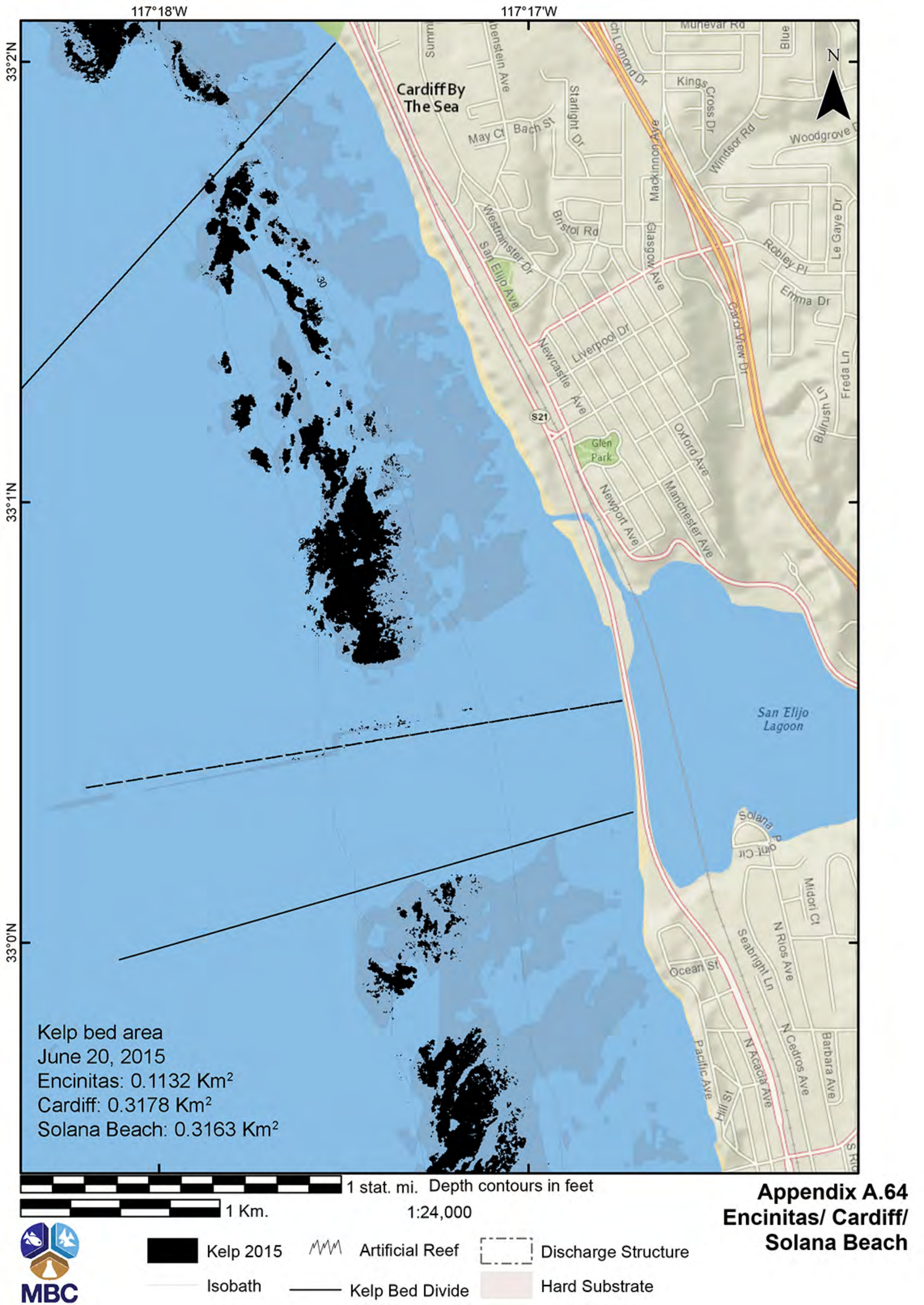
Appendix A.61
Encina Power Plant/ Carlsbad State Park



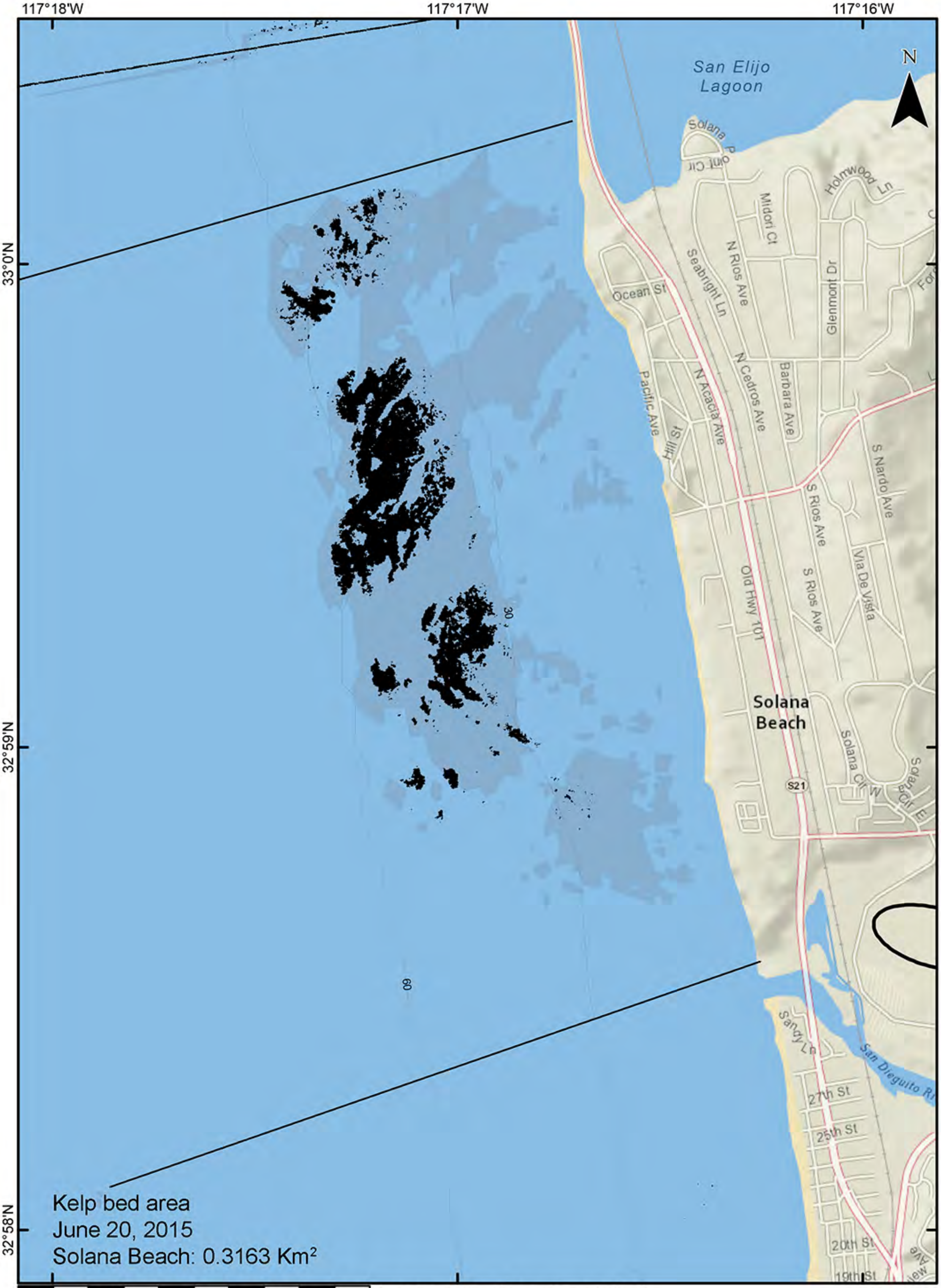
Appendix A.62
Leucadia (North, Central, South)



Appendix A.63 Leucadia (Central and South)/ Encinitas/ Cardiff



Appendix A.64 Encinitas/ Cardiff/ Solana Beach



1 stat. mi. Depth contours in feet

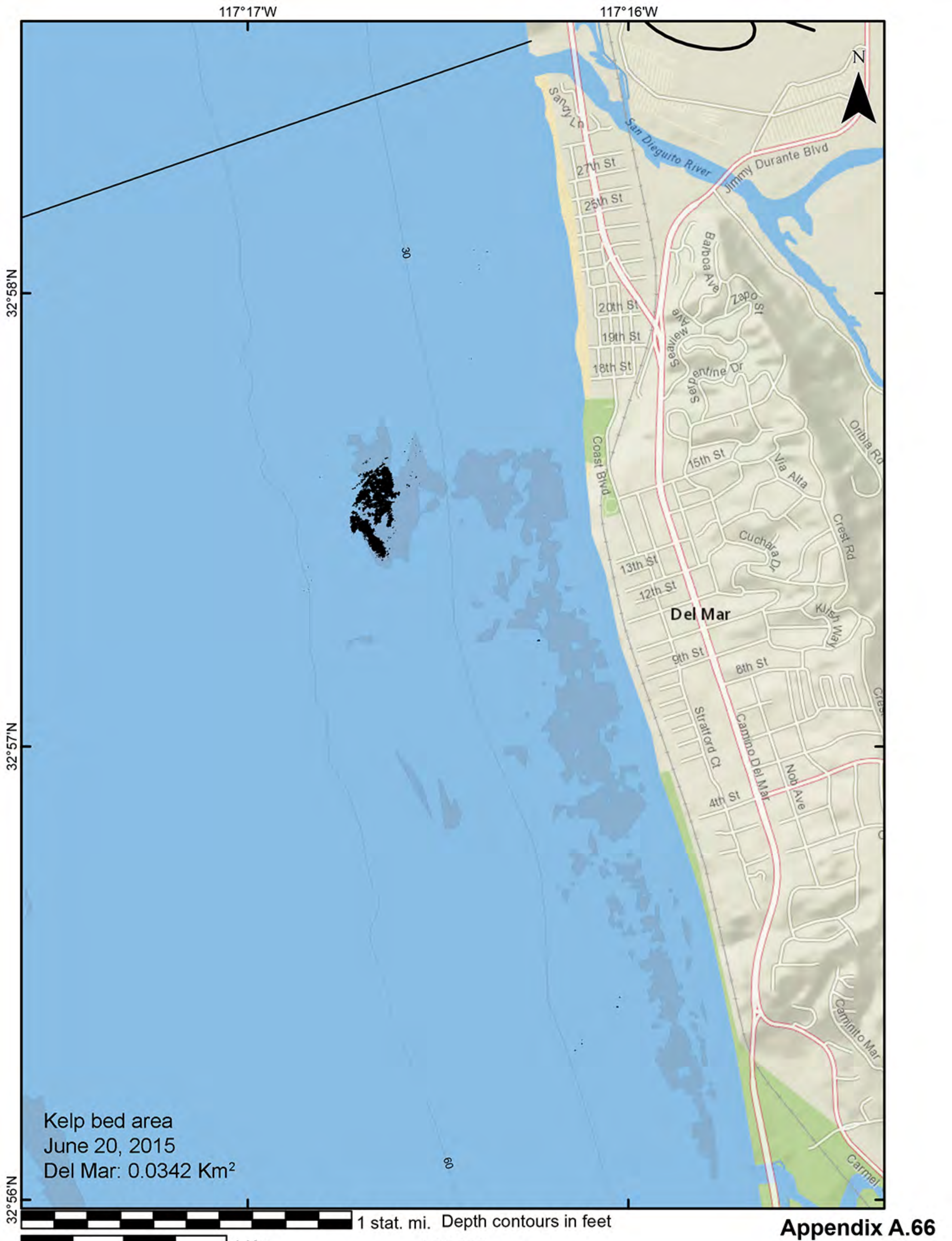
1 Km. 1:24,000

Appendix A.65
Solana Beach

MBC

Kelp 2015 | Artificial Reef | Discharge Structure

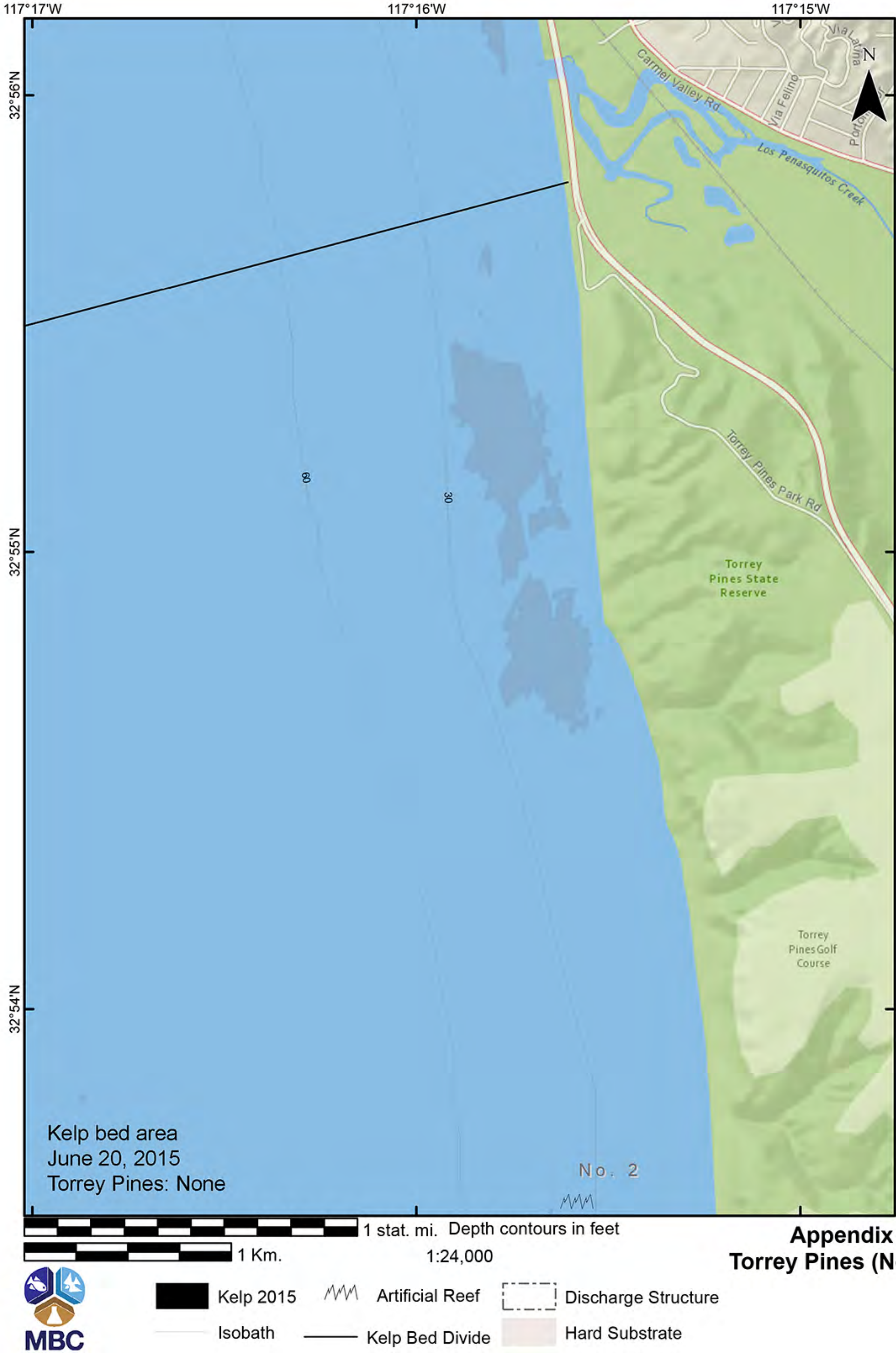
Isobath | Kelp Bed Divide | Hard Substrate



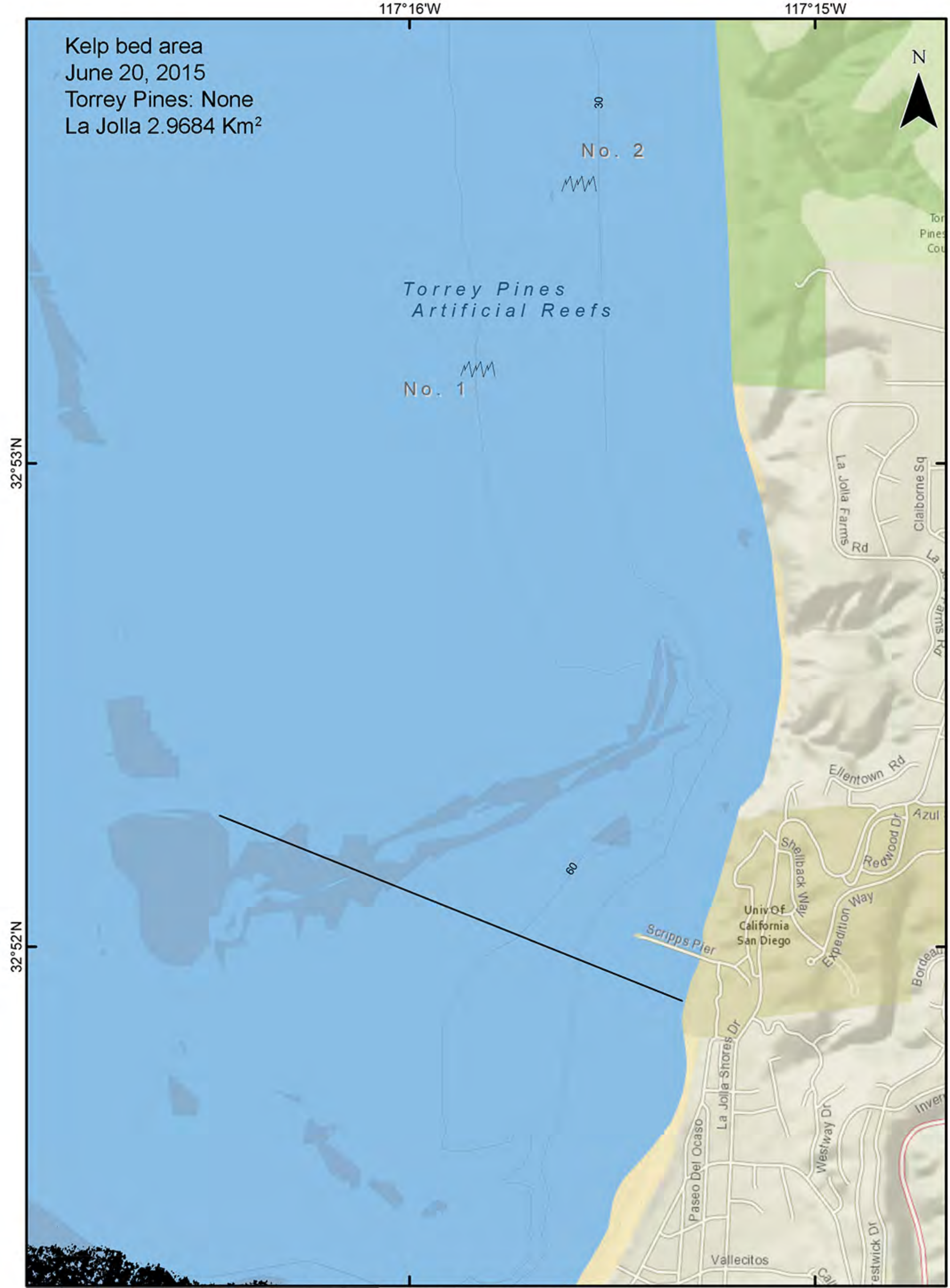
Appendix A.66
Del Mar

Kelp 2015 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate

MBC



Appendix A.67
Torrey Pines (North)



1 stat. mi. Depth contours in feet

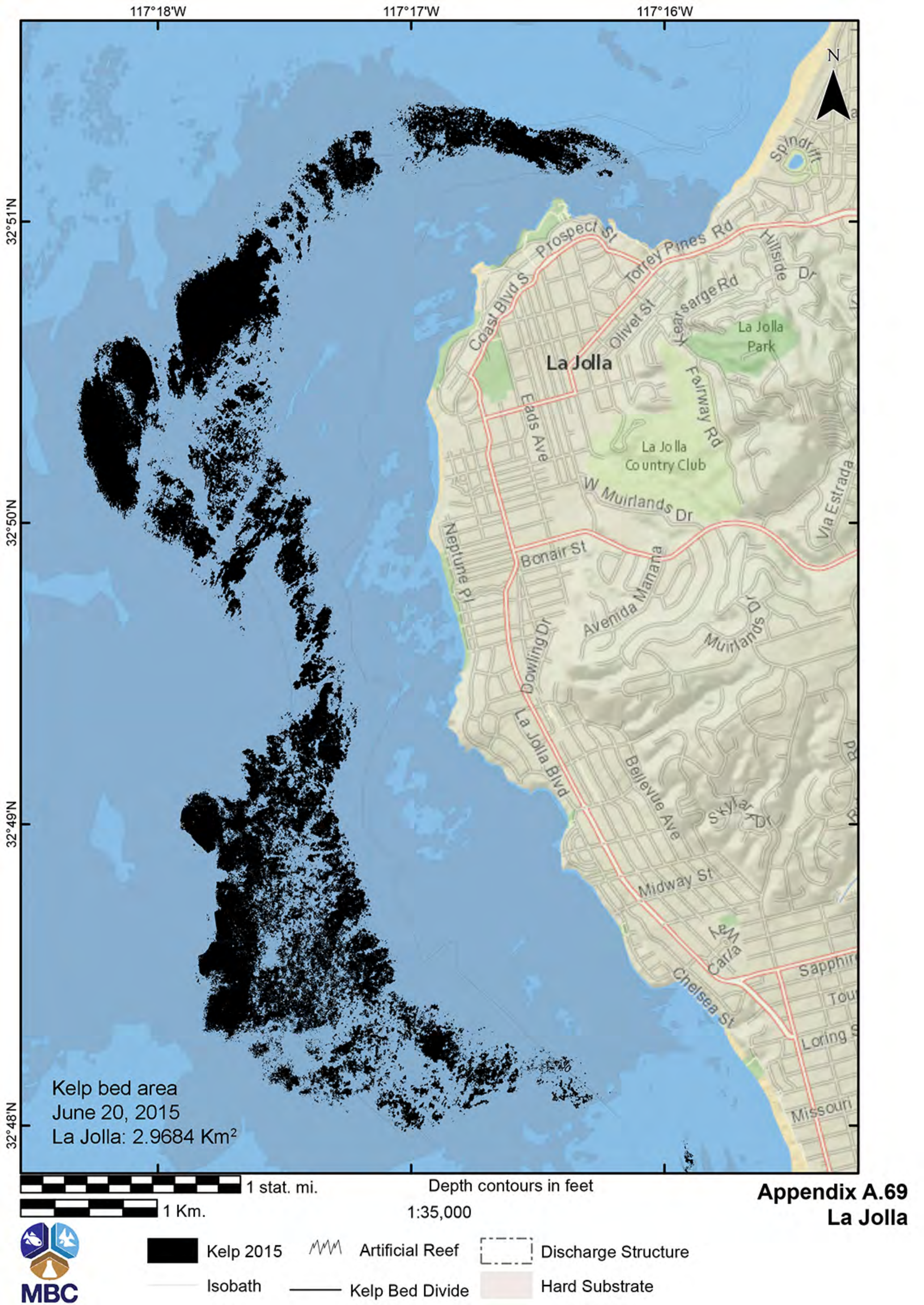
1 Km. 1:24,000

Kelp 2015 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

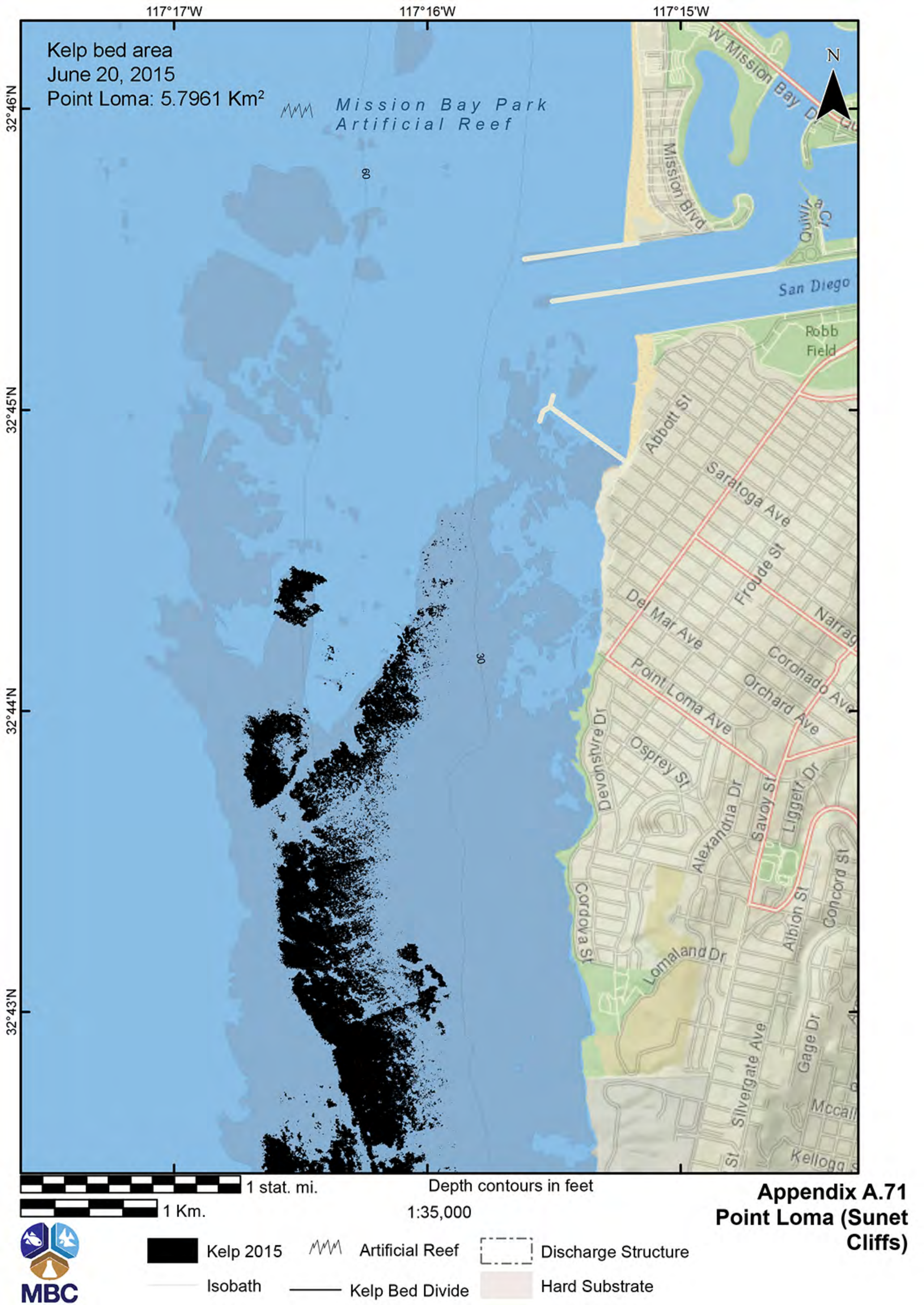
MBC

Appendix A.68
Torrey Pines Reef
(South)

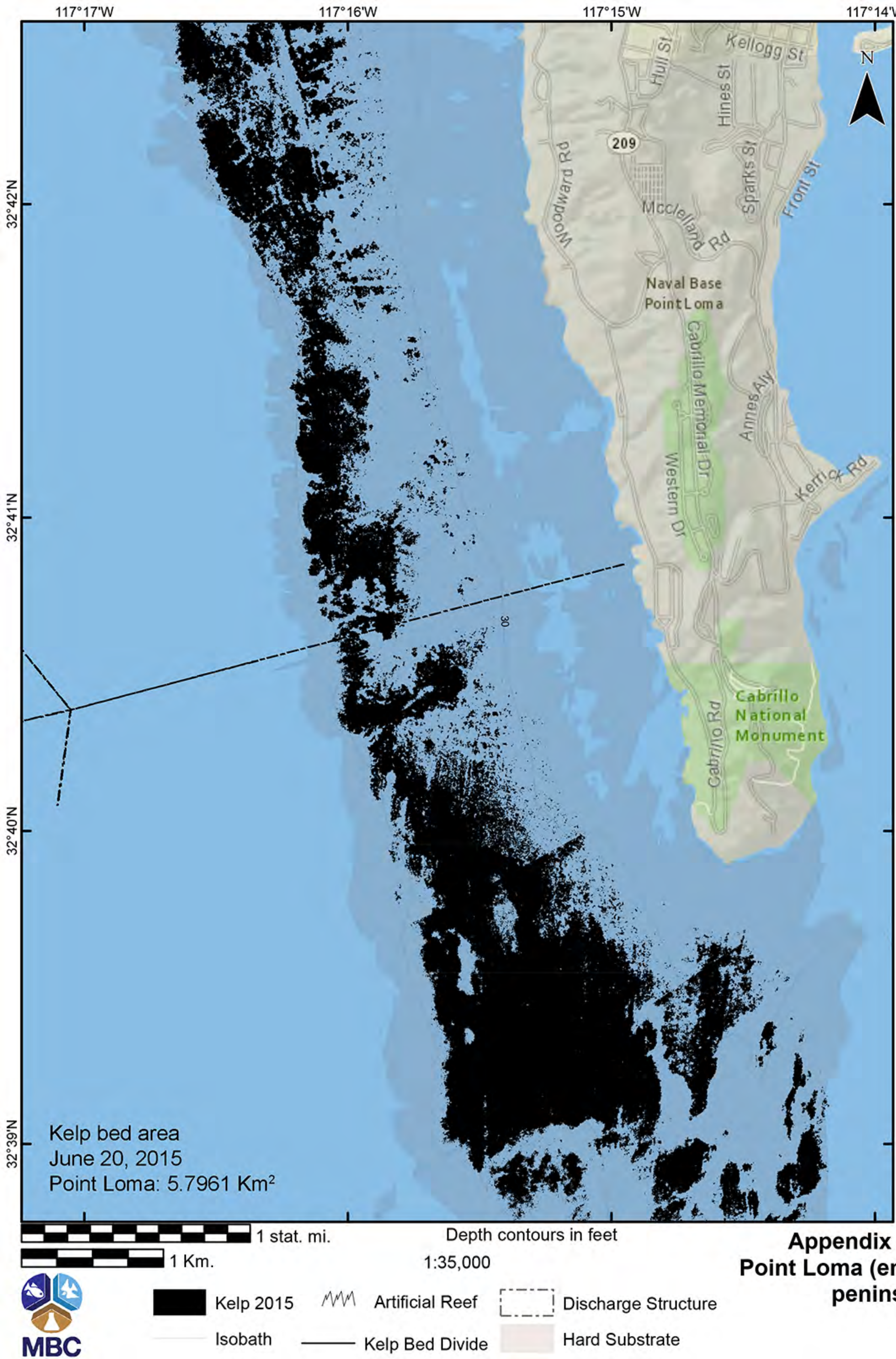


Appendix A.69
La Jolla

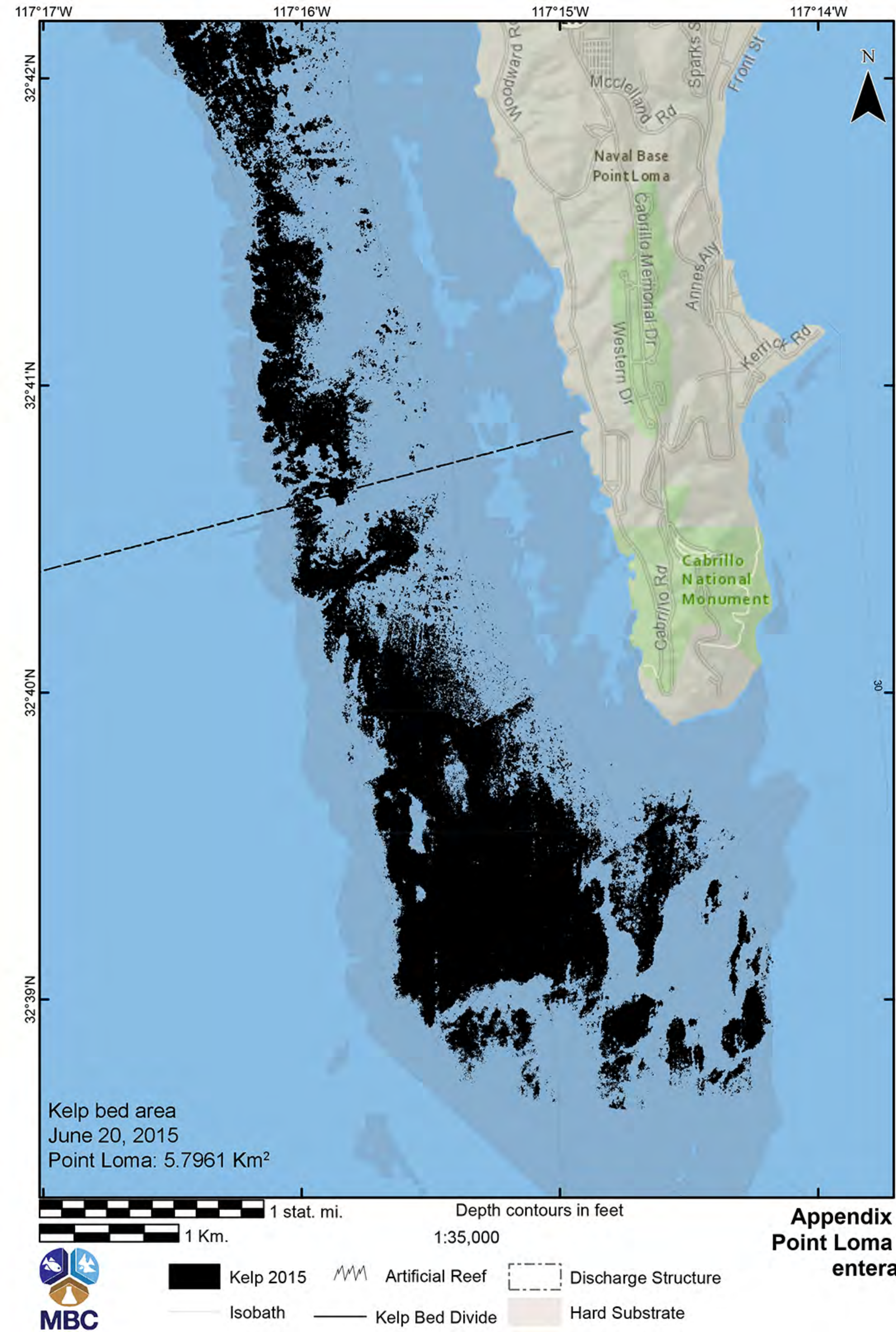
Appendix A.70
La Jolla/ Mission Bay



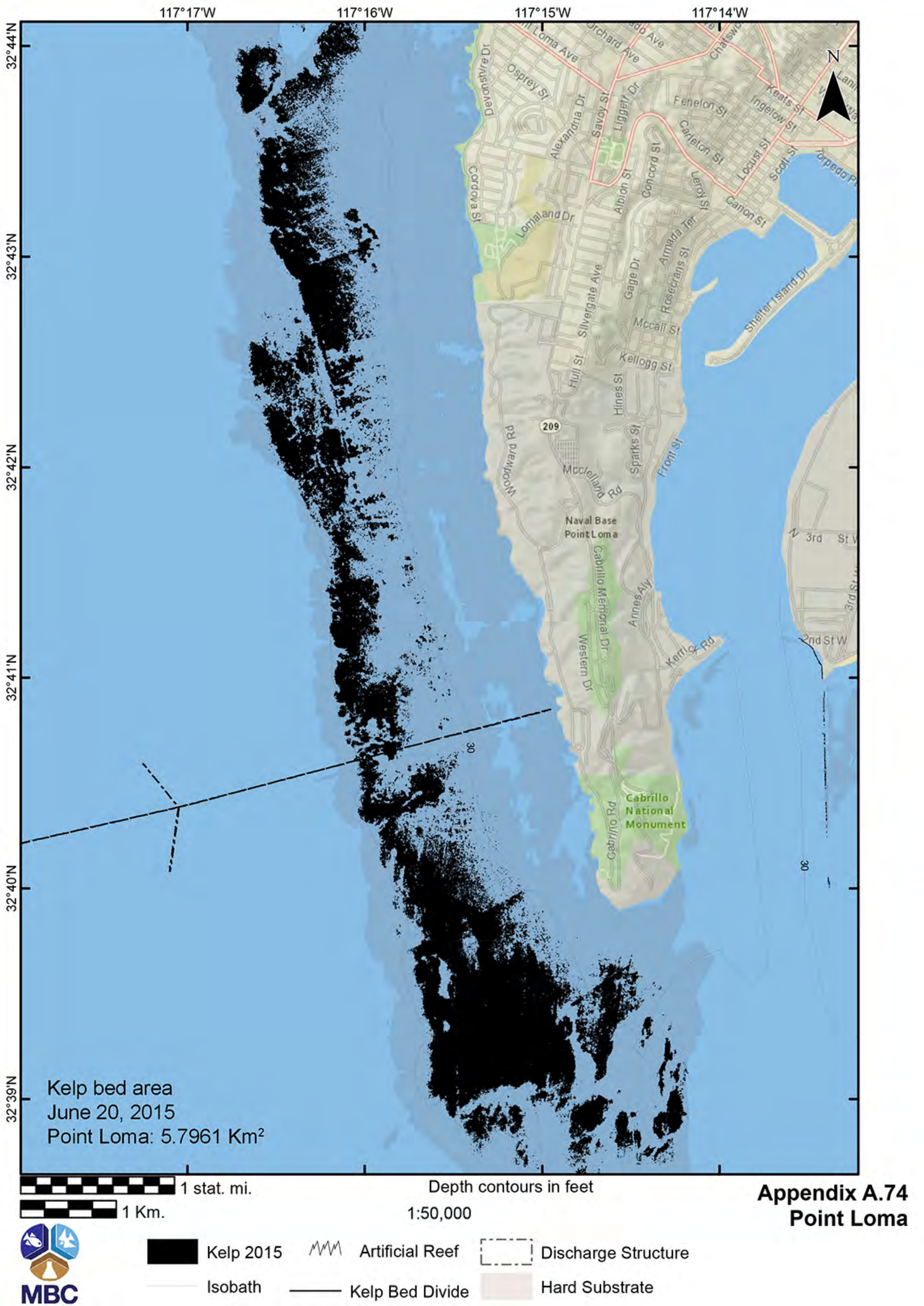
Appendix A.71
Point Loma (Sunet Cliffs)



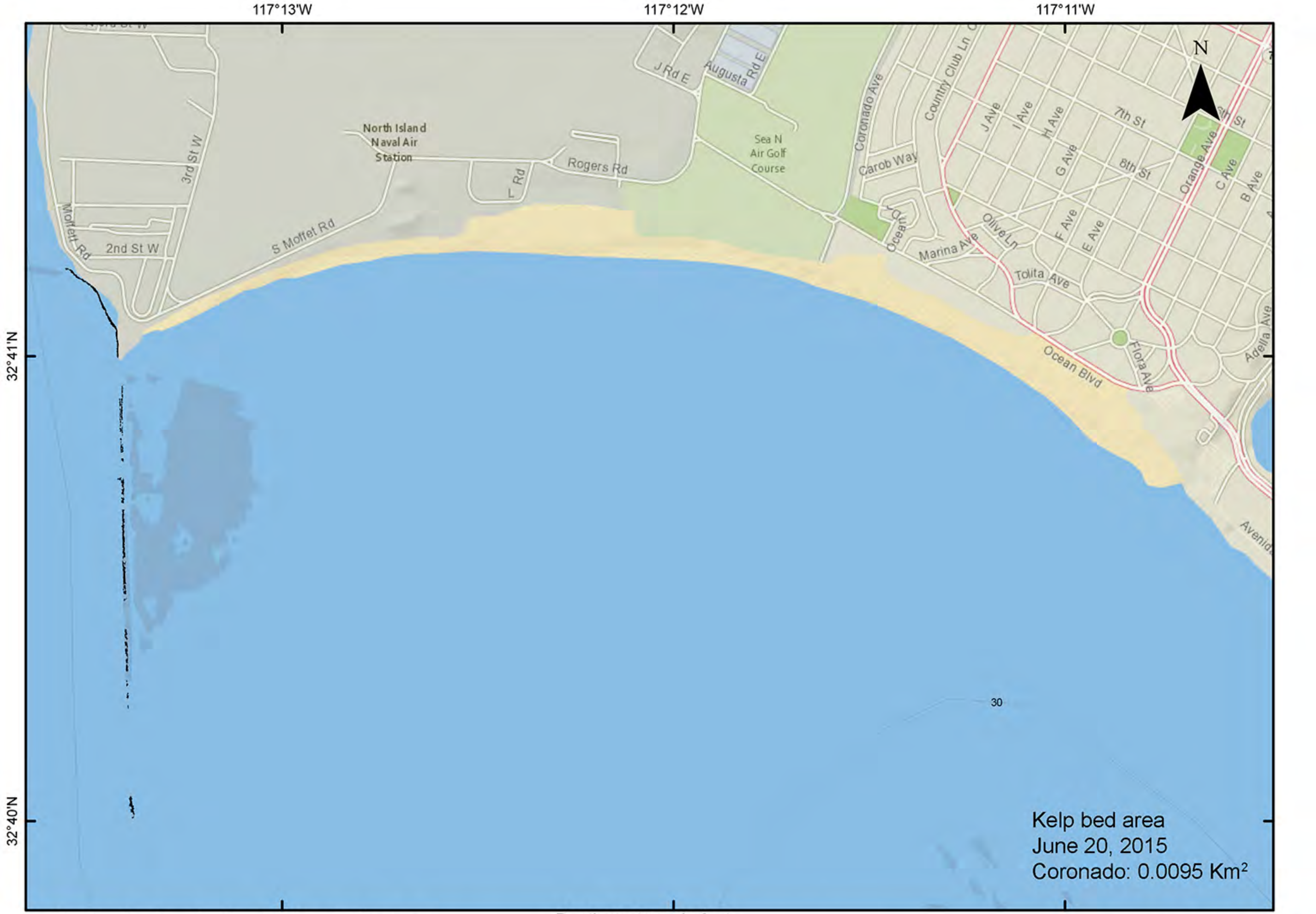
Appendix A.72
Point Loma (end of peninsula)



Appendix A.73
Point Loma (bay enterance)



Appendix A.74
Point Loma



1 stat. mi.

1 Km.

1:24,000

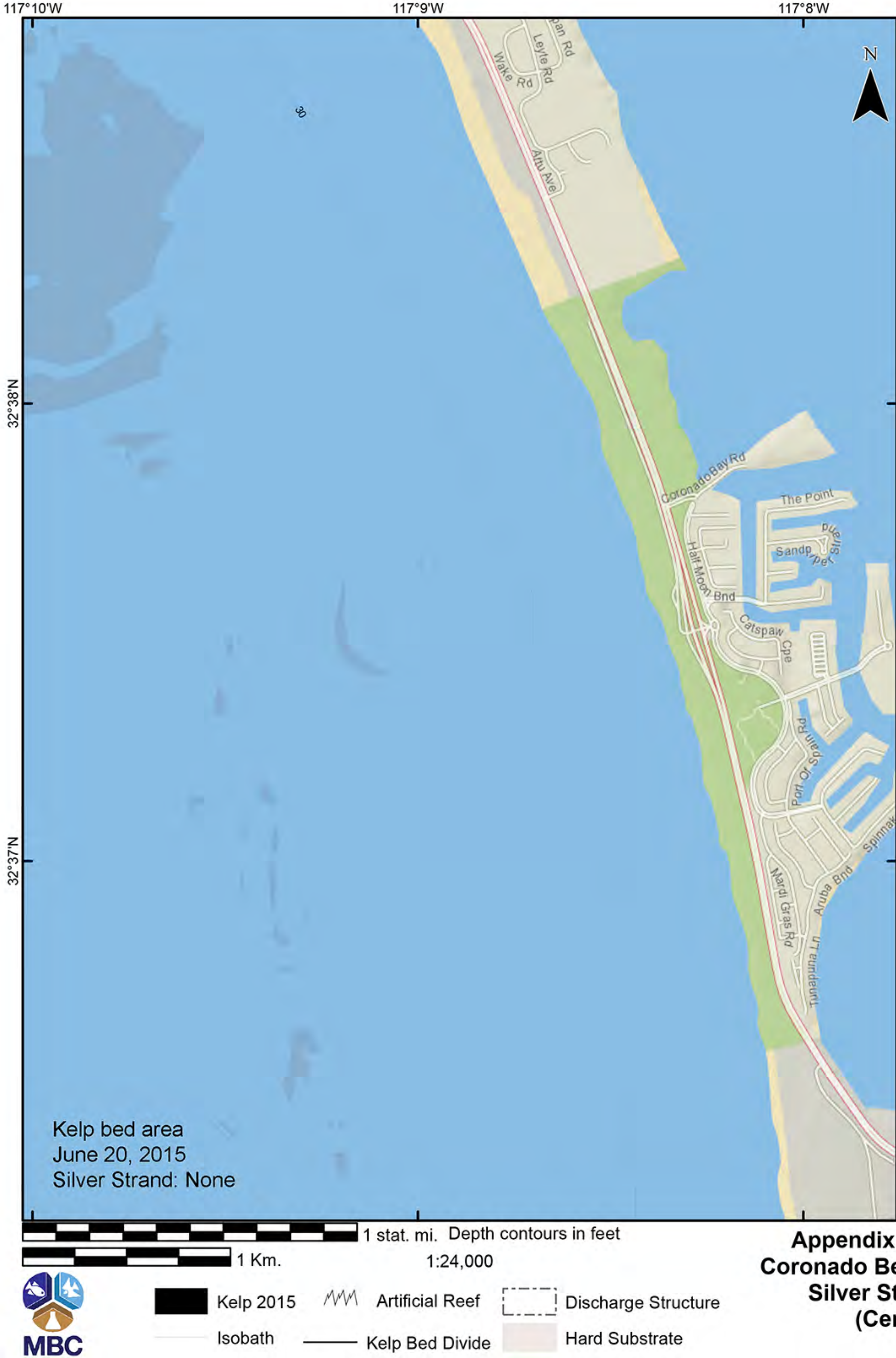
Depth contours in feet

Kelp 2015	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

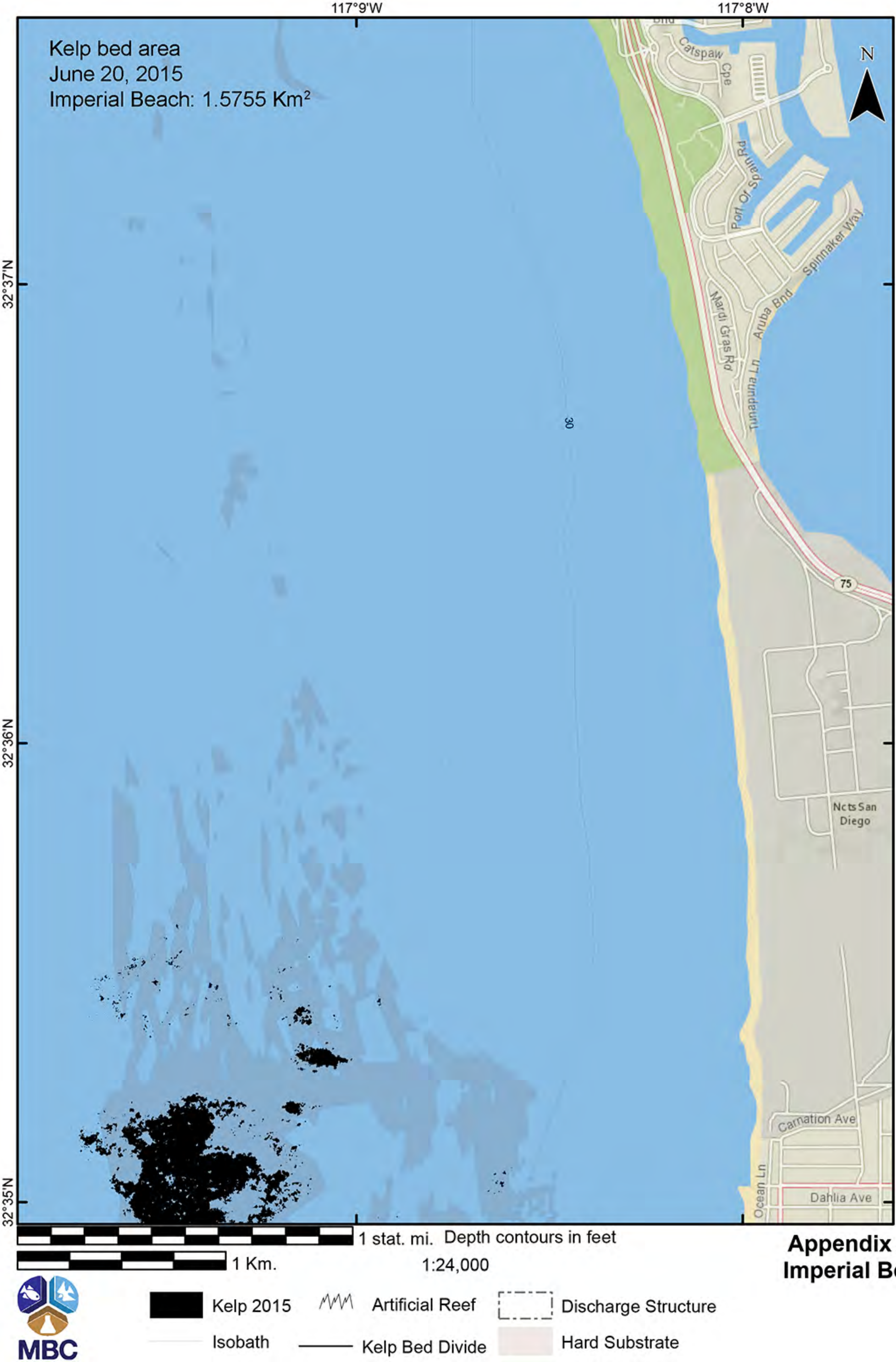
MBC

Appendix A.75
Coronado (North Island Naval Air Station)

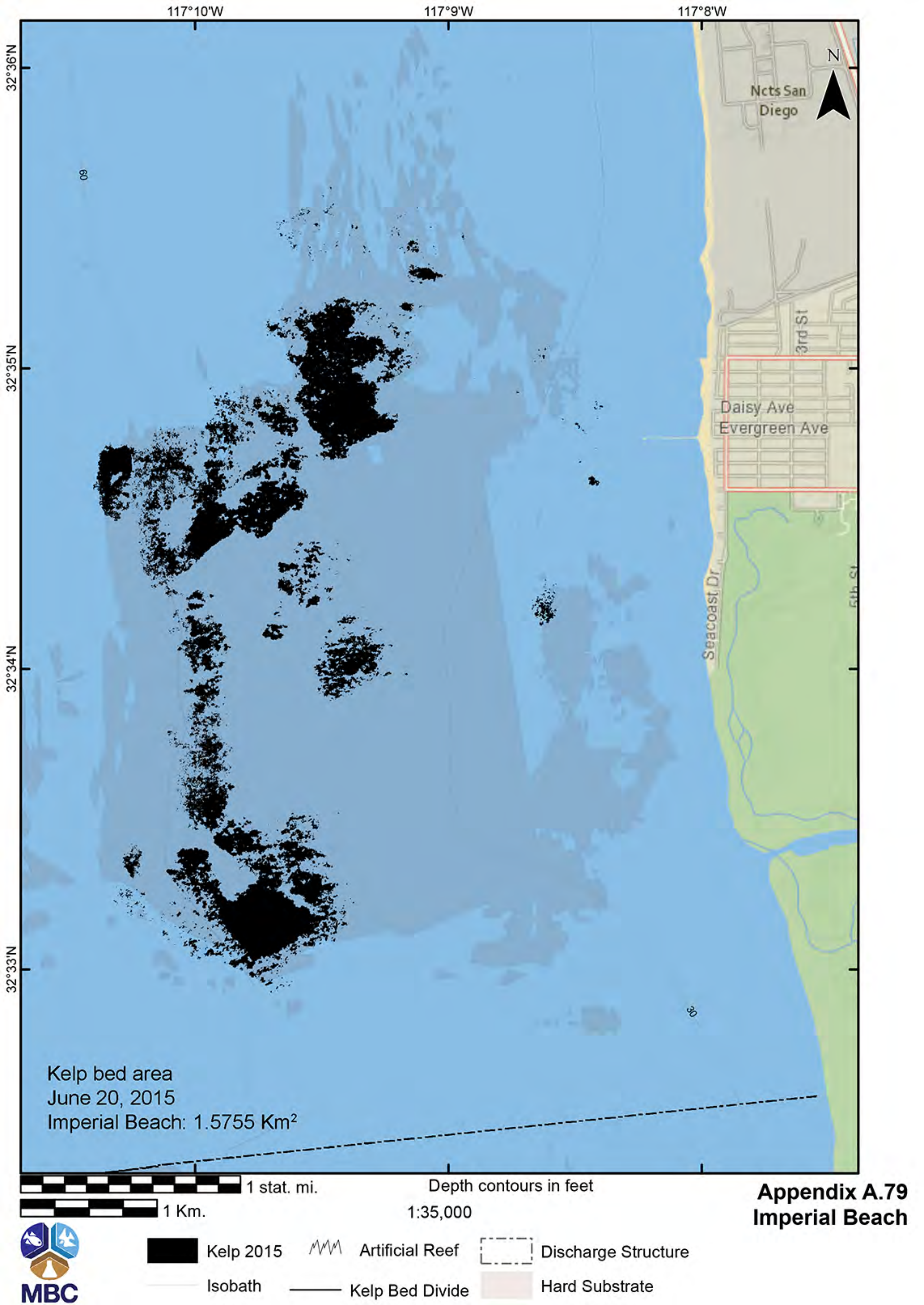
Appendix A.76
Coronado Beach/ Silver Stand (North)



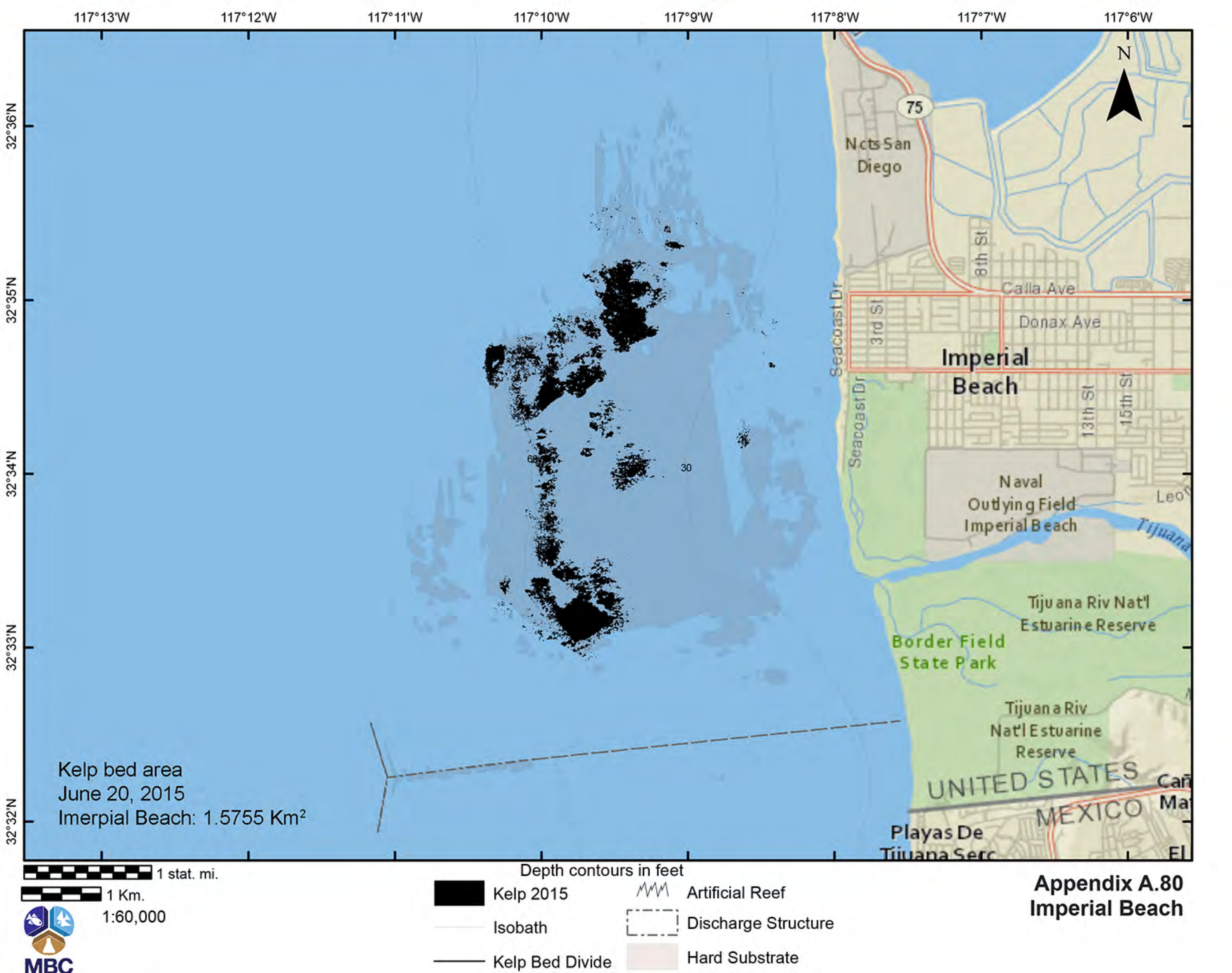
Appendix A.77
Coronado Beach/ Silver Strand (Central)



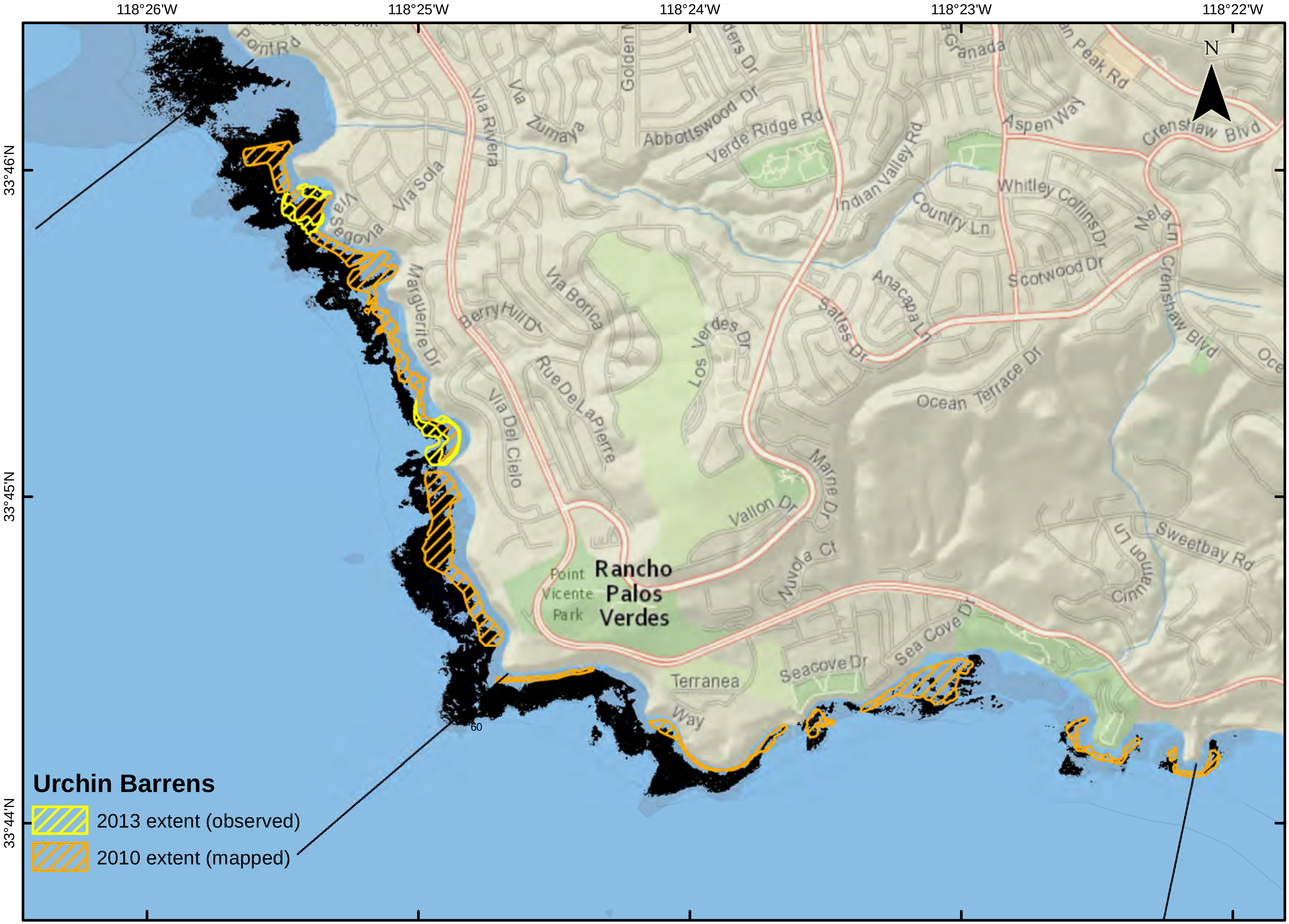
Appendix A.78
Imperial Beach



Appendix A.79
Imperial Beach



Appendix A.80
Imperial Beach



1 stat. mi.

1 Km.

1:35,000

Depth contours in feet

Kelp 2015

Isobath

Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

MBC

Appendix A.81
Palos Verde III and II
(Point Vicente)

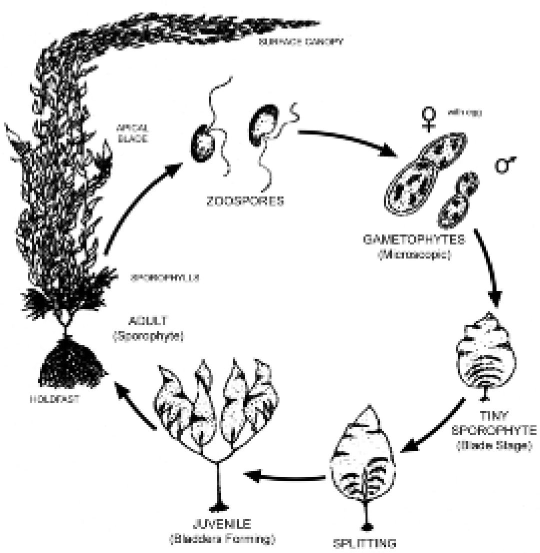
APPENDIX B

Life History of Giant Kelp
Historical Kelp Surveys
Crandall's Maps

LIFE HISTORY OF GIANT KELP

Kelp consists of a number of species of brown algae, of which 10 are typically found from Point Conception to the Mexican Border (the Southern California Bight [SCB]). Compared to most other algae, kelp species can attain remarkable size and long life span (Kain 1979; Dayton 1985; Reed et al. 2006). Along the central and southern California coast, giant kelp *Macrocystis pyrifera* is the largest species colonizing rocky (and in some cases sandy) subtidal habitats, and is the dominant canopy-forming kelp. Giant kelp is a very important component of coastal and island communities in southern California, providing food and habitat for numerous animals (North 1971; Patton and Harmon 1983; Dayton 1985; Foster and Schiel 1985). Darwin (1860) noted the resemblance of the three-dimensional structure of giant kelp stands to that of terrestrial forests. Because of its imposing physical presence, giant kelp biology and ecology have been the focus of considerable research since the early 1900s. Much effort was expended in the early years deciphering its enigmatic life history (Neushul 1963; North 1971; Dayton 1985; Schiel and Foster 1986; Witman and Dayton 2001; Reed et al. 2006). Giant kelp commonly attains lengths of 15 to 25 m and can be found at depths of 30 m. In conditions of unusually good water clarity, giant kelp may even thrive to depths of 45 m (Dayton et al. 1984).

Giant kelp may form beds wherever suitable substrate occurs, typically on rocky, subtidal reefs (North 1971). Such substrate must be free of continuous sediment intrusion. Giant kelp beds can form in sandy-bottom habitats protected from direct swells where individuals will attach to worm tubes; this occurs along portions of the Santa Barbara coastline (Bedford 2001). Like terrestrial plants, algae undergo photosynthesis and therefore require light energy to generate sugars. For this reason, light availability at depth is an important limiting factor to giant kelp growth. Greater water clarity normally occurs at the offshore islands, and as a result, giant kelp is commonly found growing there in depths exceeding 30 m. Along the mainland coast, high biological productivity, terrestrial inputs and nearshore mixing result in greater turbidity and hence lower light levels. Consequently, giant kelp generally does not commonly grow deeper than 20 m along the coastal shelf, although exceptional conditions off San Diego produce impressively large beds that can grow vigorously beyond 30 m.



Appendix B.1 Life cycle for giant kelp.

Giant kelp has a complex life cycle and undergoes a heteromorphic alternation of generations, where the phenotypic expression of each generation does not resemble the generation before or after it (Appendix B.1). The stage of giant kelp that is most familiar is the adult canopy-forming diploid sporophyte generation. Sporophyll blades at the base of an adult giant kelp release zoospores, especially in the presence of cold, nutrient-rich waters. These zoospores disperse into the water column and generally settle a short distance from the parent sporophyte (Reed et al. 1988). Within three weeks, the zoospores mature into microscopic male and female gametophytes that in turn produce sperm and eggs. This second generation does not resemble the sporophyte. The life cycle is completed when fertilization of the gametophyte egg develops into the adult sporophyte stage. Successful completion of the life cycle relies on the persistence of favorable conditions throughout the process.

Giant kelp grows in groups called forests because erect bundles of fronds (stipes and blades) resemble tree trunks, and spreading canopies at the sea surface represent the stems and leaves (Dawson and Foster 1982). *Macrocysti*s anchors to rocks (or occasionally in sand) by a holdfast, and new fronds, comprised of stipes and attached blades, grow up to the sea surface at rapid rates. Giant kelp is known as a biological facilitator (Bruno and Bertness 2001), where its three-dimensional structure and the complexity of its holdfast provides substrate, refuge, reduction of physical stress, and a food source for many fishes (Carr 1989) and invertebrates (Duggins et al. 1990). Stands of giant kelp can also affect flow characteristics in the nearshore zone, and enhance recruitment (Duggins et al. 1990), thus increasing animal biomass. For these reasons, giant kelp is also of great importance to sport and commercial fisheries.

HISTORICAL KELP SURVEYS

Giant kelp bed size and health are known to be highly variable but there has been a downward trend in canopy coverage since the inception of surveying in 1911 (Crandall 1912). In 1911, a mapping expedition of canopy-forming kelps along most of the Pacific coast was conducted to determine the amount of potash (potassium carbonate, an essential ingredient in explosives at the time) potentially available from the kelp. Using rowboats, compass, and sextants to triangulate positions, U.S. Army Captain William Crandall produced one of the most complete surface density kelp maps of the west coast of North America. Using this methodology, all of the existing kelp beds in the Central Region and Region Nine areas were mapped and these measurements have been used to define a baseline for southern California kelp beds (Appendix B.2) (Crandall Maps).

Despite the value of Crandall's maps, the accuracy of his measurements was questioned (Hodder and Mel 1978 [SAI 1978], Neushul 1981). These authors contended that measurement errors might have resulted from using a rowboat and triangulations from shore to compute the bed perimeters, particularly on very large beds such as Palos Verdes, Point Loma, and La Jolla. Although Crandall's ability to accurately triangulate a position was adequate, his measurements of large beds resulted from fewer fixed points and estimation of the area between points. Modern aerial surveys reveal numerous holes and a fair degree of patchiness in such beds. Crandall's estimates did not account for these natural gaps and therefore the 1911 survey probably overestimated the size of these larger beds. Given this ambiguity, Crandall's measurements should be viewed qualitatively rather than as quantitative estimates comparable to aerial survey data taken since the 1920s. However, the data are a very good approximation to use as a baseline. Anecdotal reports from area stakeholders reported by Cameron (1915) indicate kelp beds in 1911 were in fairly poor condition compared to previous years.

Although the historical El Niño Southern Oscillation (ENSO) index suggests that the five years prior to 1911 were favorable to the kelp, the Pacific Decadal Oscillation (PDO) (another environmental metric that has historical data extending back to that period) is in agreement with Cameron's 1915 statement. While the PDO is a poor predictor of oceanographic conditions in the Southern California Bight (Di Lorenzo et al. 2008), it does correlate with sea surface temperature (SST). Therefore, it provides some insight into the local hydrographic conditions at the time. The annual mean PDO was slightly negative between 1909 and 1911, before transitioning to a warm phase from 1912 through 1915. This is suggestive, but not conclusive, of lower nutrient concentrations in 1912–1915 that would result in poor kelp growth. To add further credibility to the premise that beds were larger than current trends would indicate, aerial photos of Palos Verdes kelp beds taken in 1928 (measured by North in 1964) found the area to be more than 10% larger than Crandall reported in 1911.

In 1964, Dr. Wheeler North, working for the State Water Quality Control Board (1964), re-measured Crandall's Palos Verdes charts and found the 2.66 square nautical miles (Nm^2 [9.12 km^2]) Crandall reported to be very similar to his measurement of 2.42 Nm^2, but North's measurement did not include much of Malaga Cove (that added an additional 0.130 Nm^2 of kelp to the Palos Verdes beds), resulting in North's measurement of about 2.55 Nm^2 (Crandall Maps).

Due to the large sizes reported by Crandall, Neushul (1981) assumed there was a scaling error, re-measured the maps, and calculated a value that was 10% less than Crandall's original measurement. However, Neushul (1981) wrote that his measurements resulted in

Appendix B.2 Kelp beds of the California coast as described by Crandall in 1911.

Crandall Sheet (Map in report) No.	Kelp Bed No.	Density	Bed Name 2013	Area Square Nautical Miles	Area Square Statute Miles	Area Square Kilometers
Sheet 52		Medium	Imperial Beach	0.287	0.3801	0.9844
Sheet 18	1	Very Heavy.	Point Loma	5.400	7.1516	18.5226
	2	Very Heavy.	La Jolla	2.300	3.0461	7.8893
Sheet 17	3	Medium	Del Mar	0.240	0.3178	0.8232
		N. Present	No Solana Beach	0.000	0.0000	0.0000
		N. Present	No Cardiff	0.000	0.0000	0.0000
	4	Medium	Encinitas 30% (0.970)	0.291	0.3854	0.9982
	4	Medium	Leucadia 50% (0.970)	0.485	0.6423	1.6636
	4	Medium	Carlsbad St Bch 20%	0.194	0.2569	0.6654
	5	Medium	Encina Power	0.125	0.1655	0.4288
	5	Medium	Agua Hedionda	0.125	0.1655	0.4288
	6	Medium	Carlsbad	0.140	0.1854	0.4802
	7	Medium	Santa Margarita	0.250	0.3311	0.8575
	8	Thin	Barn Kelp	0.370	0.4900	1.2691
	9	Thin	Barn Kelp	0.080	0.1059	0.2744
	10	Thin	Barn Kelp	0.260	0.3443	0.8918
	11	Thin	Horno Canyon	0.050	0.0662	0.1715
	12	Thin	San Onofre	0.110	0.1457	0.3773
	13	Thin	San Onofre	0.130	0.1722	0.4459
	14	Thin	San Onofre	0.060	0.0795	0.2058
	15	Thin	San Mateo	0.360	0.4768	1.2348
Sheet 14, 15, and 16	16	Thin	San Clemente	0.060	0.0795	0.2058
	17	Medium	Capistrano	0.240	0.3178	0.8232
	18	Medium	Doheny	0.220	0.2914	0.7546
	19	Medium	Dana Point/Salt Creek	0.340	0.4503	1.1662
		N. Present	Laguna Beach	0.000	0.0000	0.0000
	20	Medium	Corona Del Mar	0.220	0.2914	0.7546
	21	Medium	Cabrillo to Port Bend	0.760	1.0065	2.6069
	22	Thin	Portuguese Bend	0.100	0.1324	0.3430
	23	Thin	Point Vicente, PV	0.070	0.0927	0.2401
	24	Medium	PV Pt to Flat Rk, PV	1.600	2.1190	5.4882
	25	Medium	Malaga Cove, PV	0.130	0.1722	0.4459
Chart 13	1	Thin	Sunset Beach	0.280	0.3708	0.9604
	2	Thin	Topanga (50%)	0.005	0.0066	0.0172
	2	Thin	Las Tunas (50%)	0.005	0.0066	0.0172
	3	Thin	Big Rock	0.005	0.0066	0.0172
	4	Thin	Las Flores	0.004	0.0053	0.0137
	5	Thin	La Costa	0.006	0.0079	0.0206
		N. Present	Malibu Point	0.000	0.0000	0.0000
	6	Thin	Puerco/Amarillo (10%)	0.100	0.1324	0.3430
	6	Thin	Latigo Canyon (13%)	0.130	0.1722	0.4459
	6	Thin	Escondido Wash (17%)	0.170	0.2251	0.5831
	6	Thin	Paradise Cove (40%)	0.400	0.5297	1.3720
Chart 13	6	Thin	Point Dume (20%)	0.200	0.2649	0.6860
	7	Thin	Lechuza (33%)	0.037	0.0485	0.1255
	7	Thin	Pescador/Piedra (67%)	0.073	0.0971	0.2515
	8	Medium	Nicolas Canyon (33%)	0.367	0.4855	1.2575
	8	Medium	Leo Carillo (67%)	0.733	0.9712	2.5153
		N. Present	Deer Crk	0.000	0.0000	0.0000
Totals				17.512	23.192	60.068

only slight improvements from what Crandall measured: "*The smaller areas obtained by measurements from more recent maps of southern California kelp beds probably reflect both a slight increase in mapping precision over Crandall's methods, and an actual decrease in size.*" In 2004, Crandall's original maps of Palos Verdes were re-measured by MBC Applied Environmental Sciences (MBC) using computer-aided spatial estimation software (including Malaga Cove), and the resulting area (2.57 Nm^2) was about 3% smaller but very similar to that reported by Crandall (2.66 Nm^2). Therefore, the actual sizes of the beds that Crandall reported were probably relatively accurate because the areal survey extent and configuration he reported was subsequently confirmed from contemporary charts (Hodder and Mel 1978, Neushul 1981).

Thus, Crandall's kelp bed areas are retained as the baseline estimate, and the total regional area was probably larger from 1928–1934 than the area Crandall measured in 1911 (Tables 2 and 3). Based on the sizes of the Palos Verdes beds in 1928 (9.912 km^2) and La Jolla kelp beds in 1934 (8.161 km^2) from aerial photos that North measured in 1964 (SWQCB 1964), the bed sizes were well above Crandall's measurements of 9.124 km^2 (2.66 Nm^2) for Palos Verdes (including the bed at Malaga Cove) and 7.889 km^2 (2.3 Nm^2) for La Jolla. This lends credence to Cameron's comment that kelp harvesters reported that the beds were at minimal levels at the time of Crandall's survey, and suggests even larger losses have occurred over time (Cameron 1915).

The next complete kelp survey of the southern California region was not undertaken until 1955. By that time, the beds in the Central Region had decreased greatly (to 6.750 km^2), and were only 36% of that recorded in 1911 (18.815 km^2). Beds in Region Nine were similarly reduced to 40% (16.310 km^2) of the 1911 total of 41.563 km^2. The most significant loss during this period was that of Sunset Kelp (offshore of Santa Monica); Sunset Kelp covered almost 1.0 km^2 in 1911, but was very small by 1955. The Sunset kelp bed remained small or completely missing through the intervening years, and the Palos Verdes beds were also small, having decreased sometime after 1945. By 1947, the Palos Verdes beds were only 3.6 km^2, and further to 1.5 km^2 by 1953. During an aerial survey conducted in 1963, kelp canopies were in very poor condition, with Palos Verdes covering only 0.180 km^2 and the La Jolla and Point Loma beds covering only 0.9 km^2. Exceptionally good conditions in 1967 resulted in a total of 7.856 km^2 of kelp canopy coverage in the Central Region, but this was only about 42% of the estimate from 1911. Palos Verdes kelp beds south of Point Vicente were missing, but north of Point Vicente, they totaled almost 1.0 km^2. In Region Nine, similar results were observed in 1967 with the La Jolla/Point Loma kelp beds covering 3.03 km^2 and the total for the region only 4.4 km^2. La Jolla kelp bed was only about 0.330 km^2 in 1967, and it stayed small until after 1975, when it became a consistently large kelp bed (over 1 km^2) through most of the next four decades.

Restoration activities began in 1974 by the Kelp Habitat Improvement Project. At that time, the Palos Verdes beds were only 0.015 km^2. In 1975, after restoration, those beds began increasing and covered 4.6 km^2 during the exceptionally favorable conditions in 1989 (North and Jones 1991). The impetus provided by the 1989 La Niña resulted in almost 6 km^2 of kelp canopy in the Central Region and more than 16 km^2 in Region Nine, but kelp coverage decreased to less than one-third of these totals during the subsequent two decades. In 2009 (Central) and 2008 (Region Nine), favorable conditions again increased canopy totals to about 6.5 km^2 in the Central Region and 18.7 km^2 in Region Nine, larger than they had been since 1967 and 1955, respectively (Appendix B.3 and B.4; Text Tables 1 and 2).

Appendix B.3 Historical canopy coverage of the kelp beds from Deer Creek to Laguna Beach (Newport/Irvine Coast) from 1911 to 2002. Values represent an estimate of coverage utilizing varying methods over the years. Red denotes warm-water years, blue

	Canopy Area (km²)														
Kelp Bed	1911	1928	1945	1955	1963	1967	1972	1975	1977	1980	1984	1989	1999	2000	2002
Deer Creek	ND	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Leo Carillo	2.515	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Nicolas Canyon	1.258	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
El Pesc/La Piedra	0.252	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Lechuza	0.126	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Total F&W 17	**4.151a**	**ND**	**ND**	**3.010**	**ND**	**4.144**	**2.589**	**1.606**	**1.579**	**ND**	**ND**	**0.914**	**0.530**	**ND**	**ND**
Pt. Dume	0.686	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Paradise Cove	1.372	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Escondido Wash	0.583	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Latigo Canyon	0.446	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Puerco/Amarillo	0.343	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Malibu Pt.	ND	ND	ND	p	p	p	p	p	p	ND	ND	p	p	ND	ND
Total F&W 16	**3.43a**	**ND**	**ND**	**2.140**	**1.780**	**2.538**	**1.813**	**1.502**	**1.528**	**ND**	**ND**	**0.220**	**0.033**	**ND**	**ND**
La Costa	0.021	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Las Flores	0.014	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Big Rock	0.017	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Las Tunas	0.017	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Topanga	0.017	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Sunset	0.960	ND	ND	p	p	p	ND	p	p	ND	ND	p	p	ND	ND
Total F&W 15	**1.355a**	**ND**	**ND**	**0.020**	**0.000**	**0.026**	**ND**	**0.026**	**0.000**	**ND**	**ND**	**0.045**	**0.000**	**ND**	**ND**
Malaga Cove-PV Pt. (IV)	5.934	ND	ND	p	p	p	ND	p	p	0.940	0.655	p	p	p	1.400
PV Pt-PT. Vic (III)	0.240	ND	ND	p	p	p	ND	p	p	0.215	0.692	p	p	p	0.028
Total F&W 14	**6.174**	**ND**	**ND**	**0.820**	**0.030**	**1.062**	**ND**	**0.009**	**0.026**	**1.155**	**1.347**	**3.312**	**0.737**	**0.648**	**1.429**
Pt Vic to Pt Insp (II)	p	ND	ND	p	p	p	ND	p	p	0.190	0.171	p	p	p	0.039
Pt Insp to Cabr (I)	p	ND	ND	p	p	p	ND	p	p	1.052	1.342	p	p	p	1.208
Cabrillo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0001	0.0001	ND	ND
Total F&W 13	**2.950**	**ND**	**ND**	**0.080**	**0.150**	**0.000**	**ND**	**0.259**	**0.104**	**1.342**	**1.513**	**1.248**	**0.530**	**0.582**	**1.247**
Total PV	**9.124a**	**9.912a**	**5.591a**	**0.900**	**0.180**	**1.062**	**ND**	**0.268**	**0.130**	**2.497**	**2.860**	**4.560c**	**1.267**	**1.230**	**2.676a**
POLA-POLB Harbor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Horseshoe	ND	1.94b	ND	ND	ND	ND	ND	ND	ND	ND	ND	tr	0.0001	tr	0.0001
Huntington Flats	ND	ND	ND	ND	ND	-	-	-	-	-	-	tr	-	-	-
Newport-Irvine Coast	0.755	ND	ND	0.680	0.000	0.086	0.100	0.160	0.160	0.148	0.008	0.010	-	-	tr
Total F&W 10	**0.755**	**-**	**-**	**0.680**	**0.000**	**0.086**	**0.100**	**0.160**	**0.160**	**0.148**	**0.008**	**0.010**	**0.0001**	**-**	**0.000**
TOTAL	**18.815d**	**11.852d**	**5.591**	**6.750**	**1.960**	**7.856**	**4.502d**	**3.562**	**3.397**	**2.681d**	**2.893d**	**5.748**	**1.829**	**1.230**	**2.676d**

ND = No Data; p = this bed included in the total below; tr = trace of kelp; "'-" = 0
red = warm year El Nino; **blue** = cold year La Nina; **no color** = neutral year

a = Earlier measurement in naut mi^2 converted to km^2

b = Estimate in mid-1920s

c = Ecoscan (1990) indicates 2.003 km^2 from a July 1989 survey.
Used Wilson (1989) results for PV showing the kelp beds at greatest extent.

d = Total is not inclusive of all beds in region

Sources: Crandall (1912); 1928, 1945, 1955 from SWQCB (1964); 1955, 1963 from Neushul (1981); 1967, 1972, 1975, 1977 from Hodder and Mel (1978); Ecoscan (1990) and Wilson (1989), North (2000); TMLandsat 7 (2002).

Appendix B.4 Historical canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 1911 to 1987. Values represent an estimate of coverage utilizing varying methods over the years. Red denotes warm-water years, blue denotes cold-water years, and neutral years are in black.

Kelp Bed	Canopy Area (km²)														
	1911	1934	1941	1955*	1959*	1963*	1967	1970	1975	1980	1983	1984	1985	1986	1987
North Laguna Beach	Tr	ND	ND	p	0.160	ND	0.001	0.011	0.003	0.036	0.035	0.025	0.028	0.022	0.028
South Laguna Beach	Tr	ND	ND	p	ND	ND	0.001	0.011	0.003	0.036	0.040	0.028	0.077	0.041	0.087
South Laguna	Tr	ND	ND	p	0.180	0.020	-	0.014	0.008	-	0.004	-	-	-	-
Dana Point-Salt Creek	1.166	ND	ND	p	p	p	0.240	0.077	0.096	0.008	0.013	0.007	0.036	0.031	0.174
Capistrano Beach	1.578	ND	ND	p	p	p	0.080	0.050	0.070	0.020	-	-	-	-	-
Total F&W 9	2.744	-	-	2.020	0.340	0.020	0.322	0.163	0.180	0.100	0.092	0.060	0.141	0.094	0.289
San Clemente	0.206	ND	ND	6.310	3.710	0.010	0.080	0.050	0.070	0.020	-	-	-	-	0.017
San Mateo Point	1.235	ND	ND	p	p	p	-	0.057	0.140	0.360	0.163	0.045	0.152	0.077	0.200
San Onofre	1.029	ND	ND	p	p	p	-	-	0.300	0.160	0.102	0.031	0.042	0.053	0.045
Total F&W 8	2.470	-	-	6.310	3.710	0.010	0.080	0.107	0.510	0.540	0.265	0.076	0.194	0.130	0.262
Horno Canyon	0.172	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-
Barn Kelp	2.435	ND	ND	1.370	ND	0.130	0.017	0.019	0.160	0.056	-	-	-	-	-
Santa Margarita	0.858	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-
Total F&W 7	3.465	-	-	1.370	-	0.130	0.017	0.019	0.160	0.056	-	-	-	-	-
North Carlsbad	0.480	ND	ND	2.620	2.520	1.180	0.009	0.060	0.100	0.120	-	-	-	-	0.031
Agua Hedionda	0.429	ND	ND	p	p	p	-	0.006	0.036	0.019	-	0.001	0.011	0.018	0.021
Encina Power Plant	0.429	ND	ND	p	p	p	-	0.025	0.144	0.074	-	0.002	0.024	0.045	0.120
Carlsbad State Beach	0.499	ND	ND	p	p	p	0.032	0.120	0.200	0.078	-	-	0.027	0.018	0.077
Total F&W 6	1.837	-	-	2.620	2.520	1.180	0.041	0.211	0.480	0.291	-	0.003	0.062	0.081	0.249
Leucadia	1.996	ND	ND	p	p	p	0.240	0.440	0.500	0.670	0.001	0.002	0.104	0.074	0.426
Encinitas	0.832	ND	ND	p	p	p	0.065	0.173	0.153	0.228	-	0.016	0.083	0.032	0.177
Cardiff	ND	ND	ND	0.340	0.400	0.160	0.125	0.337	0.297	0.442	0.018	0.021	0.176	0.120	0.340
Solana Beach	ND	ND	ND	p	p	p	0.290	0.490	0.560	0.690	-	0.001	0.115	0.120	0.367
Del Mar	0.823	ND	ND	p	p	p	0.190	0.260	0.190	0.210	-	-	0.008	0.021	0.081
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total F&W 5	3.651	-	-	0.340	0.400	0.160	0.910	1.700	1.700	2.240	0.019	0.040	0.486	0.367	1.391
La Jolla F&W 4	7.889	8.161	7.847	1.660	6.490	0.640	0.330	0.290	0.840	1.900	0.032	0.034	0.720	0.930	2.369
Point Loma F&W 3&2	18.523	11.465	8.286	1.990	0.610	0.240	2.700	4.900	3.000	4.200	0.200	0.160	1.570	2.100	3.682
Imperial Beach F&W 1	0.984	ND	ND	ND	ND	ND	-	-	-	0.350	-	-	0.058	0.150	0.727
TOTAL	41.563	19.626	16.133	16.310	14.070	2.380	4.400	7.390	6.870	9.327	0.608	0.373	3.173	3.702	8.242

NOTE: p = part of above value; * = Incomplete data; ND - No Data; "-" = 0; Tr = Trace <100 m²

Sources: 1934, 1941 from SWQCB(1964); 1955, 1959, 1963 from Neushul (1981).

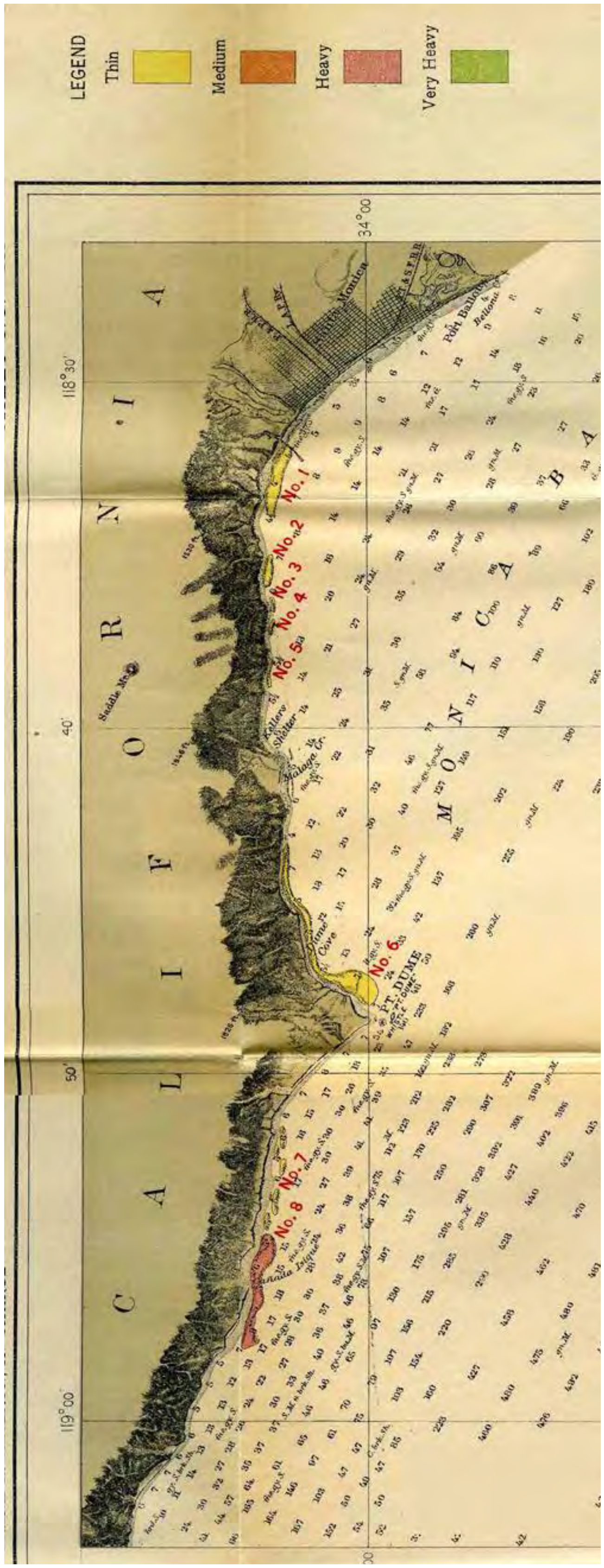
Appendix B.4 (Cont.). Historical canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 1988 to 2002. Values represent an estimate of coverage utilizing varying methods over the years. Red denotes warm-water years, blue denotes cold-water years, and neutral years are in black.

	Canopy Area (km^2)														
Kelp Bed	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
North Laguna Beach	0.042	0.055	0.034	0.029	-	-	-	-	0.001	-	-	-	-	-	-
South Laguna Beach	0.145	0.264	0.243	0.093	0.056	0.028	-	-	-	-	-	-	-	-	0.005
South Laguna	0.023	0.041	0.023	0.030	0.009	0.006	0.005	-	-	-	-	-	0.003	0.002	<0.001
Dana Point-Salt Creek	0.568	0.878	0.329	0.480	0.184	0.234	0.116	0.076	0.061	0.034	0.005	0.080	0.170	0.314	0.432
Capistrano Beach	0.032	0.233	0.110	0.134	0.148	0.022	-	-	-	-	-	<0.001	<0.001	0.044	0.118
Total F&W 9	0.810	1.471	0.739	0.766	0.397	0.290	0.121	0.076	0.062	0.034	0.005	0.080	0.173	0.359	0.555
San Clemente	0.124	0.444	0.304	0.243	0.044	0.051	0.010	0.010	0.047	-	-	0.006	0.005	0.124	0.316
San Mateo Point	0.432	0.870	0.472	0.120	0.103	0.220	0.080	0.010	0.073	0.098	-	0.051	0.050	0.090	0.155
San Onofre	0.348	0.638	0.763	0.170	0.053	0.163	0.201	0.096	0.196	0.108	<0.001	0.005	0.020	0.041	0.030
Total F&W 8	0.904	1.952	1.539	0.533	0.200	0.434	0.291	0.116	0.316	0.206	-	0.062	0.075	0.255	0.501
Horno Canyon	0.006	0.033	0.010	0.018	0.040	-	-	-	-	-	-	-	0.002	0.034	-
Barn Kelp	0.008	0.116	0.382	0.262	0.124	0.002	0.010	0.172	0.204	0.178	-	0.310	0.375	0.547	0.667
Santa Margarita	-	-	-	0.049	0.009	-	-	-	-	-	-	-	-	-	-
Total F&W 7	0.014	0.149	0.392	0.329	0.173	0.002	0.010	0.172	0.204	0.178	-	0.310	0.377	0.581	0.667
North Carlsbad	0.049	0.096	0.119	0.044	0.004	0.018	0.020	0.008	-	-	0.003	-	-	0.017	0.053
Agua Hedionda	0.032	0.047	0.046	0.016	0.004	0.012	0.004	0.008	0.009	-	-	-	-	-	<0.001
Encina Power Plant	0.161	0.251	0.179	0.083	0.025	0.022	0.011	0.058	0.032	0.013	-	-	0.002	0.029	0.097
Carlsbad State Beach	0.032	0.049	0.081	0.035	0.008	0.002	0.011	0.025	0.013	-	-	-	0.003	0.023	0.047
Total F&W 6	0.274	0.443	0.425	0.178	0.041	0.054	0.046	0.099	0.054	0.013	0.003	-	0.005	0.069	0.197
Leucadia	0.197	0.291	0.341	0.163	0.084	0.035	0.010	0.189	0.087	0.062	-	0.015	0.090	0.209	0.334
Encinitas	0.153	0.209	0.241	0.080	0.036	0.037	0.016	0.061	0.023	0.048	-	0.029	0.040	0.131	0.153
Cardiff	0.229	0.575	0.468	0.072	0.054	0.034	0.080	0.092	0.026	0.031	0.016	0.063	0.150	0.309	0.405
Solana Beach	0.427	0.488	0.466	0.257	0.053	0.023	0.108	0.134	0.003	0.073	0.009	0.091	0.200	0.407	0.488
Del Mar	0.063	0.104	0.082	0.097	0.006	0.003	0.029	0.082	-	*Tr	0.004	-	0.006	0.015	0.035
Torrey Pines	Tr	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-
Total F&W 5	1.069	1.667	1.598	0.669	0.233	0.132	0.243	0.558	0.139	0.214	0.029	0.198	0.486	1.071	1.415
La Jolla F&W 4	2.200	4.755	3.632	3.230	1.301	0.681	1.119	0.824	0.371	0.478	0.215	1.146	1.250	2.555	3.366
Point Loma F&W 3&2	2.322	5.842	5.943	4.310	1.153	1.917	3.589	1.134	1.187	2.235	0.295	1.725	3.290	6.574	3.799
Imperial Beach F&W 1	0.067	0.579	0.651	0.370	0.111	0.025	0.108	0.053	0.008	0.027	-	0.019	0.020	0.078	0.210
TOTAL	7.593	16.279	14.268	10.015	3.498	3.510	5.419	3.032	2.341	3.385	0.547	3.540	5.676	11.542	10.710

NOTE: p = part of above value; * = Incomplete data; ND - No Data; "-" = 0; Tr = Trace <100 m^2

The Imperial Beach kelp bed south of San Diego measured 0.984 km^2 in 1911, and was never again measured to be larger than about 0.727 km^2 for the rest of the century (occurring in 1987, Appendix B.4). However, by the end of 2007, Imperial Beach kelp bed measured 1.493 km^2 (Text Table 2, MBC 2011b), almost 50% greater than what Crandall measured, lending further credence to Cameron's (1915) statement that beds were in poor condition in 1911 compared to earlier years. It therefore follows that the Palos Verdes, La Jolla, and Point Loma kelp beds of Central and Region Nine prior to 1911 were likely much larger than they are today.

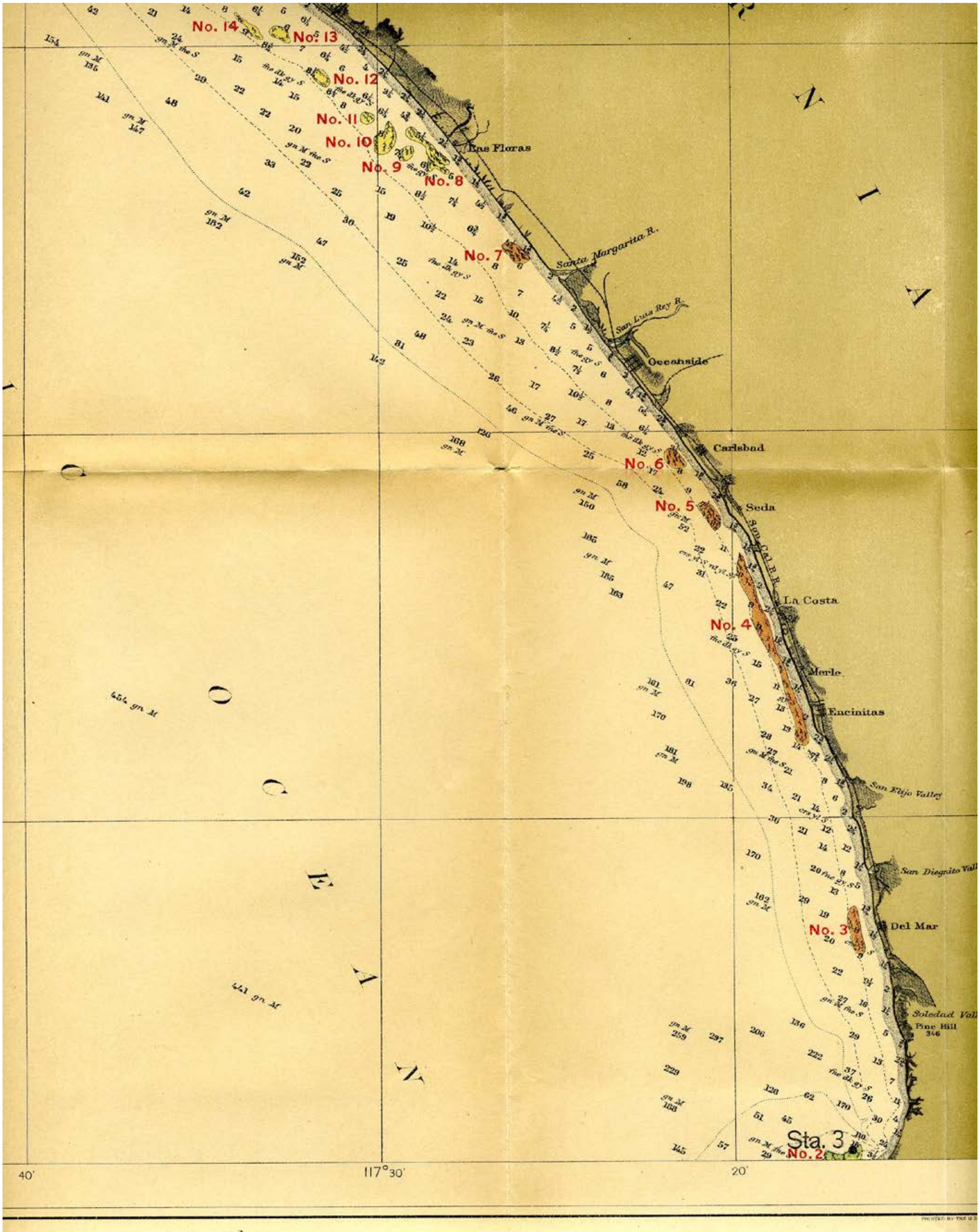
As these measurements indicate, most of the beds remain smaller than those of a century ago. Ongoing surveys attempt to determine what environmental factors have changed in the intervening years to cause such large declines.



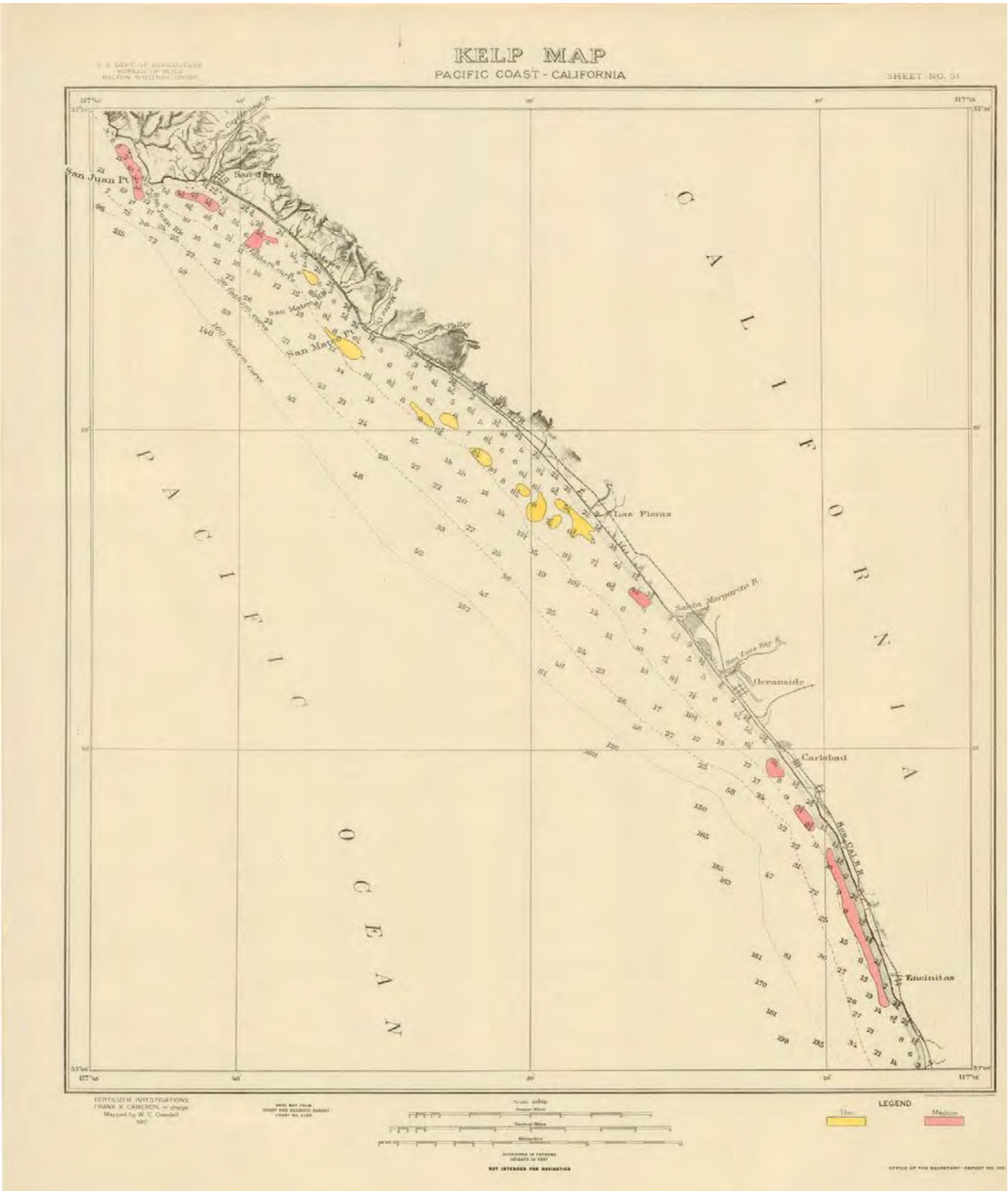
Appendix B.5 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.

Appendix B.6 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.

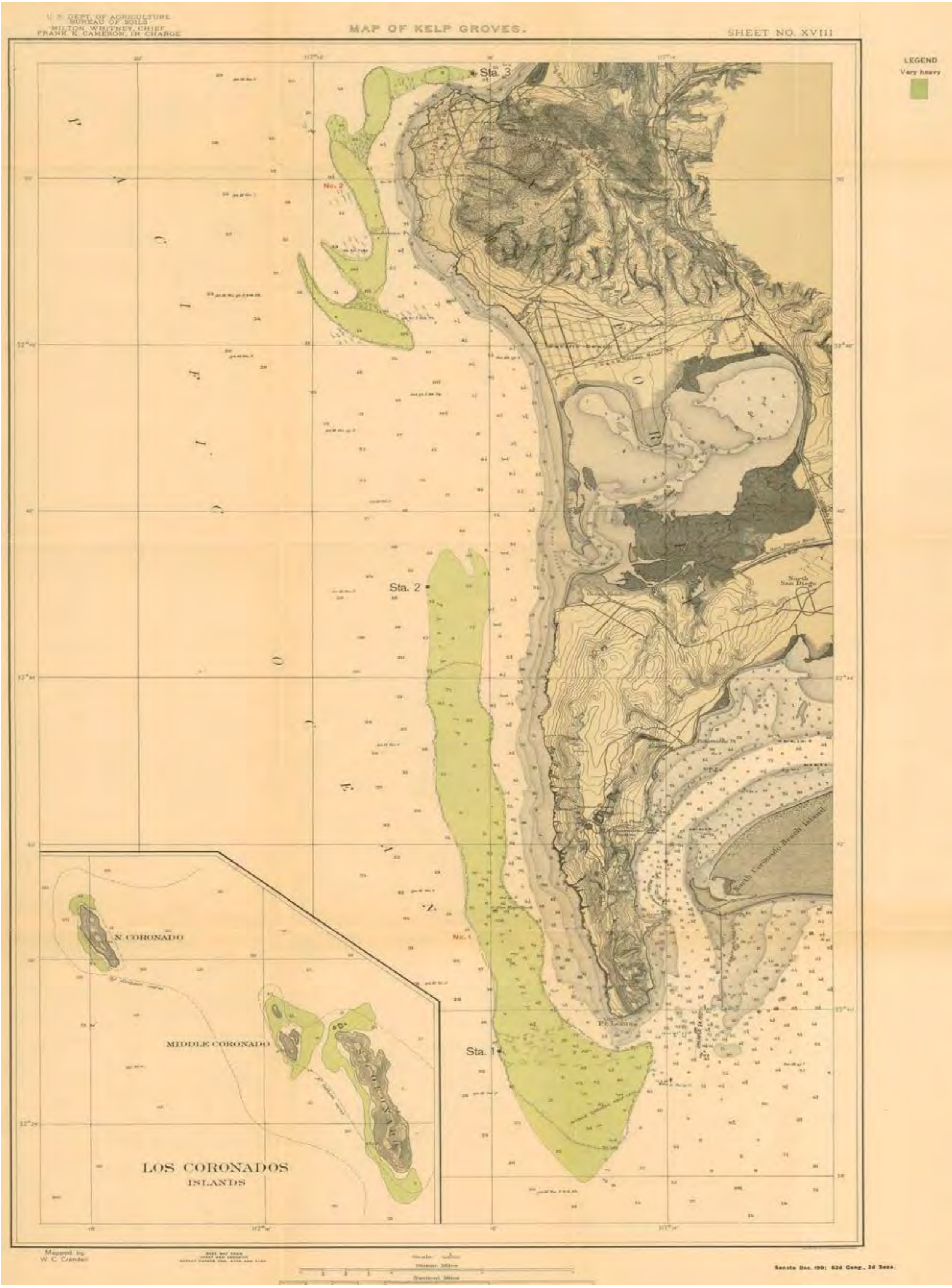
Appendix B.7 Crandall's 1911 kelp bed survey Newport to San Onofre.



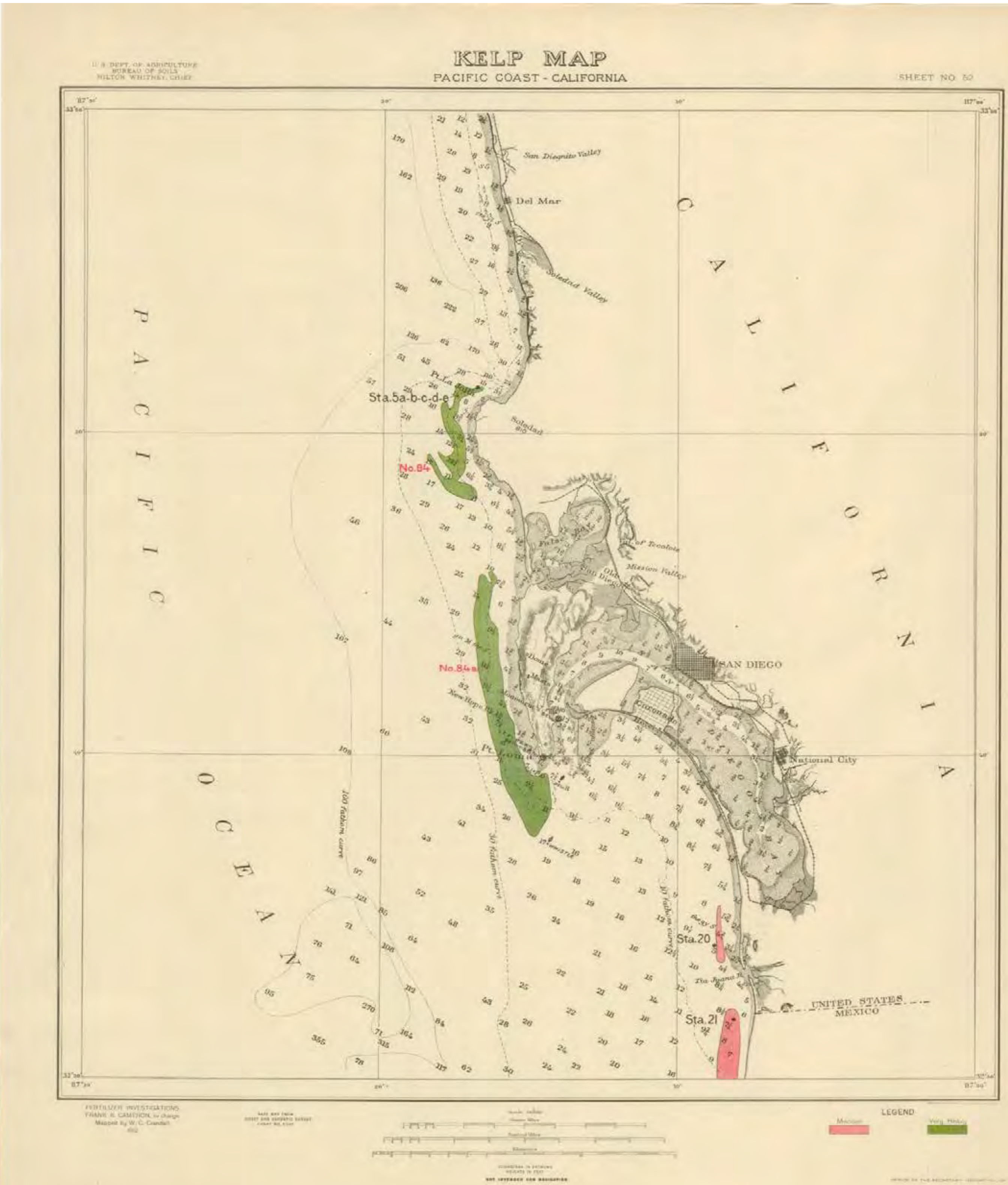
Appendix B.8 Crandall's 1911 kelp bed survey San Onofre to Del Mar.



Appendix B.9 Crandall's 1911 kelp bed survey San Juan to Encinitas.



Appendix B.10 Crandall's 1911 kelp bed survey La Jolla to Point Loma.

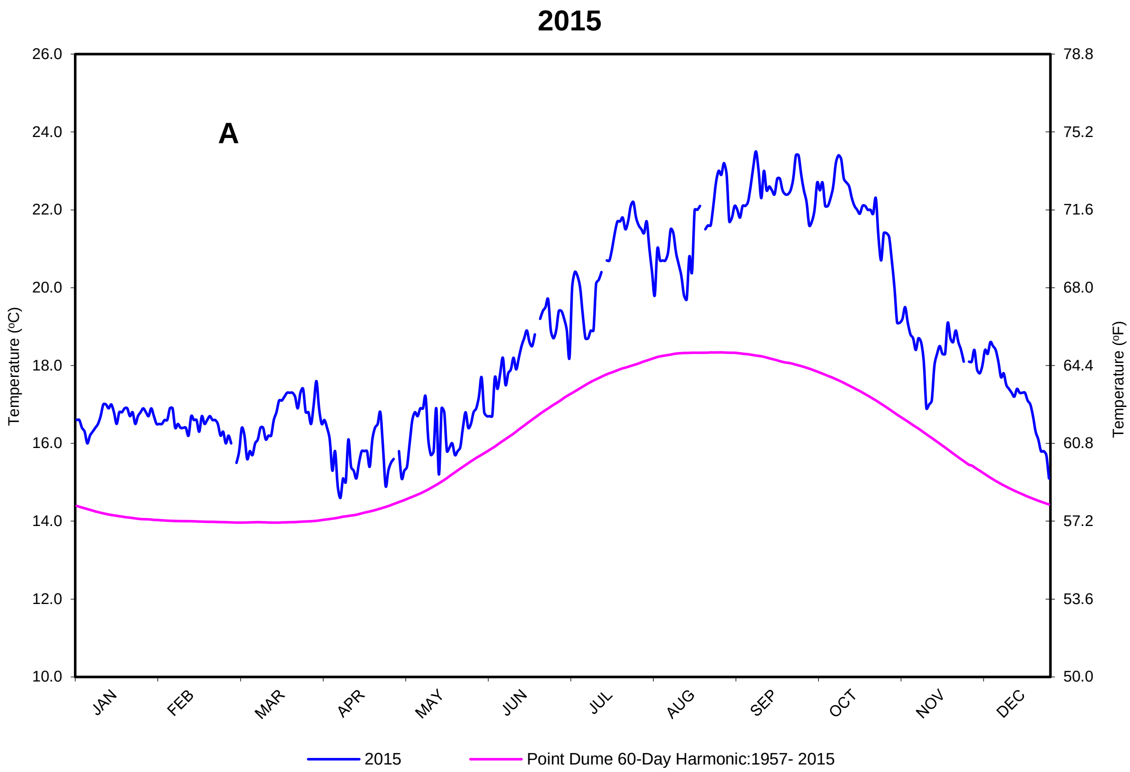


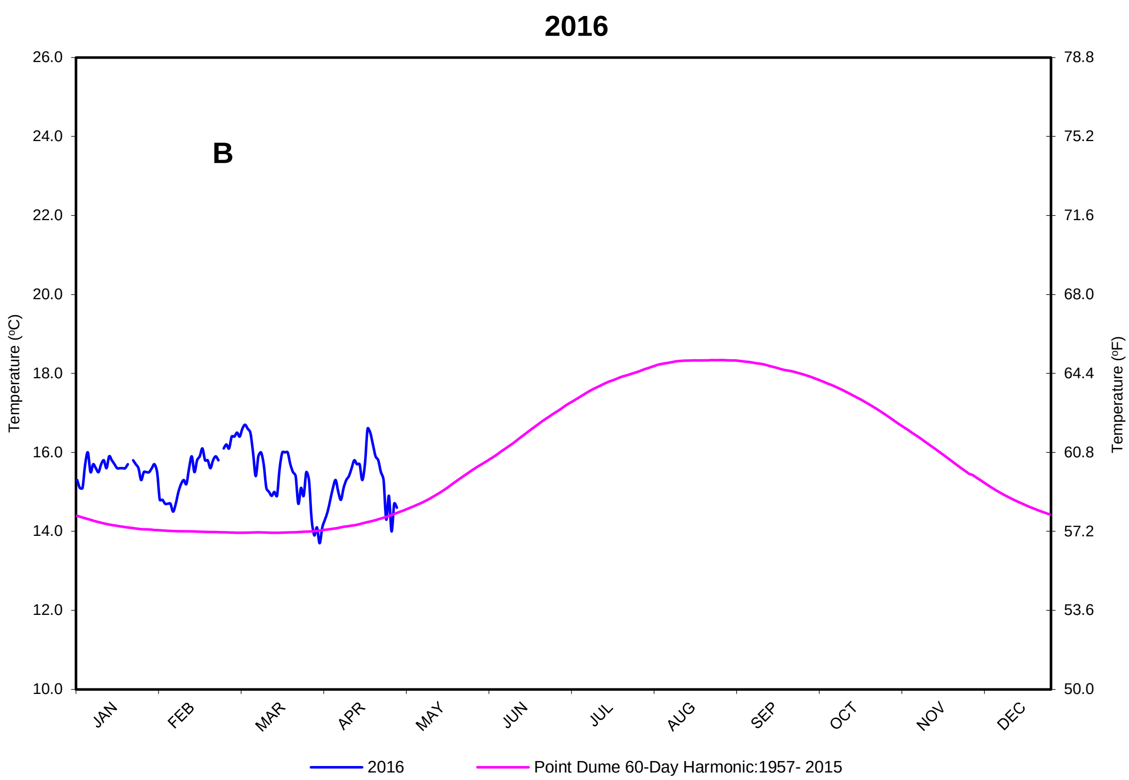
Appendix B.11 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

APPENDIX C

Sea Surface Temperatures

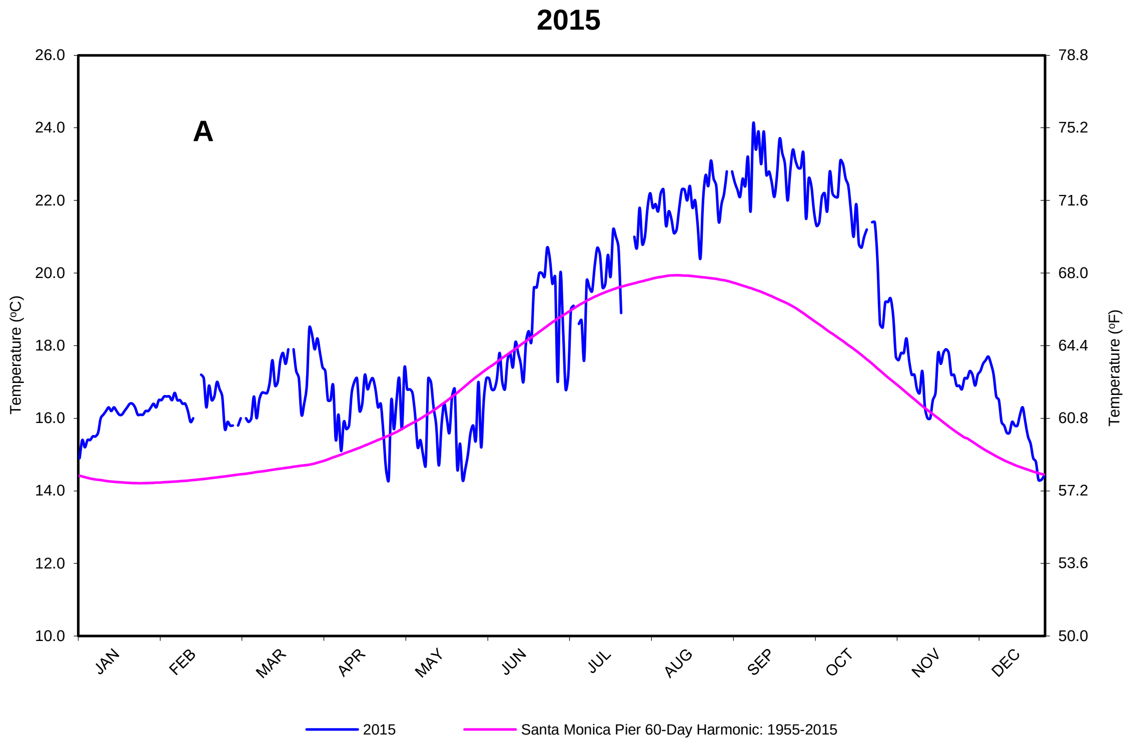
Point Dume
Sea Surface Temperature

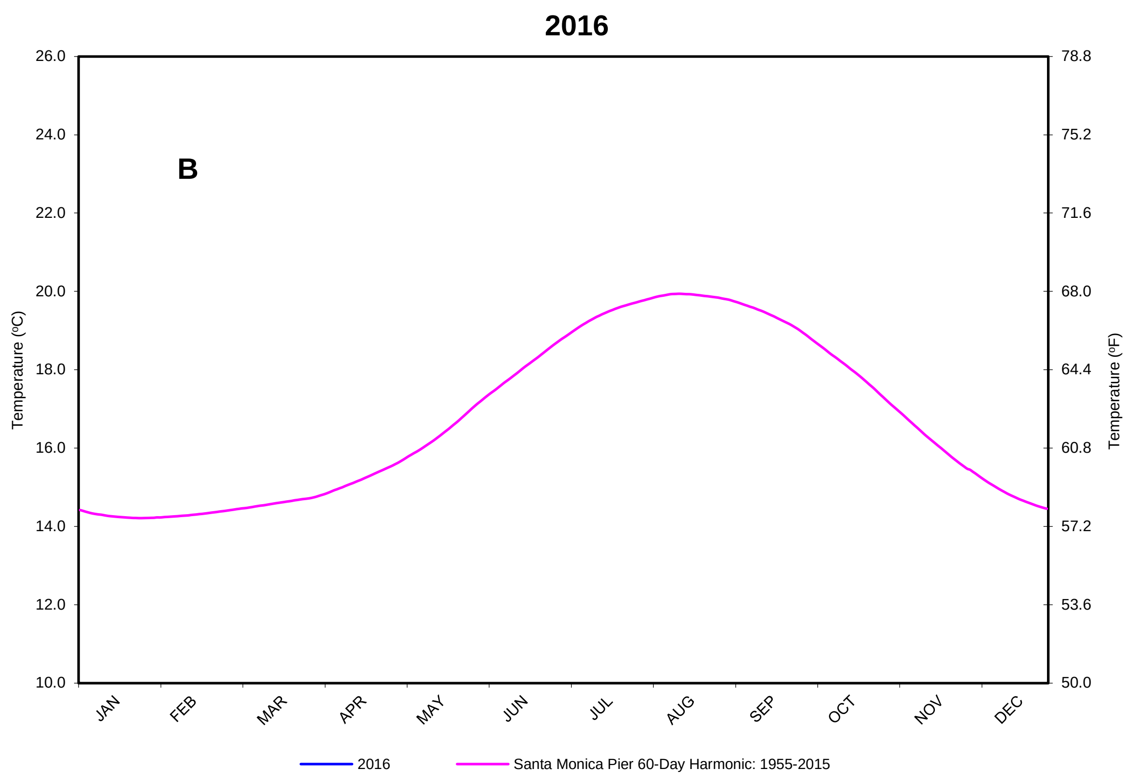




Appendix C.1 Daily sea surface temperatures (SST) at Point Dume for 2015 through April 2016.

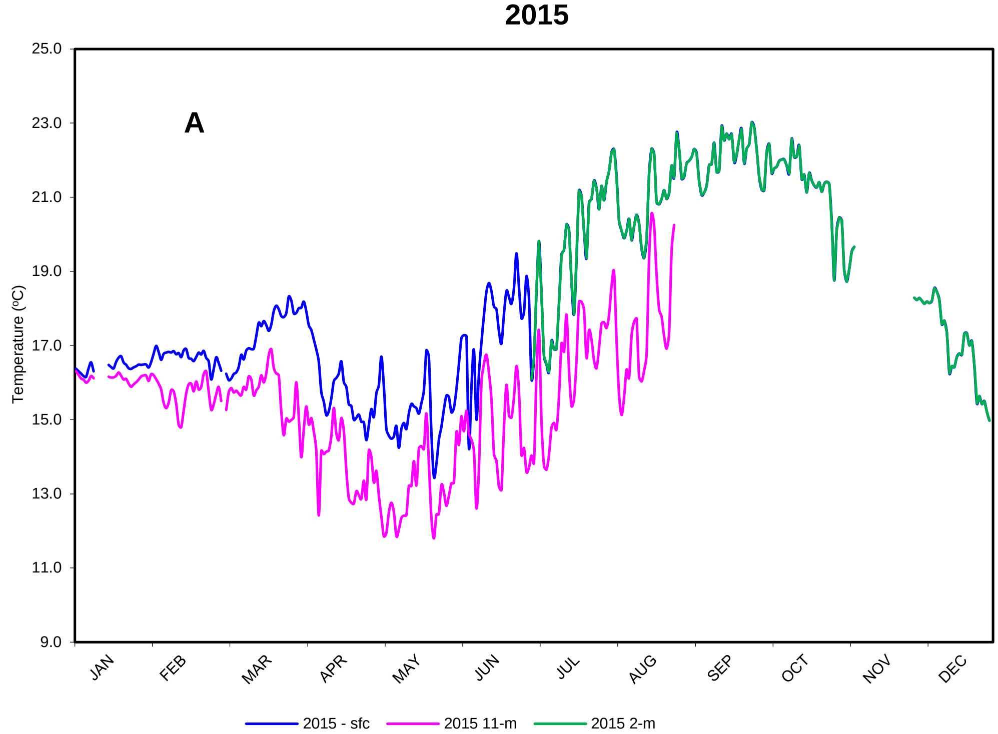
Santa Monica Pier
Sea Surface Temperature

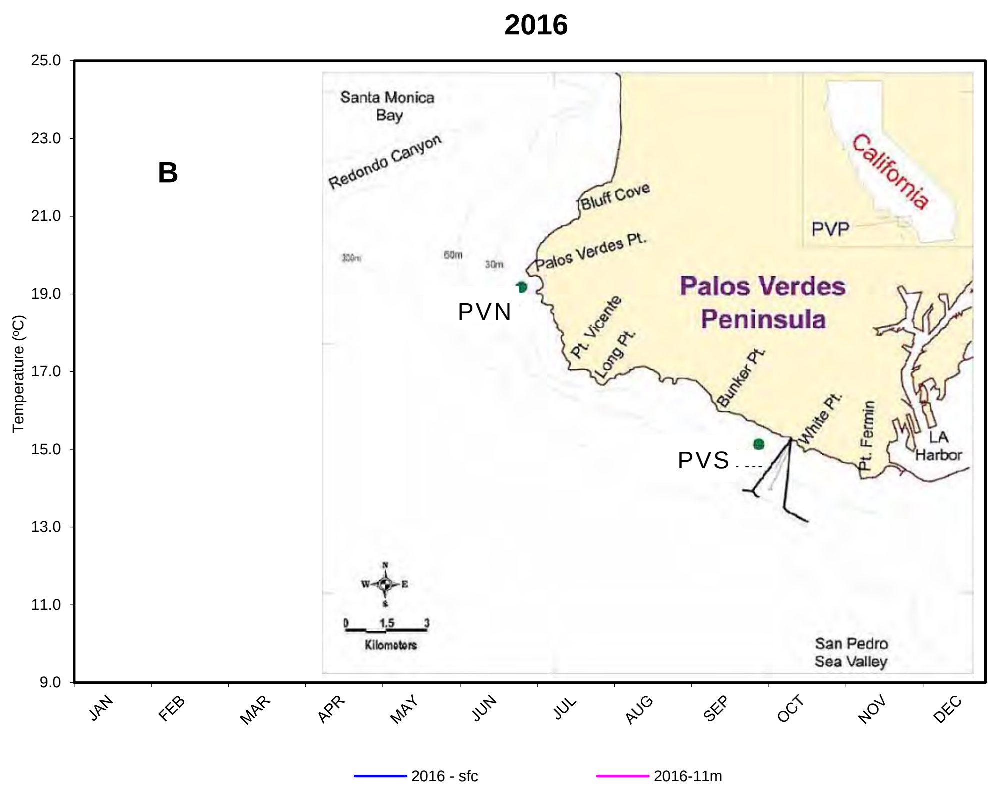




Appendix C.2 Daily sea surface temperatures (SST) at Santa Monica Pier for 2015. No data available for 2016.

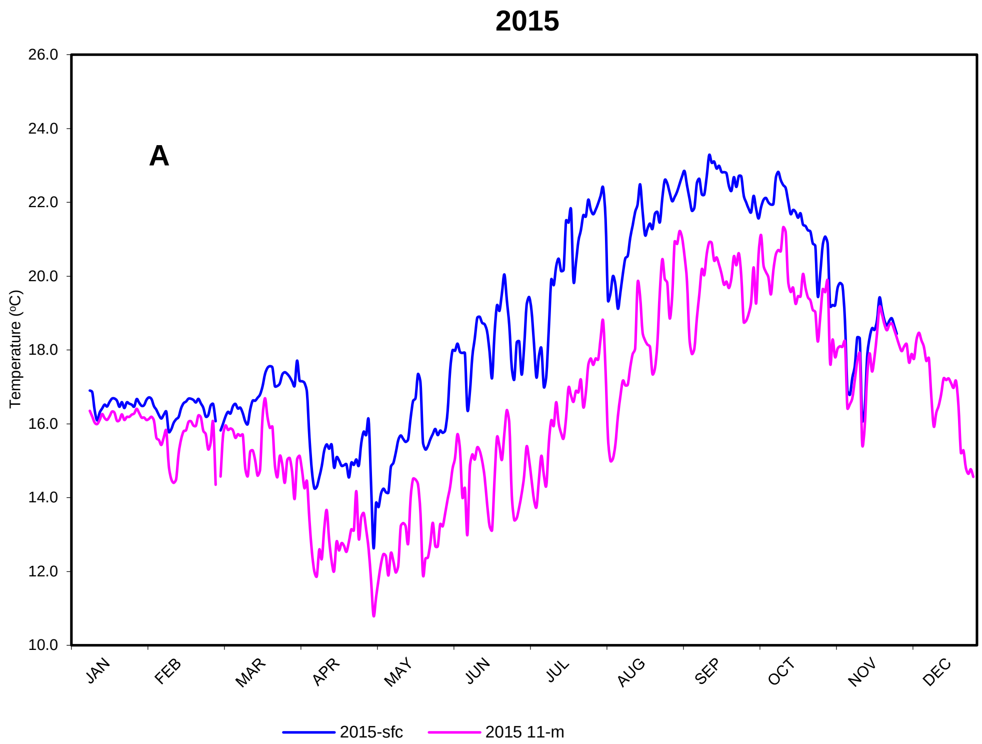
Palos Verdes PVN
Sea Surface Temperature

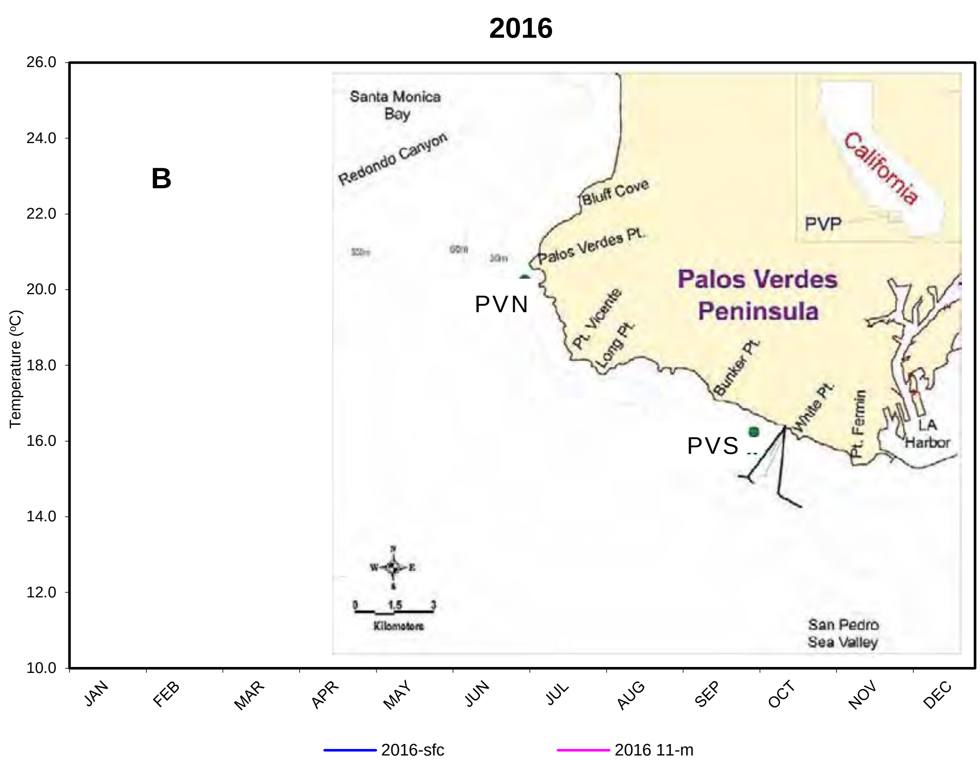




Appendix C.3 Daily sea surface temperatures (SST) at Station Palos Verdes North through June, and at 11-m through August, 2015. No data available for 2016.

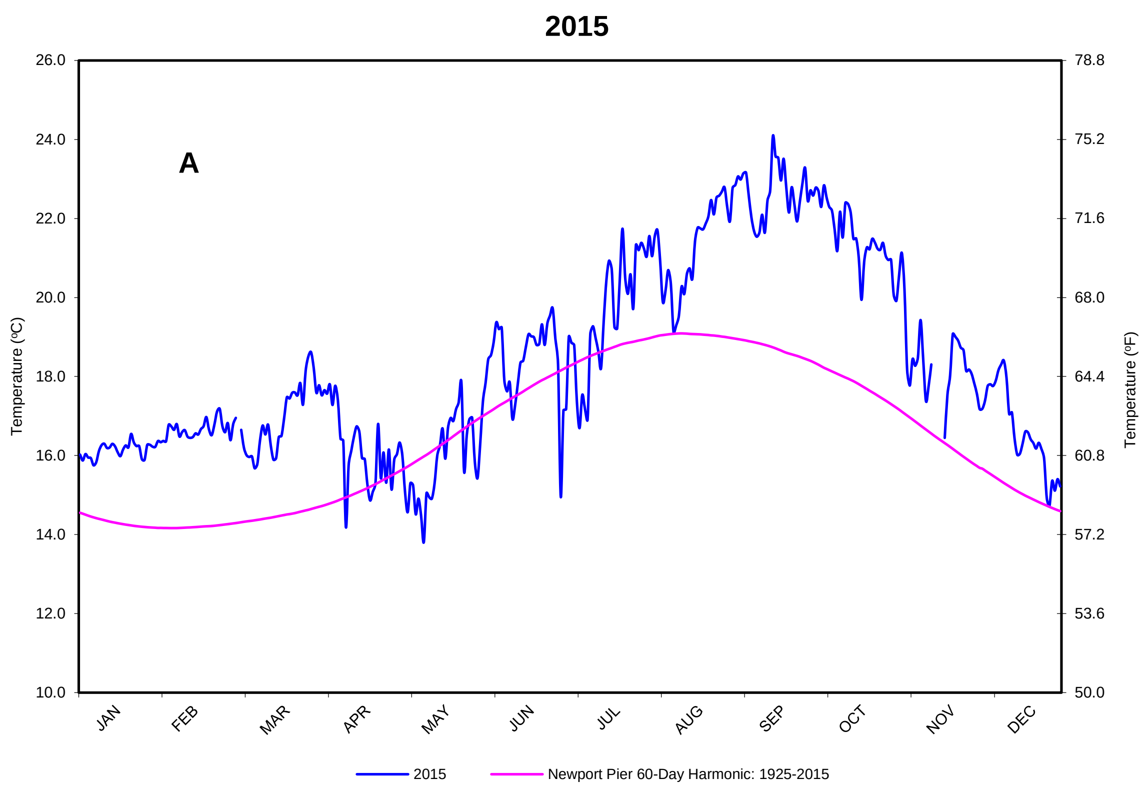
Palos Verdes PVS
Sea Surface Temperature

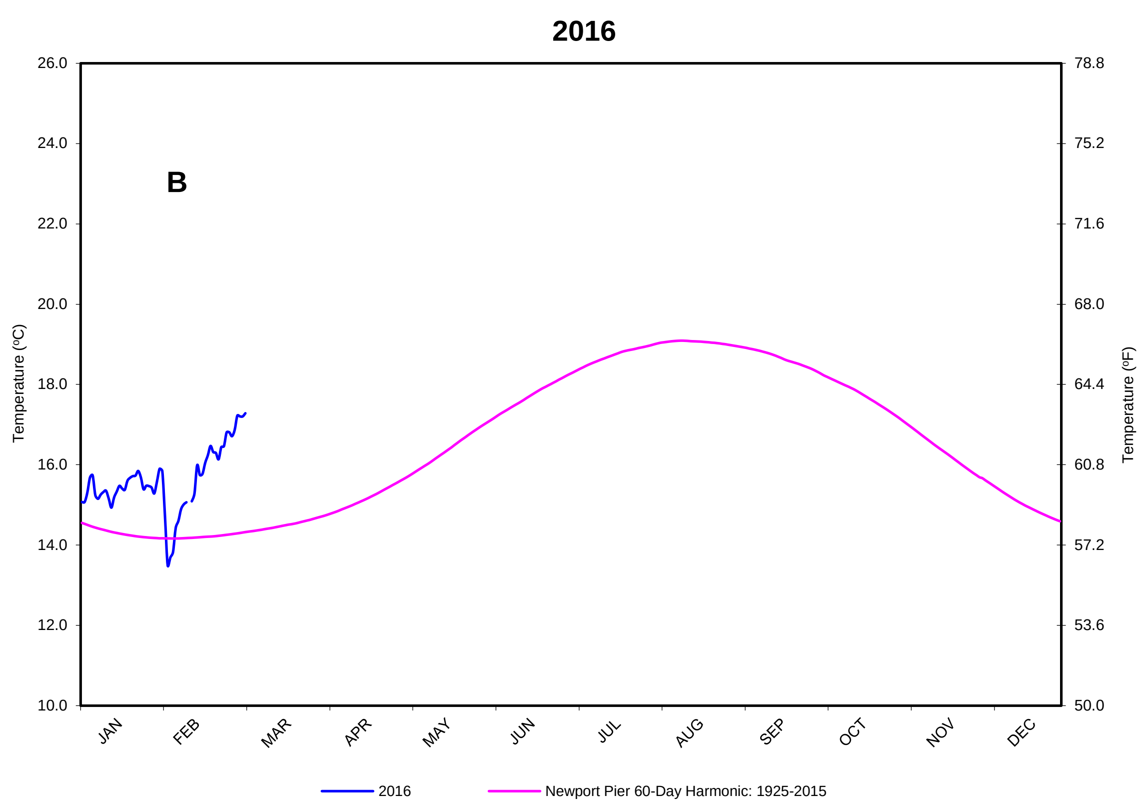




Appendix C.4 Daily sea surface temperatures (SST) at Station Palos Verdes South fhrough November 2015. No data available for 2016.

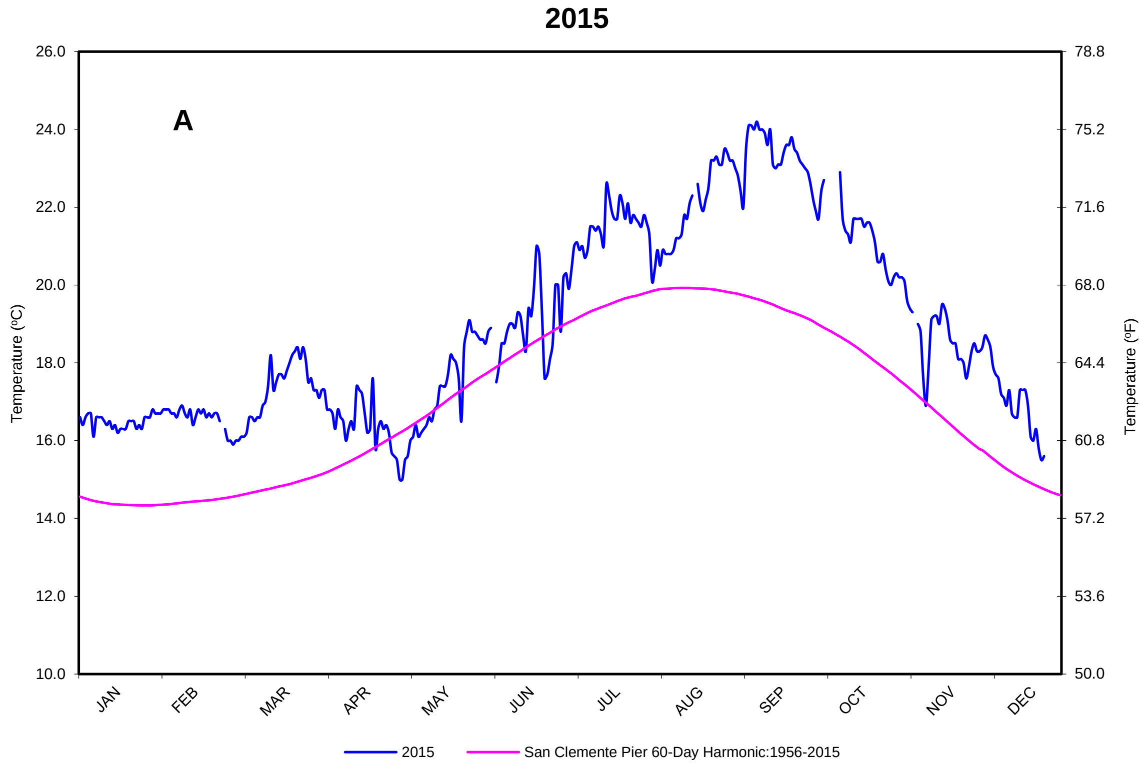
Newport Pier
Sea Surface Temperature

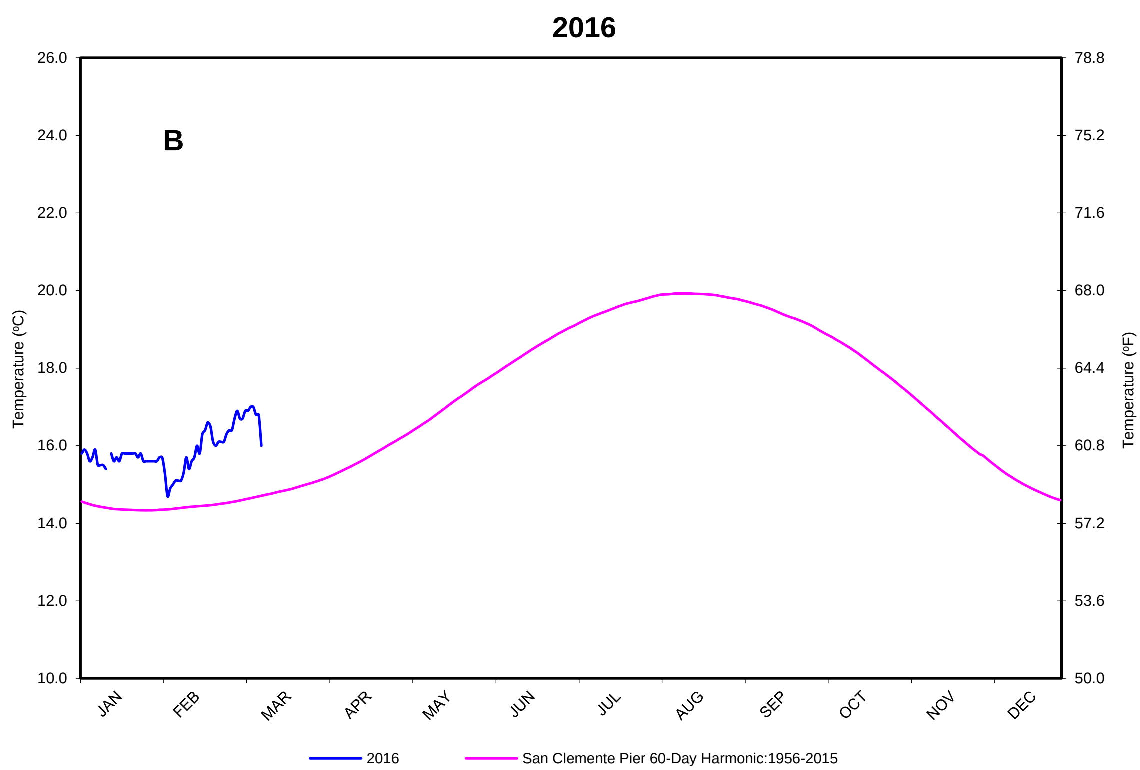




Appendix C.5 Daily sea surface temperatures (SST) at Newport Pier for 2015 through February 2016.

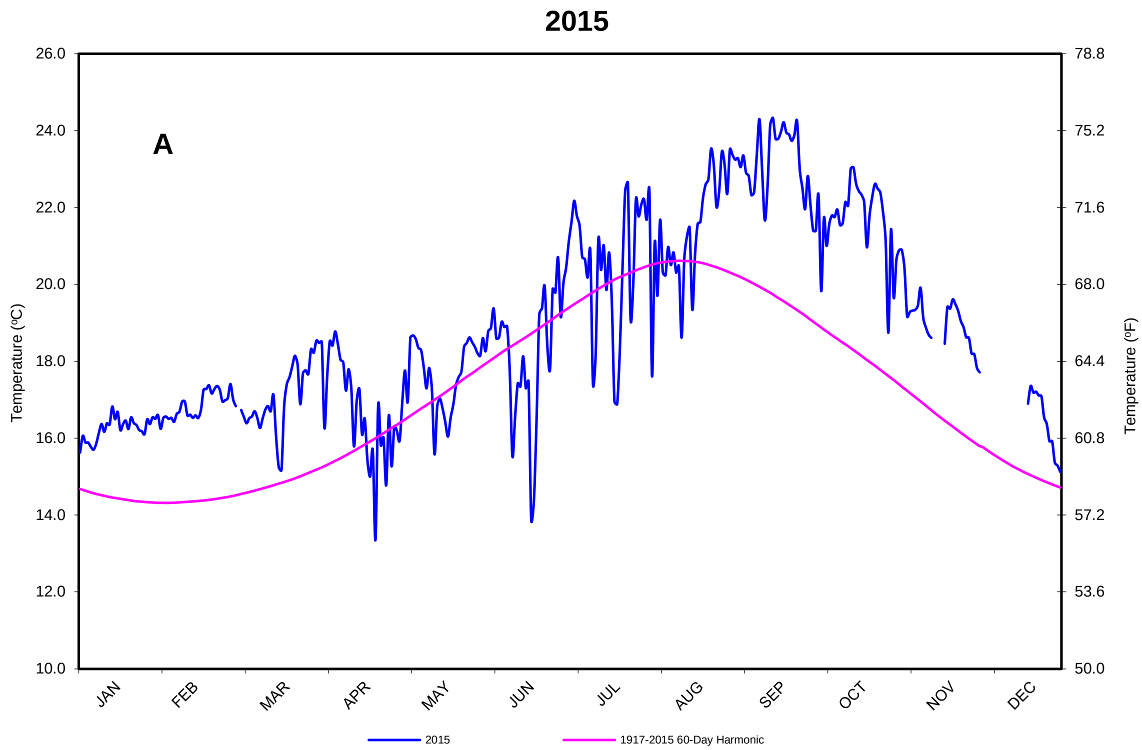
San Clemente Pier
Sea Surface Temperature

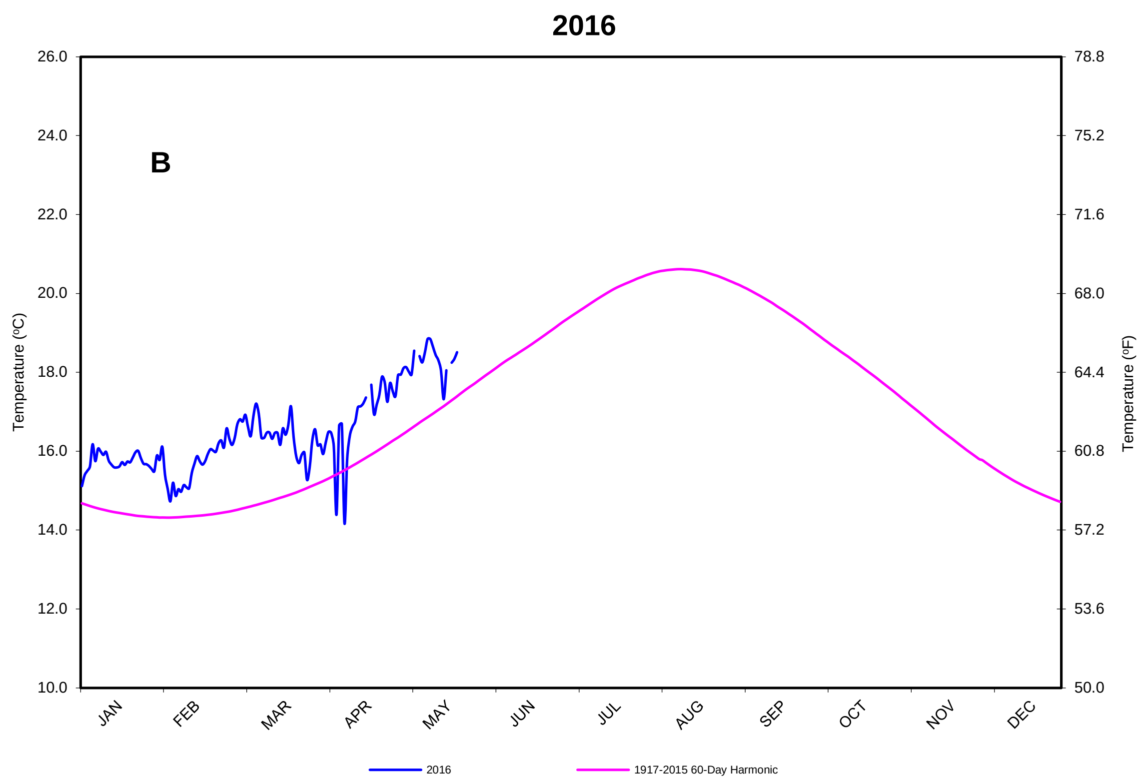




Appendix C.6 Daily sea surface temperatures (SST) at San Clemente for 2015 through March 2016.

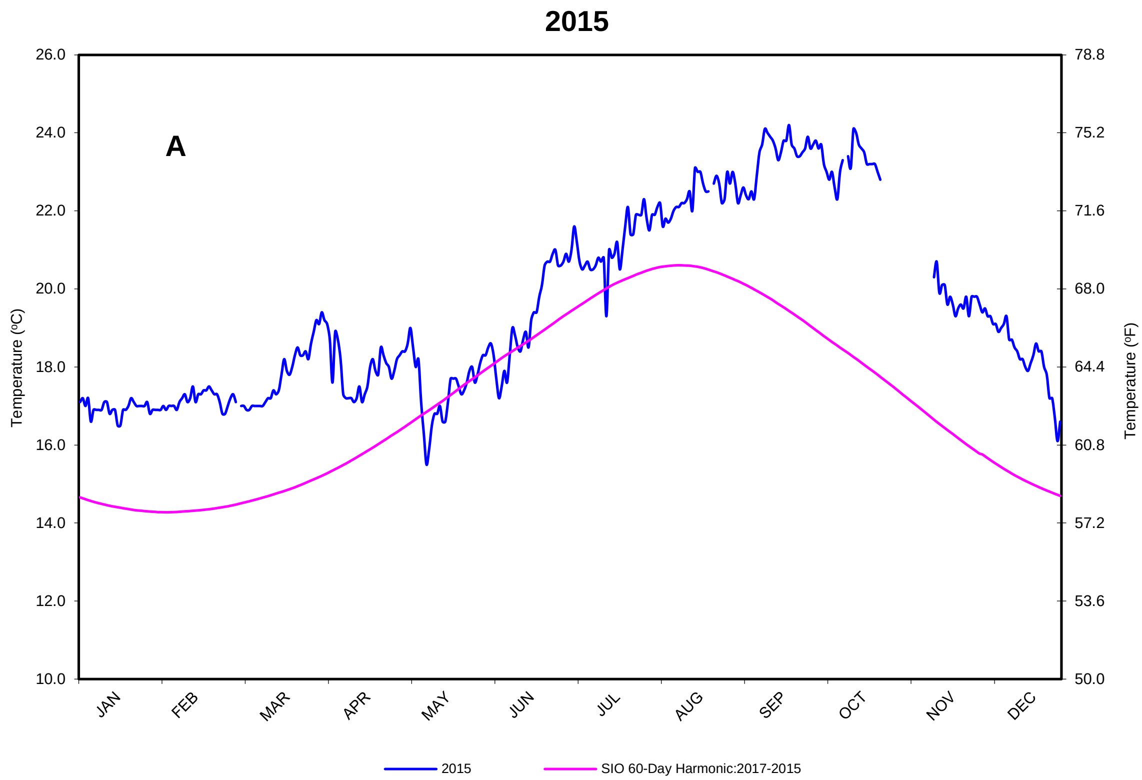
Scripps Pier
Sea Surface Temperature

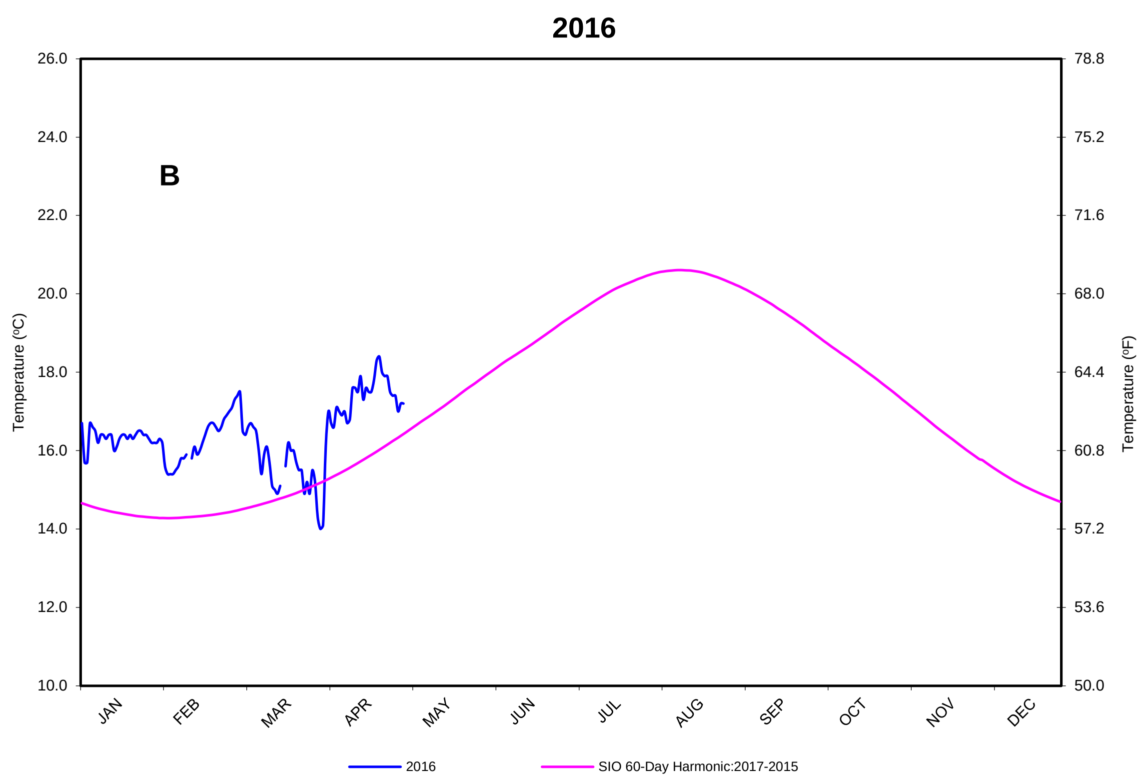




Appendix C.7 Daily sea surface temperatures (SST) at Scripps Pier for 2015 through May 2016.

Point Loma South
Sea Surface Temperature

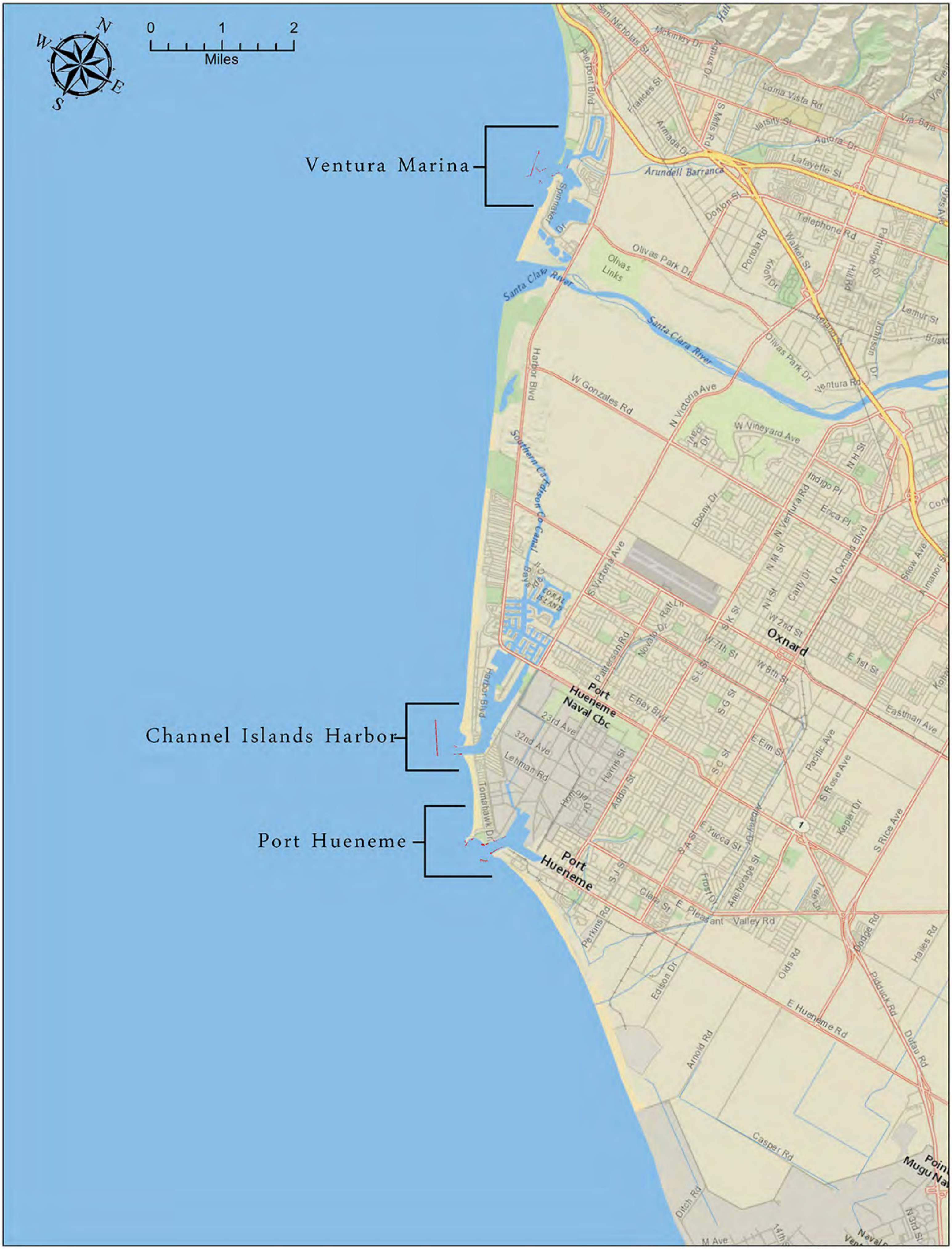




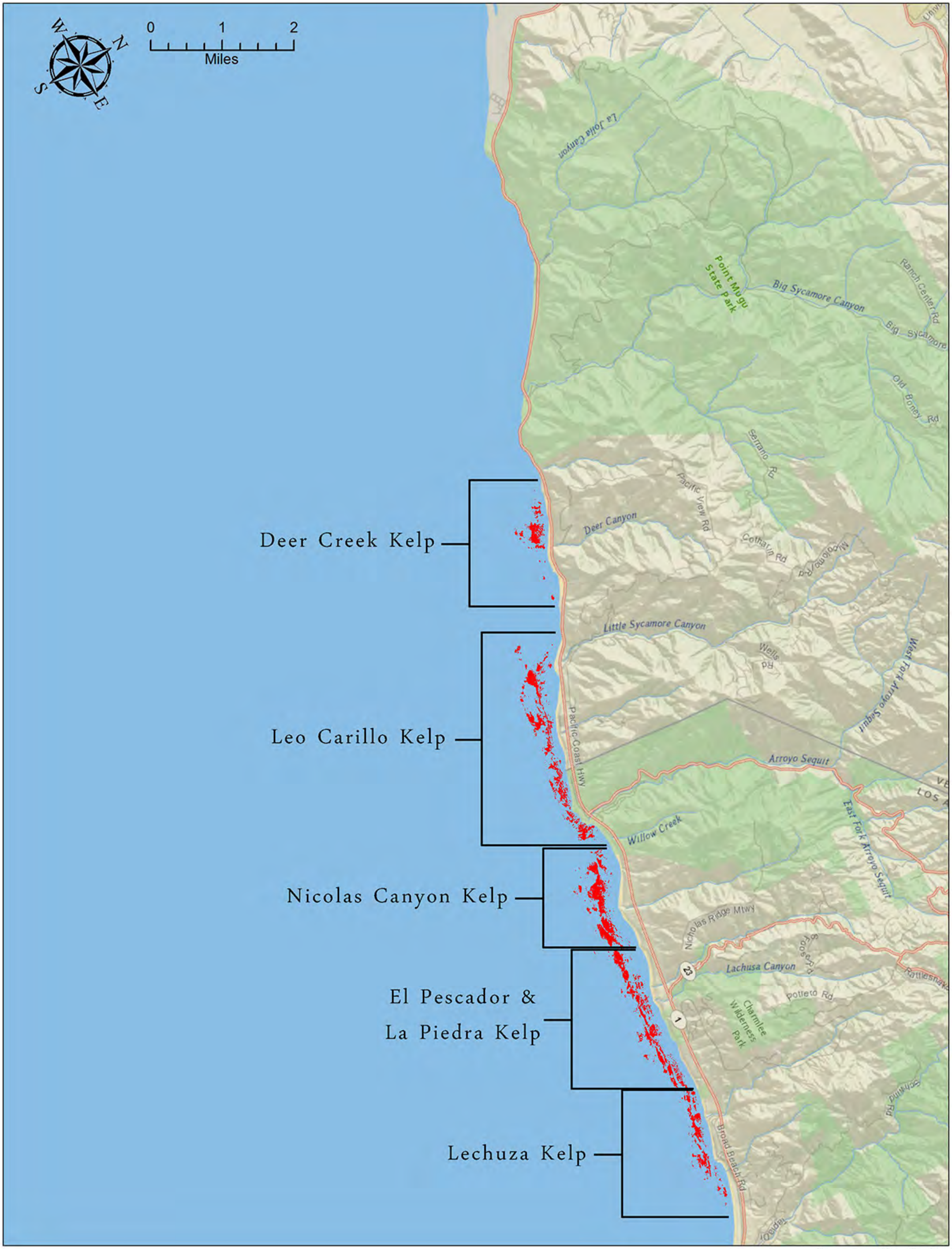
Appendix C.8 Daily sea surface temperatures (SST) at Point Loma South for 2015 through April 2016.

APPENDIX D

2015 Flight Path
(showing kelp from the 2013 Survey, for reference)
Field Data Sheets

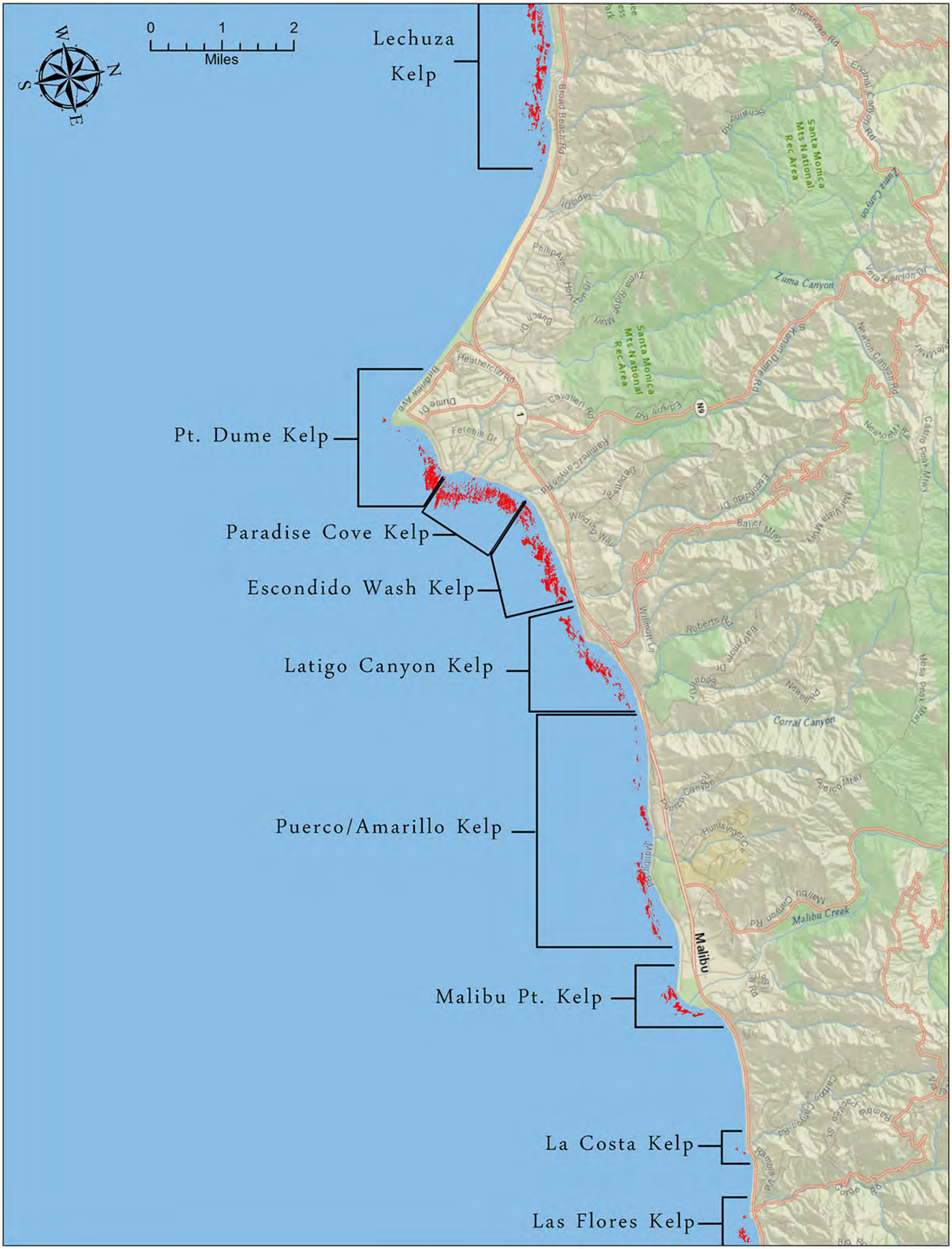

N
W
E
S
0
1
2
Miles
Ventura Marina
Channel Islands Harbor
Port Hueneme
Oxnard
Port Hueneme Naval Cbc
Santa Clara River
Harbor Blvd
W Gonzales Rd
Olivas Park Dr
Telephone Rd
Ventura Rd
Pleasant Valley Rd
E Hueneme Rd
Casper Rd

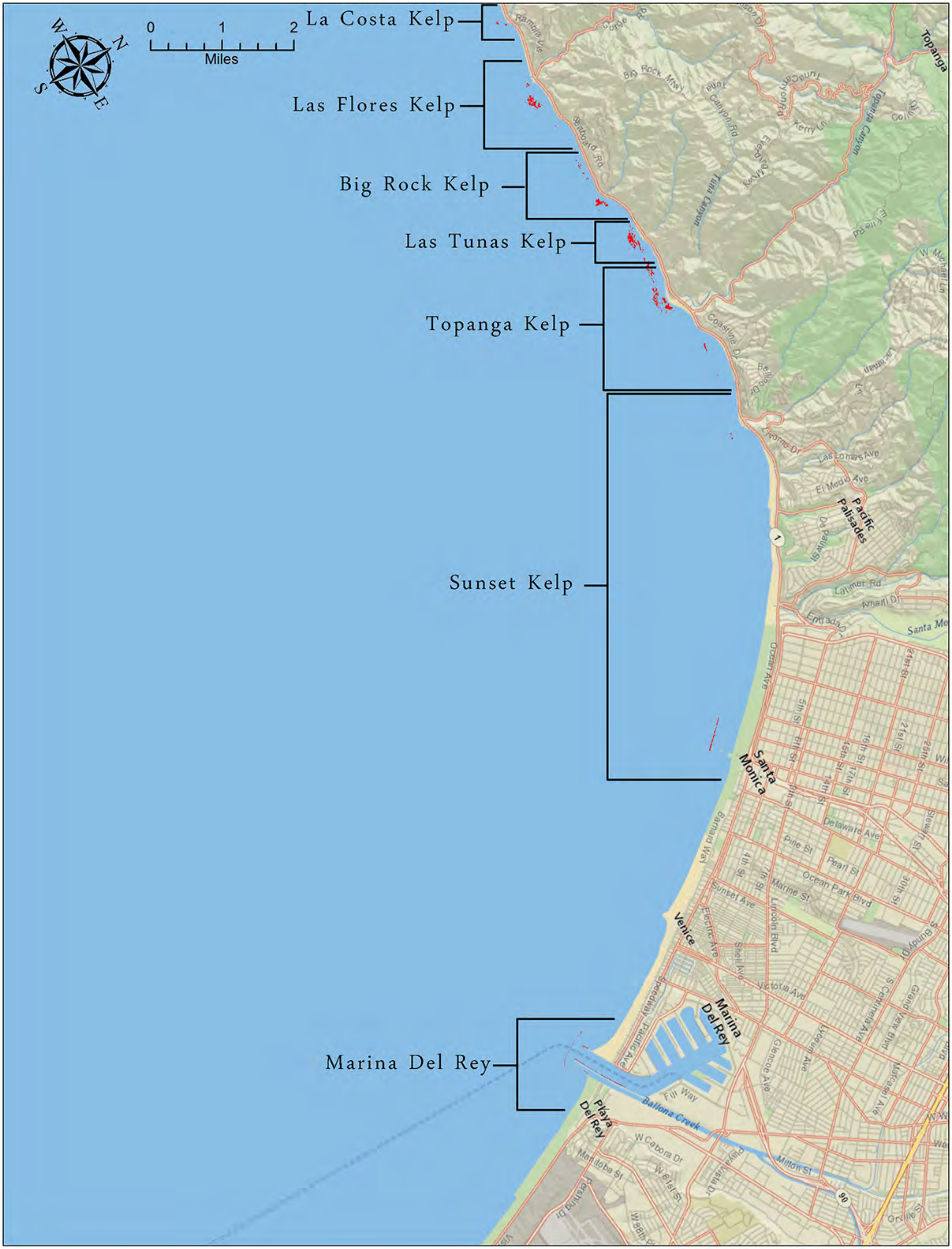
Appendix D.1



0
1
2
Miles
N
E
S
W
La Jolla Canyon
Point Mugu State Park
Big Sycamore Canyon
Ranch Center Rd
Big Sycamore
Old Boney Rd
Serrano Rd
Pacific View Rd
Deer Canyon
Cotharin Rd
Mulholland Rd
Deer Creek Kelp
Little Sycamore Canyon
Wells Rd
West Fork Arroyo Sequit
Leo Carillo Kelp
Pacific Coast Hwy
Arroyo Sequit
Willow Creek
East Fork Arroyo Sequit
Nicolas Canyon Kelp
Nicholas Ridge Mtwy
Lachusa Canyon
Potreto Rd
Charmlee Wilderness Park
El Pescador &
La Piedra Kelp
Lechuza Kelp
Broad Beach Rd
23
1

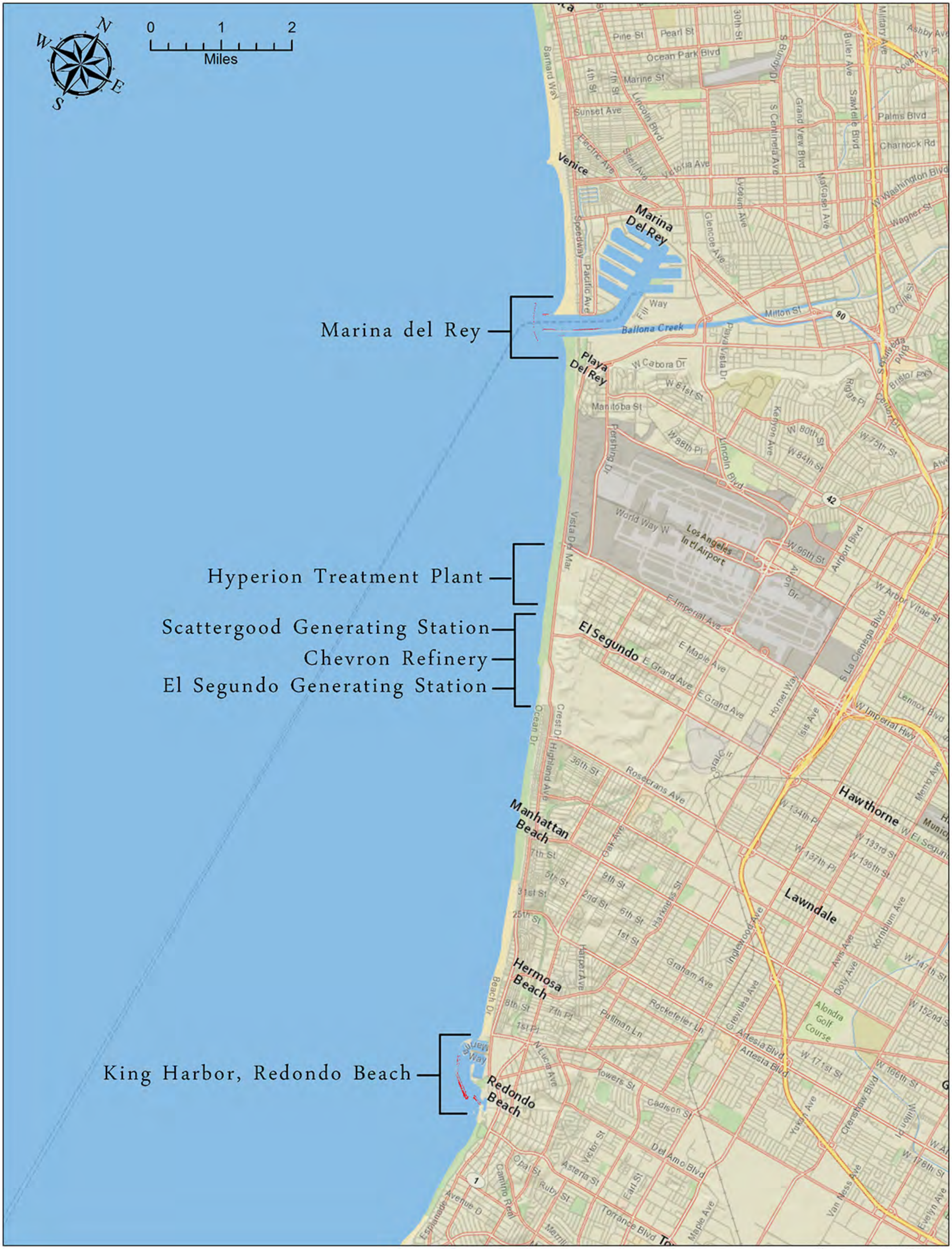
Appendix D.2


Lechuza Kelp
Pt. Dume Kelp
Paradise Cove Kelp
Escondido Wash Kelp
Latigo Canyon Kelp
Puerco/Amarillo Kelp
Malibu Pt. Kelp
La Costa Kelp
Las Flores Kelp
Miles
0
1
2
Santa Monica Mts National Rec Area
Zuma Canyon
Malibu Creek
Corral Canyon
Malibu



0 1 2
Miles
La Costa Kelp
Las Flores Kelp
Big Rock Kelp
Las Tunas Kelp
Topanga Kelp
Sunset Kelp
Marina Del Rey
Topanga
Pacific Palisades
Santa Monica
Venice
Marina Del Rey
Playa Del Rey
Ballona Creek

Appendix D.4


N
E
S
W
0 1 2
Miles
Marina del Rey
Hyperion Treatment Plant
Scattergood Generating Station
Chevron Refinery
El Segundo Generating Station
King Harbor, Redondo Beach
Venice
Marina Del Rey
Playa Del Rey
Los Angeles Int'l Airport
El Segundo
Manhattan Beach
Hermosa Beach
Redondo Beach
Hawthorne
Lawndale
Ballona Creek
Alondra Golf Course

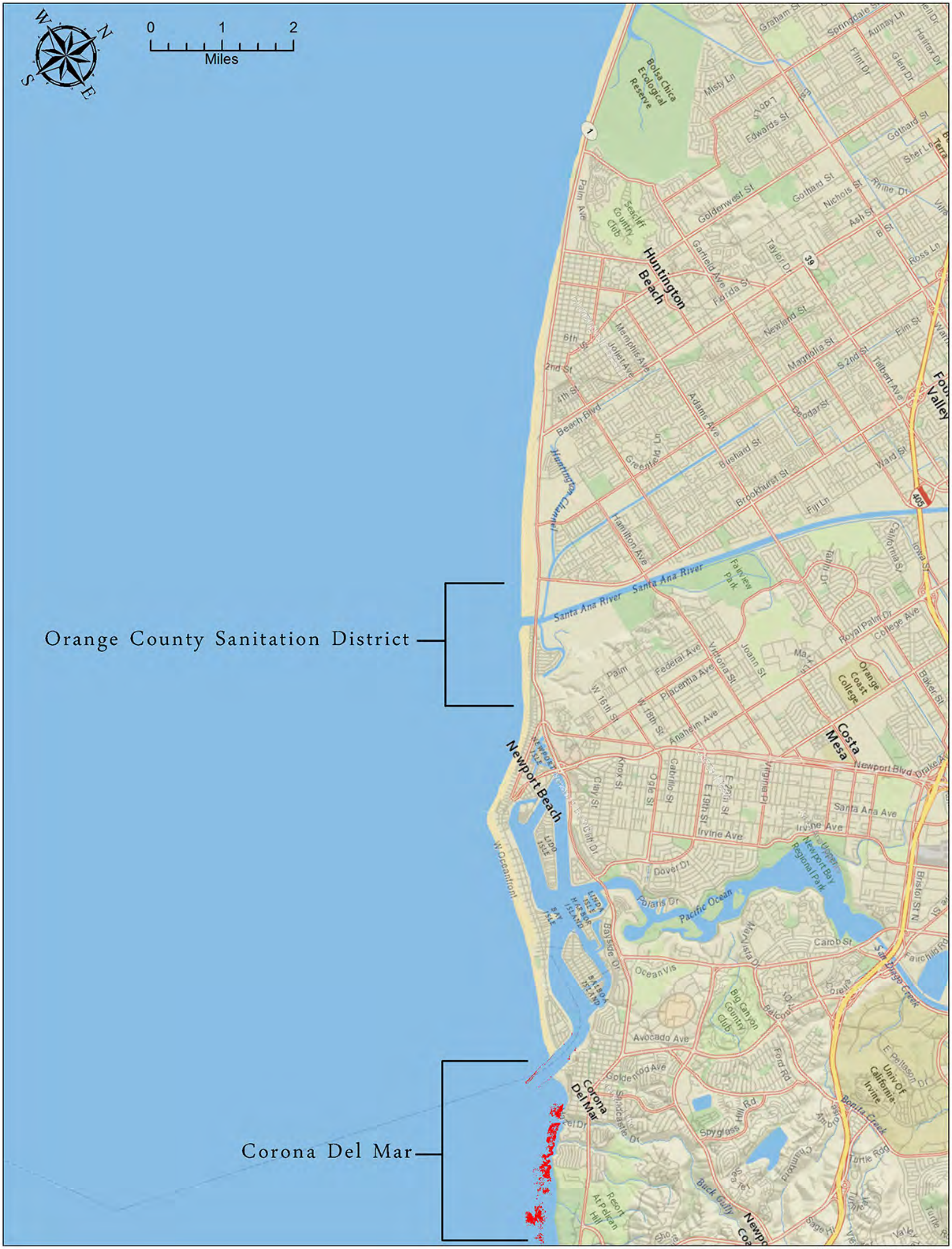
Appendix D.5

0
1
2
Miles
King Harbor
Palos Verdes IV
Palos Verdes III
Palos Verdes II
Palos Verdes I
Cabrillo Kelp
Hermosa Beach
Redondo Beach
Palos Verdes Estates
Palos Verdes Peninsula
Rancho Palos Verdes
Rolling Hills Estates
Rolling Hills
Torrance
Lomita
Harbor City
San Pedro
Wilmington
Los Angeles Harbor
Torrance Municipal Airport
Defense Fuel Supply Point San Pedro

Appendix D.6

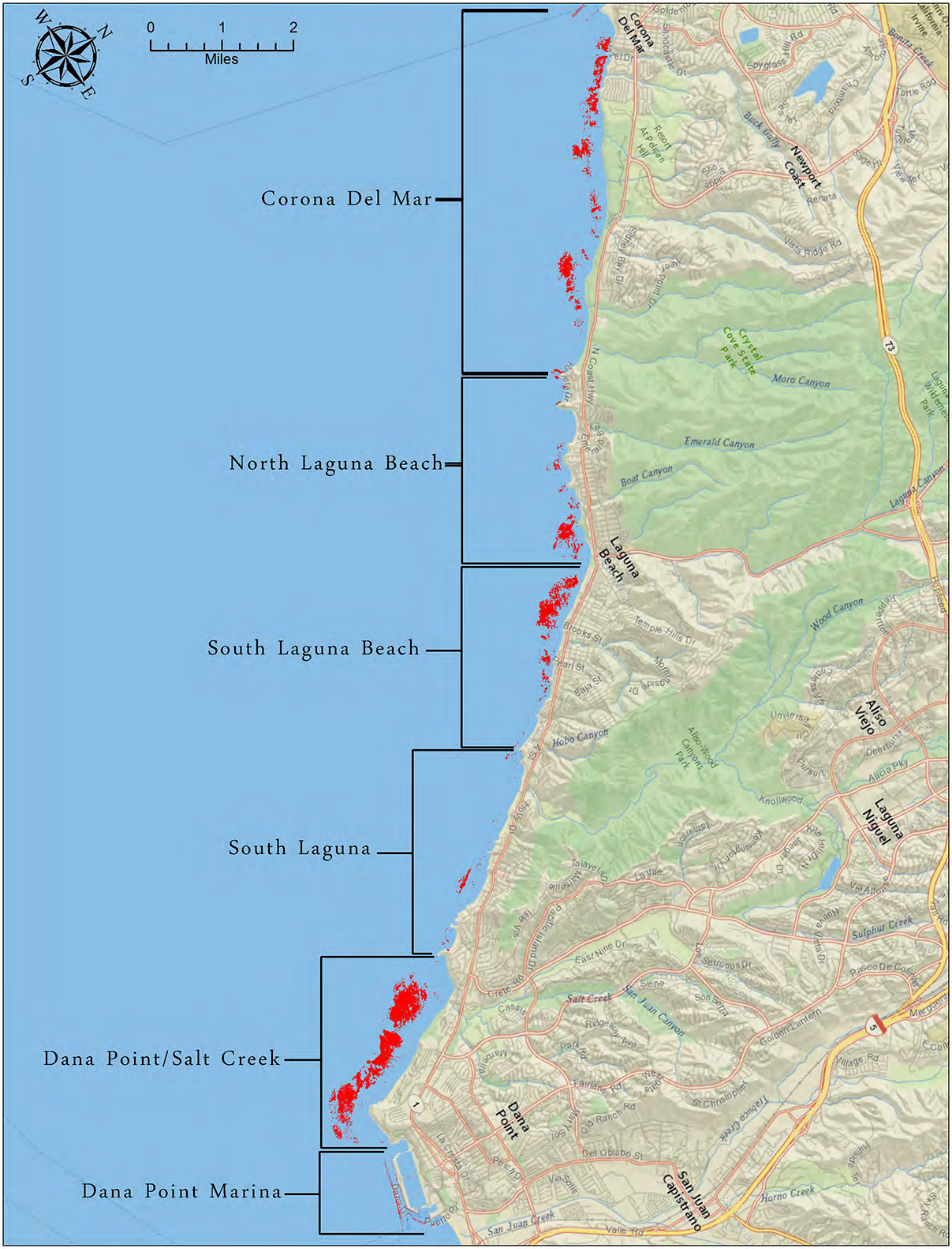

0
1
2
Miles
N
E
S
W
POLA/POLB
Los Angeles Harbor
Long Beach Harbor
Long Beach Harbor
Terminal Island
San Pedro
Wilmington
Seal Beach
Surfside
Sunset Beach
Pacific Ocean
Los Angeles River
Island Grissom
Island White
Island Freeman
Island Chaffee
Paseo Del Mar
Harbor Scenic Way
W Ocean Blvd
E Ocean Blvd
Pico Ave
Alameda St
New Dock St
Anaheim St
Long Beach Blvd
Pine Ave
Alamitos Ave
Redondo Ave
Termino Ave
Argonne Ave
Wilmington Ave
Pier A St
Pier E St
Pier F Ave
Pier J Ave
Terminal Way
Seaside Ave
Ferry St
Miner St
Berth
Quay Ave
Yacht St
S Fries Ave
S Alameda St
Carrack Ave
Caspian Ave
Harbor Ave
San Francisco Ave
Delta Ave
Daisy Ave
Linden Ave
Orange Ave
Ohio Ave
Obispo Ave
Lime Ave
Olive Ave
Eubank Ave
Coil Ave
Anchorage Rd
Pacific Coast Hwy
Edinger Ave
Heil Ave
Seal Way
16th St
Catalina Ave
Lido Ln
47
103
1

Appendix D.7

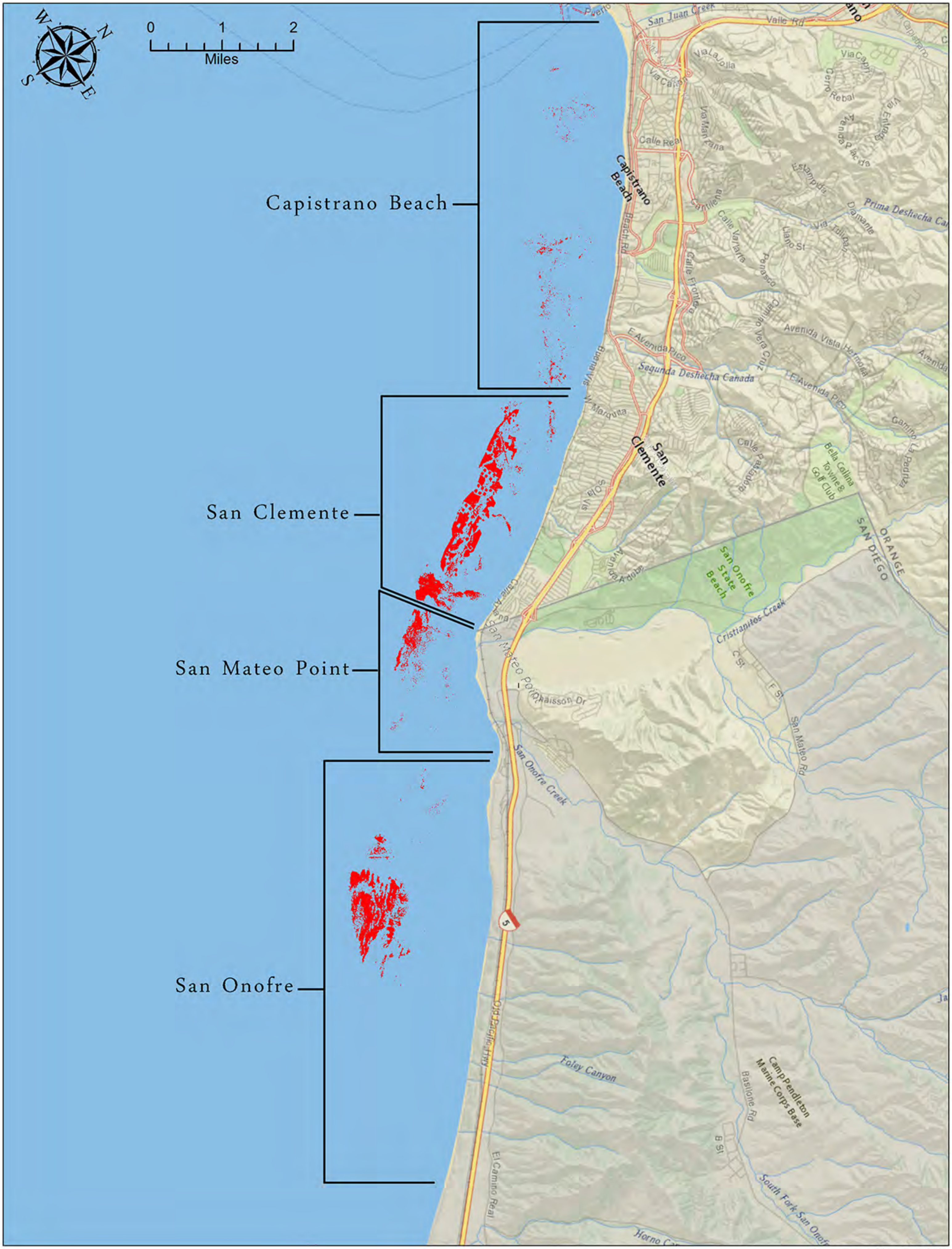


0 1 2
Miles
N
E
S
W
Orange County Sanitation District
Corona Del Mar
Huntington Beach
Newport Beach
Costa Mesa
Bolsa Chica Ecological Reserve
Seacliff Country Club
Orange Coast College
Big Canyon Country Club
Santa Ana River
Huntington Channel
Fairview Park
Upper Newport Bay Regional Park
Lido Isle
Balboa Island
Bay Isle
Harbor Island
Linda Isle
Pacific Ocean
Univ Of California-Irvine
San Diego Creek
Bonita Creek
Buck Gully
Resort At Pelican Hill

Appendix D.8


0 1 2
Miles
N
E
S
W
Corona Del Mar
North Laguna Beach
South Laguna Beach
South Laguna
Dana Point/Salt Creek
Dana Point Marina
Corona Del Mar
Newport Coast
Crystal Cove State Park
Moro Canyon
Emerald Canyon
Boat Canyon
Laguna Beach
Wood Canyon
Hobo Canyon
Aliso-Wood Canyons Park
Aliso Viejo
Laguna Niguel
Sulphur Creek
Salt Creek
San Juan Canyon
Dana Point
San Juan Capistrano
San Juan Creek
Horno Creek
Trabuco Creek
73
5
1

Appendix D.9



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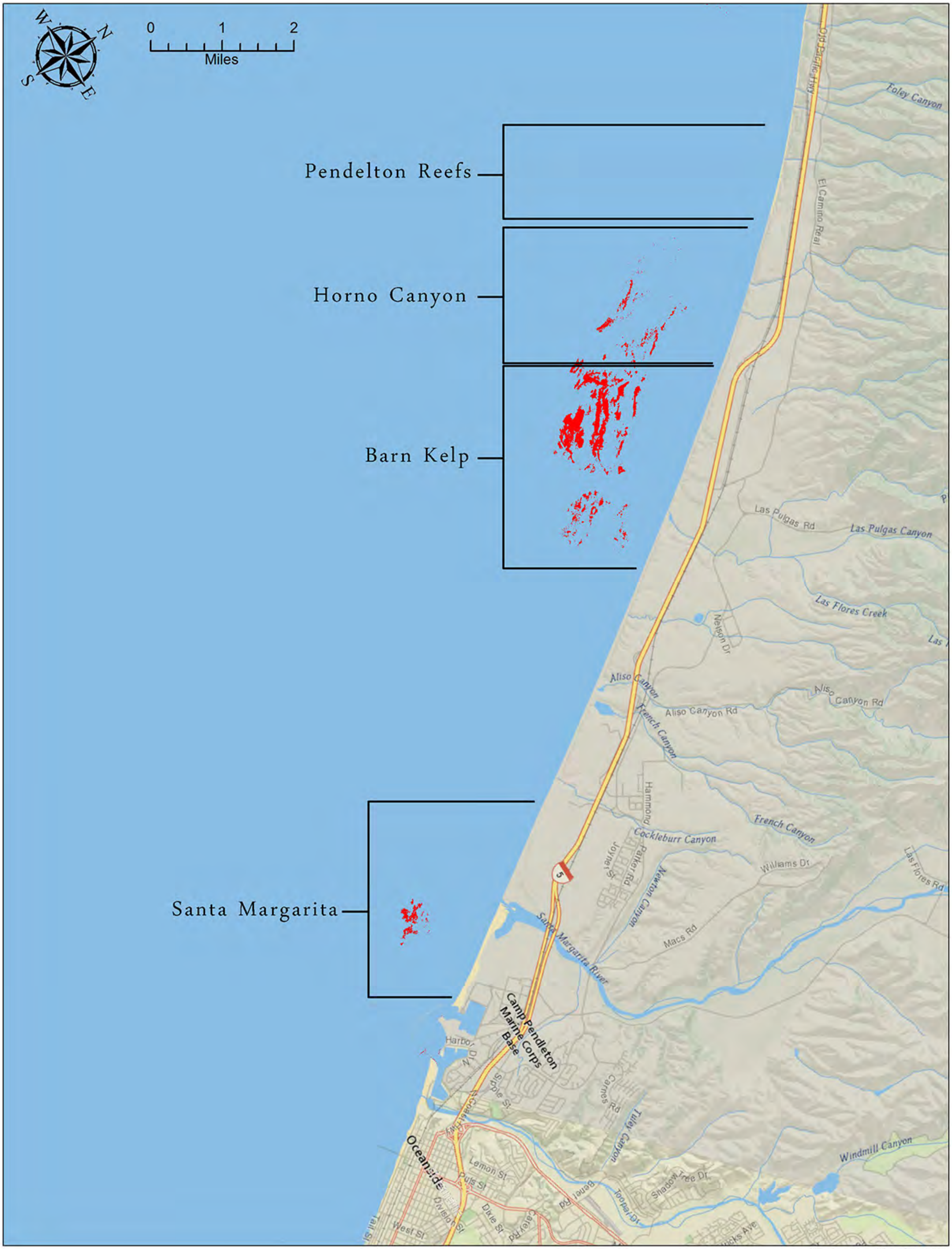
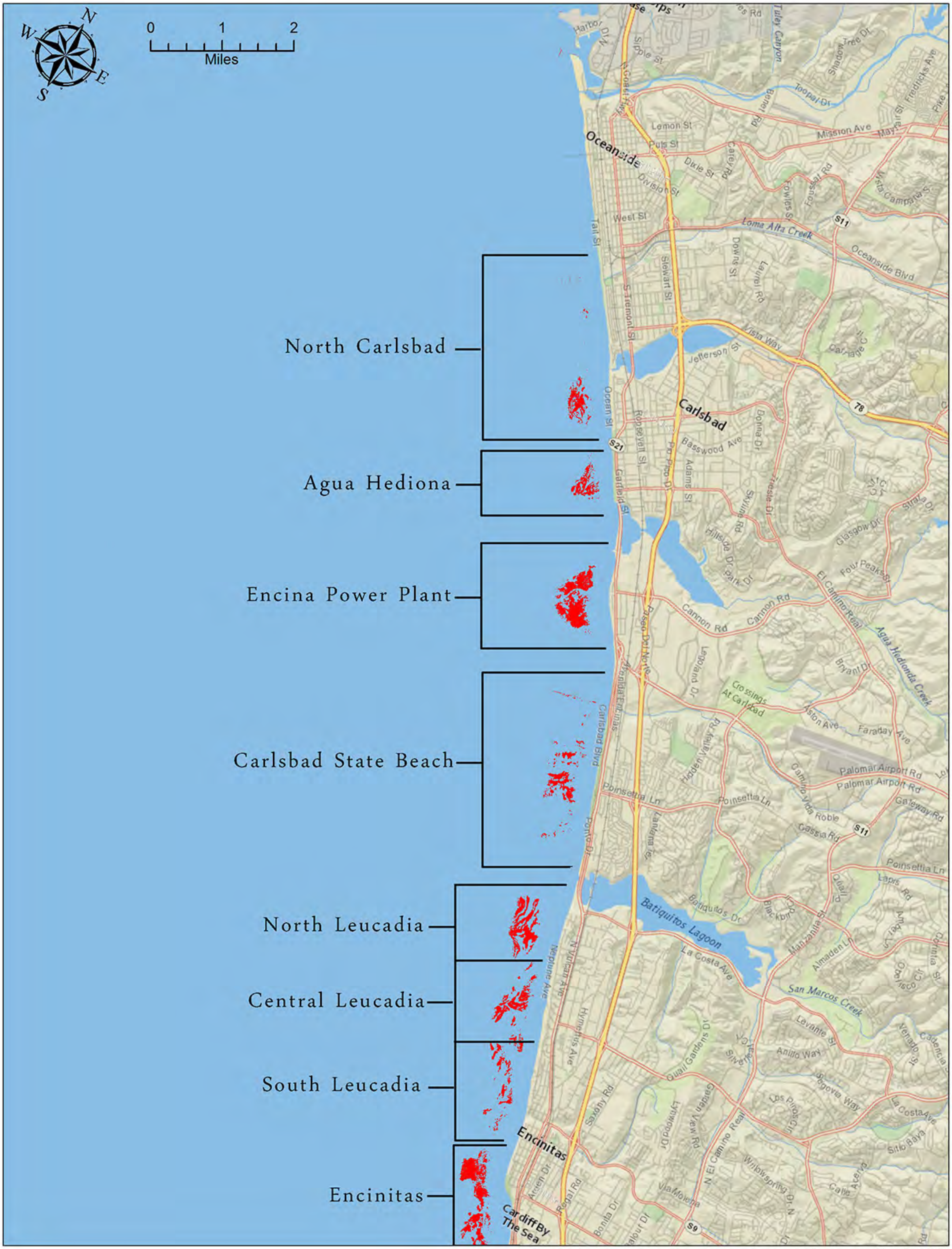
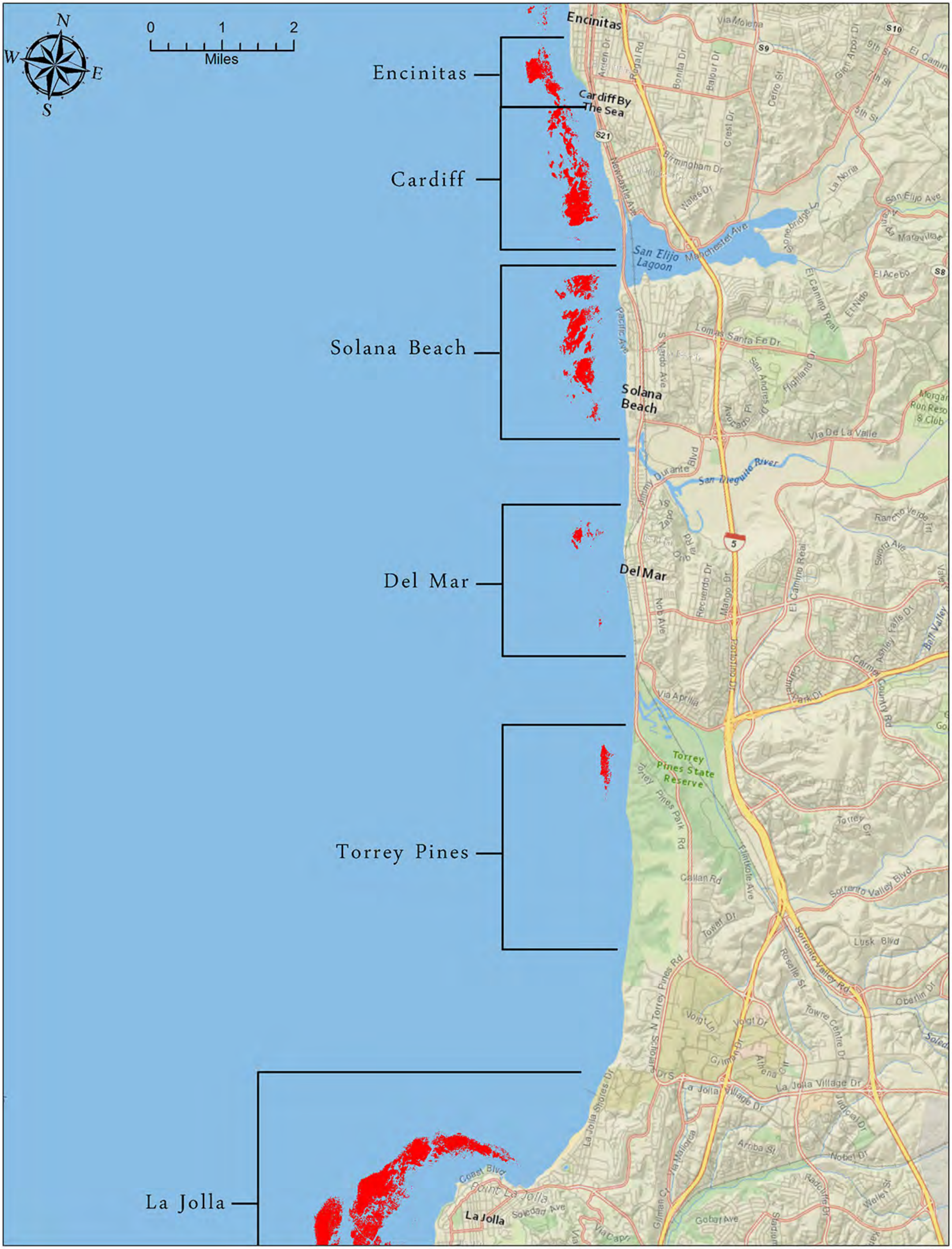
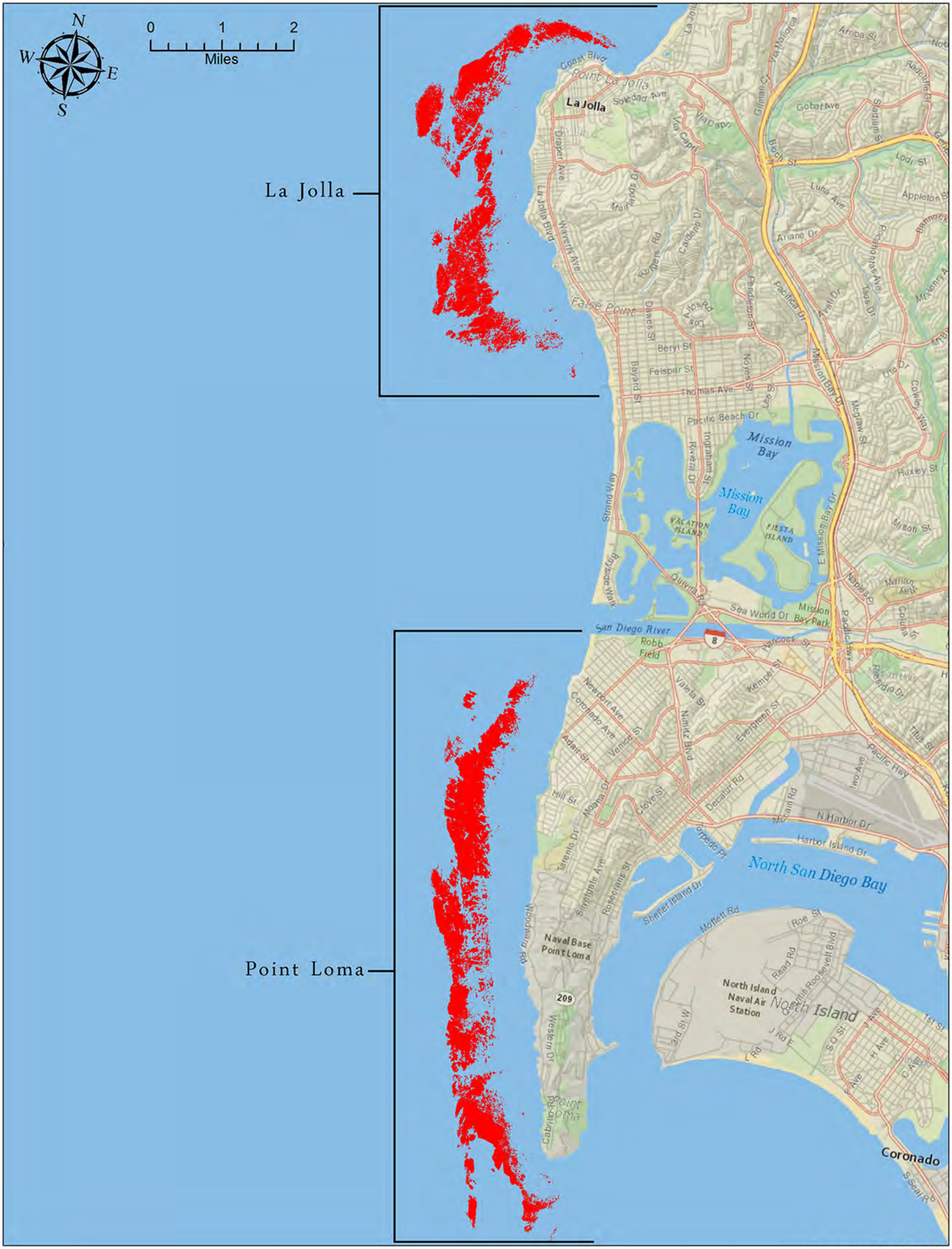


Appendix D.11

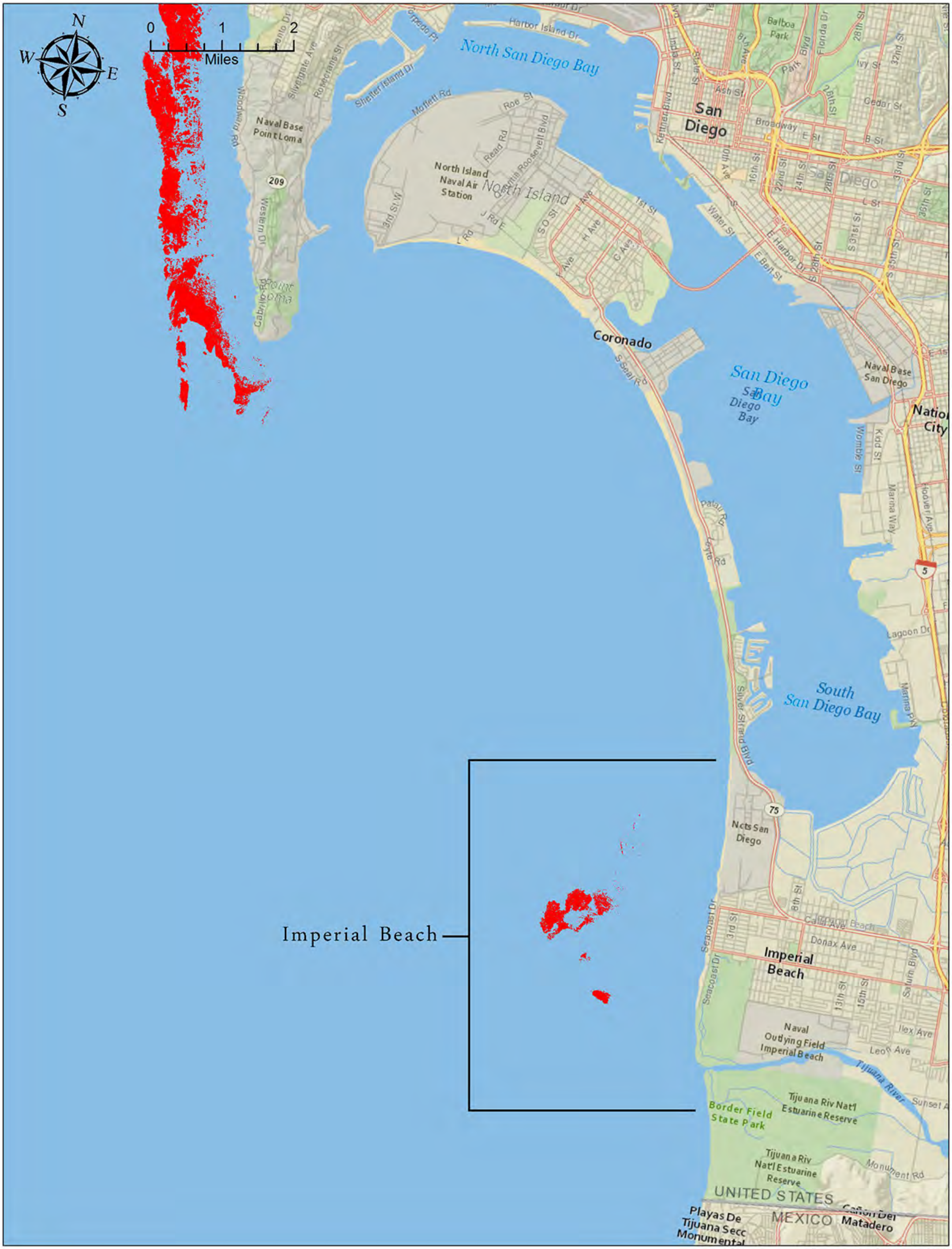


Appendix D.12


N
W
E
S
0 1 2
Miles
Encinitas
Cardiff
Solana Beach
Del Mar
Torrey Pines
La Jolla
Cardiff By The Sea
San Elijo Lagoon
San Dieguito River
Torrey Pines State Reserve
Point La Jolla



Appendix D.14



Appendix D.15

Appendix D.16A Flight record for April 9, 2015.

Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Curtis, Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	3/15
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	4/9/15
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	4/15

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 4/9/15**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Newport Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for: April 9, 2015

	Survey Type	Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1434-1615
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.9' (+) to 2.5' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the range were observed to have a reduced surface extent, with the exception of the northern portion of the Palos Verdes peninsula. Kelp canopies within this range appeared near summer maximum areal extent.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

Ecoscan Resource Data
143 Browns Valley Rd.
Watsonville, CA 95076
(831) 728-5900 (ph./fax)

Signed: ______________________ Bob Van Wagenen, Director

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Appendix D.16B Flight record for June 20, 2015.

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Curtis, Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	6/15
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	6/20/15
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	6/15

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 6/20/15**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Newport Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**June 20, 2015**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1544-1727
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	3.4' (+) to 2.5' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the range were observed to have a reduced surface extent, with the exception of the northern portion of the Palos Verdes peninsula. Kelp canopies within this range appeared near summer maximum areal extent.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

Ecoscan Resource Data
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Signed: ______________________ Bob Van Wagenen, Director

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Appendix D.16C Flight record for September 13, 2015.

Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Curtis, Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	9/15
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	9/13/15
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	10/15

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 9/13/15**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Newport Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for: September 13, 2015

Survey Type		Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1415-1615
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.1' (+) to 0.9' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the range were observed to have a reduced surface extent, with the exception of the range from La Jolla to the U.S. Mexican border, which appeared at near summer maximum areal extent.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

Ecoscan Resource Data
143 Browns Valley Rd.
Watsonville, CA 95076
(831) 728-5900 (ph./fax)

Signed: ______________________ Bob Van Wagenen, Director

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Appendix D. 16D Flight record for December 6, 2015.

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Curtis, Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	12/15
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/6/15
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	12/15

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 12/6/15**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Newport Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		December 6, 2015			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	3-5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1119-1300
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.3' (+) to 0.8' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the range were observed to have a reduced surface extent.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

Ecoscan Resource Data
143 Browns Valley Rd.
Watsonville, CA 95076
(831) 728-5900 (ph./fax)

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

CONDITION OF MACROCYSTIS BED

Date 2/16/15
Location CRYSTAL COVE NO
Time 1120
Wind/Direction 10 K
Current
Weather CLEAR
UW Visibility
Swell Ht/Period 1-2 FT 5

SIDE OBSERVATIONS

26 FT

Kelp Canopy LAT/LONG: 33.33.673 117 49.579

Extent SCATTERED 1/2 DOZ KELP
Density 900 M X 160 M
Tissue color MED YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustaceans 10%
Apical blades OCRY FEW - MOST TATTERED 35 FT 33.33.880 117 50.285
Sediment on blades
Remarks

Subsurface EX TO N SIDE KELP ARCH BAY

33 35.233 117 52.160
22 FT

LOTS OF SUBSURFACE KELP

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location Whistlers
Time 1130
Wind/Direction 10 KS
Current
Weather CLEAR
UW Visibility 5-7 ft
Swell Ht/Period 1-2 ft

SIDE OBSERVATIONS

Kelp Canopy

LAT/LONG: 33°34.574'/117°51.374'

Extent
Density
Tissue color MED YELLOW
% Frond comp. ______ Senile 90% Mature 10% Young ______ Other
Disease
Encrustaceans 5%
Apical blades NONE OBSERVED
Sediment on blades NO
Remarks 3334574117 57 374 WHISTLERS 34FT
100 M x 100 M

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location SO ~~#~~ LAGUNA BCH
Time 1050
Wind/Direction 10-15 K
Current
Weather CLEAR
UW Visibility
Swell Ht/Period 1-2 FT

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG: 33.32.038 / 117.47.018

Extent SCATTERED 150-200 ON SURFACE
Density
Tissue color DARK YELLOW
% Frond comp. ______ Senile 80% Mature 20% Young ______ Other
Disease NO
Encrustaceans 10%
Apical blades NONE
Sediment on blades NO
Remarks LOOKS GOOD IN SHALLOW

Subsurface KELP ON BOTTOM SOLID DEEPER
GOOD IN 35 FT

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location
Time
Wind/Direction 10K SO
Current
Weather CLEAR
UW Visibility 5-8 M
Swell Ht/Period 1-2FT

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG:

Extent EXTENSIVE KELP
Density
Tissue color DARK YELLOW
% Frond comp. ______ Senile 80% Mature 20 Young ______ Other
Disease
Encrustaceans 5%
Apical blades 100
Sediment on blades NO TATTERED

53 FT
33.35.342/117.47.531

Remarks

Subsurface SOLID ON BOTTOM
EXTENDS OUT TO 53 FT

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location SOUTH LAGUNA
Time 1015
Wind/Direction 10 K S
Current
Weather CLEAR
UW Visibility 5-6 M
Swell Ht/Period 1-2 FT S

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG:

Extent NO SURFACE KELP
Density
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustaceans
Apical blades
Sediment on blades
Remarks

45 FT

Subsurface SCATTERED ~~[illegible]~~ SUB SURFACE KELP

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location WNN KELP
Time 915
Wind/Direction 5-5-10 K
Current
Weather CLEAR
UW Visibility 5-8 M
Swell Ht/Period 1-2 FT SWELL

SIDE OBSERVATIONS

Kelp Canopy

LAT/LONG:

Extent LIGHT BUT
Density SCATTERED BUT EXTENSIVE AREA
Tissue color MED YELLOW
% Frond comp. ______ Senile 50% Mature 50% Young ______ Other
Disease NO
Encrustaceans 5-10 %
Apical blades FEW
Sediment on blades NO
Remarks

50 FT
33 23 310 117 36, 779

Subsurface 4-5 M SURFACE

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location SAN MATEO
Time
Wind/Direction S 10 K
Current
Weather CLEAR
UW Visibility 5-10 FT
Swell Ht/Period 5 1-2 FT

SIDE OBSERVATIONS

41 FT

Kelp Canopy LAT/LONG: 33.22.347/117.35.620

Extent ABOUT 20 ON SURFACE
Density 1/2 MI X 1/4 MILE
Tissue color MED YELLOW
% Frond comp. ____ Senile ____ Mature 100% Young ____ Other
Disease
Encrustaceans 5-10%
Apical blades NO TIPS SOME GOOD
Sediment on blades NO
Remarks LARGE BED

45 FT 33.22010 117.36.43
1/2 X 1/4 MILE
48 FT 57 FT OUTSIDE EDGE
DARK YELLOW

Subsurface FAIR DENSITY ON FATH NO TIPS - TATTERED
LOTS OF KELP 37 FT ON BOTTOM
COHERENT CANOPY

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

LAT-LONG ____

CONDITION OF MACROCYSTIS BED

Date 2/16/16
Location SAN ONOFRE
Time 820
Wind 10-15 KT
Current ____
Weather CLEAR
UW visibility 10-15 FT

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent SCATTERED KELP ON SURFACE
Density SCATTERED ON FATHOMETER @ 45 FT NOTHING @ STA 10
Tissue color MED YELLOW
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease ____
Encrustations NONE
Apical blades LOOK GOOD
Sediment on blades ____ 33. 20, 743 / 117. 33, 325
Remarks frond length horizontal

SCATTERED KELP @ 54 FT

Subsurface SEVERAL PLANTS / SOME GOOD APICAL TIPS

STA 14 117 34339 33 21 [illegible]
45 FT
LOTS OF SUBSURFACE KELP

UNDERWATER OBSERVATIONS

Midwater

Tissue color ____
Encrustations ____
Disease ____
Sed. on blades ____
Sinking fronds ____
Grazed tissues ____

Bottom

Tissue color ____
Encrustations ____
Disease ____
Sed. on blades ____
Sinking fronds ____
Grazed tissues ____
Sporophylls ____
Juvenile fronds ____
Holdfasts ____
Old holdfasts ____
Recruitment ____

Remarks ____

Community

Litter ____
Turf algae ____
Turf invert. ____
Shrub algae ____
Large invert. ____
Fishes ____
Disease ____
Sed. on rocks ____
Urchin status ____

Remarks ____

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date: 2/16/16
Location: [illegible]
Time: 1015
Wind/Direction: 10 E
Current:
Weather: CLEAR
UW Visibility: 5-7 M
Swell Ht/Period:

SIDE OBSERVATIONS

Kelp Canopy

LAT/LONG:

Extent: D
Density: THIN SCATTERED
Tissue color: MED YELLOW
% Frond comp. ~~[illegible]~~ Senile 80% Mature 20% Young ______ Other
Disease:
Encrustaceans: 5%
Apical blades: SOME MOST MISSING
Sediment on blades:

33° 2R87C / 117 [illegible]
45 FT SCATTERED ON SURFACE

Remarks:

Subsurface: [illegible] ALL [illegible] SURFACE [illegible] TO ABOUT 20 FT [illegible]

GOOD GROWTH 40 FT BELOW SURFACE 45 FT SCATTERED KELP ON SURFACE [illegible]

UNDERWATER OBSERVATIONS

Midwater

Tissue color:
Encrustaceans:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom

Tissue color:
Encrustaceans:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:
Sporophylls:
Juvenile fronds:
Holdfasts:
Old holdfasts:
Recruitment:

Remarks:

Community

Litter:
Turf algae:
Turf invert.:
Shrub algae:
Large invert.:
Fishes:
Disease:
Sed. on rocks:
Urchin status:

Remarks:

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date: 2/16/06
Location: CAPISTRANO
Time: 940
Wind/Direction: 10K
Current:
Weather: CLEAR
UW Visibility: 5-8M
Swell Ht/Period:

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG: 33 25.696/117 38.976

Extent: NO SURFACE CANOPY
Density: THIN
Tissue color: MED YELLOW
% Frond comp. ______ Senile 50% Mature ______ Young ______ Other
Disease:
Encrustaceans: 5%
Apical blades: NO TIPS
Sediment on blades:
Remarks: DEPTH 44 FT. A FEW KELP NEAR SURFACE 10-12 FT TALL ON BOTTOM

Subsurface: MEAGER 1 DG SCATTERED KELP

UNDERWATER OBSERVATIONS

Midwater

Tissue color:
Encrustaceans:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom

Tissue color:
Encrustaceans:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:
Sporophylls:
Juvenile fronds:
Holdfasts:
Old holdfasts:
Recruitment:

Remarks:

Community

Litter:
Turf algae:
Turf invert.:
Shrub algae:
Large invert.:
Fishes:
Disease:
Sed. on rocks:
Urchin status:

Remarks:

Bottom characteristics

 LAT-LONG 17.032 29.357

CONDITION OF MACROCYSTIS BED

NO SURFACE KELP VISIBLE

Date 2/4/96
Location BARN KELP
Time 0815
Wind WNW 5-8 0-5
Current
Weather CLEAR SUNNY
UW visibility

TOPSIDE OBSERVATIONS

SPORADIC RED CRABS ON SURFACE
1 LOB TRAP 100 YDS NORTH

Kelp Canopy

Extent LOTS OF SUBSURFACE KELP ON FATHOMETER
Density
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustations
Apical blades
Sediment on blades
Remarks frond length horizontal

YELLOWTAIL 35-40 LBS
FL = 3.5
TL = 4.1

Subsurface VIS BOTTOM - 5 M

901 DOWN
918 UP
@ 50 FT

DIVE @ THIS LOCATION

UNDERWATER OBSERVATIONS

1 BLACK SEA BASS 80-100 LB
BANDED GUITARFISH 3 FT

Midwater

Tissue color LIGHT-MED BROWN
Encrustations NO
Disease NO
Sed. on blades YES
Sinking fronds
Grazed tissues 1 TATTERED

Bottom

Tissue color MED TO DARK
Encrustations NO
Disease NO / KANNO
Sed. on blades YES 50M TRANSECT
Sinking fronds DS BOB
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks NO CRABS ON BOTTOM
60° ON BOTTOM

Bottom Characteristics

COBBLE / SAND

 LAT-LONG

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location SANTA MARGARITA
Time 9:33
Wind 0-5 K
Current —
Weather CLEAR SUNNY
UW visibility 3-4 M

TOPSIDE OBSERVATIONS

SANTA MARGARITA KELP
NO SURFACE KELP

Kelp Canopy

Extent TEMP - 58° or 60° BOTTOM
Density
Tissue color
% Frond comp. Senile Mature Young Other
Disease
Encrustations
Apical blades
Sediment on blades
Remarks frond length horizontal

Subsurface NOTHING OF FATHOMETER # 1 SPOT HARD BOTTOM,
HARD BOTTOM NO KELP. # 2 SPOT 14.845 26.44.9

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts 1 + 3 BLACK
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

LAT-LONG 09175/22185
NO KELP SURF OR SUB
70 FT

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location NORTH CARLSBAD
Time 1007
Wind
Current
Weather
UW visibility

TOPSIDE OBSERVATIONS

Kelp Canopy NO SURFACE KELP

Extent SMALL PATCHES 09306/21772 - 100M/30M
Density
Tissue color DARK YELLOW 3-4M
% Frond comp. Senile Mature Young Other
Disease NO
Encrustations NO 10%
Apical blades MOST TATTERED 16-20FT SWELL LAST WEEK
Sediment on blades
Remarks frond length horizontal 3-4 M

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

 LAT-LONG ______

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location AGUA HEDIONDA
Time 1015
Wind 0-5
Current NO
Weather CLEAR
UW visibility 5-8 M

TOPSIDE OBSERVATIONS

JUVENILE WHALE OFFSHORE

Kelp Canopy

Extent A FEW ADULTS
Density ______
Tissue color MED TO DARK YELLOW
% Frond comp. ______ Senile ______ Mature 90% Young 10% Other
Disease ______
Encrustations 20 to 30%
Apical blades FEW PRESENT SOME TATTERED
Sediment on blades NO SED
Remarks frond length horizontal 4-5 M

Subsurface

ON FATHOMETER

UNDERWATER OBSERVATIONS

Midwater

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______

Bottom

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______
Sporophylls ______
Juvenile fronds ______
Holdfasts ______
Old holdfasts ______
Recruitment ______

Remarks ______

Community

Litter ______
Turf algae ______
Turf invert. ______
Shrub algae ______
Large invert. ______
Fishes ______
Disease ______
Sed. on rocks ______
Urchin status ______

Remarks ______

Bottom Characteristics

______

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location ENCINA POWER PLANT
Time 1025
Wind/Direction 0-5 K
Current NONE
Weather CLEAR
UW Visibility 4-5 M
Swell Ht/Period 1-2 FT

SIDE OBSERVATIONS

Kelp Canopy

31 FT DIVE HERE
LAT/LONG: 87/898 29536

Extent SOME SUB-SURFACE - DIVE
Density VERY SCATTERED / LOWER THAN BARN KELP
Tissue color LITE YELLOW
% Frond comp. ______ Senile 10% Mature 90% ON BOTTOM Young ______ Other
Disease
Encrustaceans
Apical blades TATTERED
Sediment on blades KELP WAS BEAT UP
(ON DIVE SLATES)
NO TUNA CRABS
Remarks
20 PURPLE/REDS
Subsurface URCHINS + LOBSTER

31 FT IN 1035
OUT 1055

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

LAT-LONG 04764 [illegible]
NORTH LEUCADIA

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location [illegible]
Time 1110
Wind
Current
Weather
UW visibility

TOPSIDE OBSERVATIONS

UP COAST 1/4 MILE

Kelp Canopy

Extent SCATTERED BUT EXTENSIVE
Density 1/4 MI / 100 M WIDTH
Tissue color DK BROWN
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustations 90% ENCRUSTED
Apical blades TATTERED
Sediment on blades
Remarks frond length horizontal 3-5 M 5YFT

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

 LAT-LONG 04387/1910805 FT

CENTRAL LEUCADIA

CONDITION OF MACROCYSTIS BED

Date 4/2/16
Location 1/3) CENTRAL
Time 1130
Wind
Current
Weather
UW visibility

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent EXTENSIVE BUT SCATTERED
Density
Tissue color DARK YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustations 40%
Apical blades
Sediment on blades
Remarks frond length horizontal Z M LONG

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

 LAT-LONG ________

CONDITION OF MACROCYSTIS BED

Date 2/4/80
Location SOUTH LEUCADIA
Time 1134
Wind 0-5K
Current NO
Weather CLEAR
UW visibility 10-15FT

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent SCATTERED
Density LIGHT
Tissue color DARK TO LT YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease ______
Encrustations 50-80%
Apical blades ______
Sediment on blades TATTERED
Remarks frond length horizontal 8-M

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______

Bottom

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______
Sporophylls ______
Juvenile fronds ______
Holdfasts ______
Old holdfasts ______
Recruitment ______

Remarks ______

Community

Litter ______
Turf algae ______
Turf invert. ______
Shrub algae ______
Large invert. ______
Fishes ______
Disease ______
Sed. on rocks ______
Urchin status ______

Remarks ______

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location CARLSBAD ST. PARK
Time ____
Wind/Direction ____
Current ____
Weather ____
UW Visibility ____
Swell Ht/Period ____

SIDE OBSERVATIONS

Kelp Canopy

LAT/LONG: ____

Extent A FEW ON SURFACE
Density ____
Tissue color MED BROWN
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease ____
Encrustaceans ____
Apical blades TATTERED
Sediment on blades ____
Remarks ____

BREACHING JUV GREY WHALE

Subsurface ____

UNDERWATER OBSERVATIONS

Midwater

Tissue color ____
Encrustaceans ____
Disease ____
Sediment on blades ____
Sinking fronds ____
Grazed tissues ____

Bottom

Tissue color ____
Encrustaceans ____
Disease ____
Sediment on blades ____
Sinking fronds ____
Grazed tissues ____
Sporophylls ____
Juvenile fronds ____
Holdfasts ____
Old holdfasts ____
Recruitment ____

Remarks ____

Community

Litter ____
Turf algae ____
Turf invert. ____
Shrub algae ____
Large invert. ____
Fishes ____
Disease ____
Sed. on rocks ____
Urchin status ____

Remarks ____

Bottom characteristics

____

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location CARDIFF
Time 1145
Wind/Direction 0-5
Current <1
Weather CLEAR
UW Visibility 10-15 FT
Swell Ht/Period

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG: 01/509/17872 64FT CARDIFF

Extent EXTENSIVE 50-100 M/LAYER
Density
Tissue color MED TO LIGHT YELLOW
% Frond comp. Senile 50% Mature 50% Young Other
Disease
Encrustaceans 60% OLD ENCRUSTED
Apical blades TATTERED. NO TIPS
Sediment on blades
BOTTLENOSE DOLPHINS
Remarks

Subsurface 3-5 M FROND LENGTHS

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location ENCINITAS
Time 1142
Wind/Direction 0-5 K
Current NONE
Weather CLEAR
UW Visibility 5 M
Swell Ht/Period 1-2 FT

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG: ENCINITAS

Extent 300 M / 100 M
Density THIN 20%
Tissue color MED YELLOW-TO DARK YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease NO
Encrustaceans 60%
Apical blades TATTERED
Sediment on blades NO
Remarks
FRONDS - 2-4 M ON SURFACE

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location CARDIFF
Time 1200
Wind/Direction 0-5
Current NO
Weather CLEAR
UW Visibility 15FT
Swell Ht/Period 1-2FT

SIDE OBSERVATIONS

Kelp Canopy

LAT/LONG: CARDIFF 32.59/117/17

Extent EXTENSIVE SUBSURFACE KELP
Density SCATTERED ON SURFACE
Tissue color 70% DARK YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease NO
Encrustaceans 10%
Apical blades TATTERED
Sediment on blades NO

150 M/0.25 MILES
GREY WHALE

Remarks

Subsurface 4-5 M FROND LENGTH

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

 LAT-LONG ______

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location TORREY PINES
Time 1534
Wind 10K
Current ______
Weather CLEAR
UW visibility ______

TOPSIDE OBSERVATIONS NO SURFACE CANOPY

Kelp Canopy

Extent COUPLE OF PLANTS ON SURFACE
Density VERY SCATTERED
Tissue color DARK YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease ______
Encrustations ______
Apical blades TATTERED
Sediment on blades ______
Remarks frond length horizontal 2-3 M

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______

Bottom

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______
Sporophylls ______
Juvenile fronds ______
Holdfasts ______
Old holdfasts ______
Recruitment ______

Remarks ______

Community

Litter ______
Turf algae ______
Turf invert. ______
Shrub algae ______
Large invert. ______
Fishes ______
Disease ______
Sed. on rocks ______
Urchin status ______

Remarks ______

Bottom Characteristics

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location DEL MAR
Time 1210
Wind/Direction ~~NO~~ 3 KN 10-12 WEST
Current NO
Weather CLEAR
UW Visibility 5-8 m
Swell Ht/Period 1-2 FT

SIDE OBSERVATIONS

Kelp Canopy LAT/LONG: 57.539/16.610

Extent NO SURFACE CANOPY
Density NO SUB SURFACE
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustaceans
Apical blades
Sediment on blades
Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

 LAT-LONG ______

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location LA JOLLA NORTH
Time 1245
Wind 10K
Current NO
Weather CLEAR
UW visibility 10-15 FT

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent LA JOLLA NORTH
Density ______
Tissue color MED DARK
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease ______
Encrustations ______
Apical blades TATTERED
Sediment on blades ______
Remarks frond length horizontal 3-4 FT

Subsurface

SCATTERED

UNDERWATER OBSERVATIONS

Midwater

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______

Bottom

Tissue color ______
Encrustations ______
Disease ______
Sed. on blades ______
Sinking fronds ______
Grazed tissues ______
Sporophylls ______
Juvenile fronds ______
Holdfasts ______
Old holdfasts ______
Recruitment ______

Remarks ______

Community

Litter ______
Turf algae ______
Turf invert. ______
Shrub algae ______
Large invert. ______
Fishes ______
Disease ______
Sed. on rocks ______
Urchin status ______

Remarks ______

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location LA JOLLA CENTRAL
Time 1254
Wind 10 K W
Current ND
Weather CLEAR
UW visibility 15 FT

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent SUBSURFACE KELP OF FATHOMETER
Density NO SURFACE CANOPY
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustations
Apical blades
Sediment on blades
Remarks frond length horizontal

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

 LAT-LONG

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location
Time 1300
Wind 10
Current
Weather
UW visibility

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent
Density NO SURFACE CANOPY
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustations
Apical blades
Sediment on blades
Remarks frond length horizontal

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location PT LOMA NORTH
Time 120
Wind 10K
Current NO
Weather CLEAR
UW visibility 10-15FT

TOPSIDE OBSERVATIONS

3 GREY WHALES HEADING SOUTH

Kelp Canopy

Extent SCATTERED KELP ON
Density THIN
Tissue color DARK YELLOW
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease NO
Encrustations 10%
Apical blades TATTERED
Sediment on blades SED
Remarks frond length horizontal 2-8 M

Subsurface FATHOMETER INDICATES KELP ON BOTTOM

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location PT LOMA SOUTH
Time 1410
Wind 10
Current
Weather CLEAR
UW visibility 10-15 FT

TOPSIDE OBSERVATIONS

40,280/117.16027

Kelp Canopy

Extent EXTENSIVE 60FT
Density
Tissue color 50% DARK YELL 50% LIGHT
% Frond comp. Senile Mature Young Other
Disease NO
Encrustations 70%
Apical blades NO TIPS
Sediment on blades NO
Remarks frond length horizontal 3-6 M

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustations
Disease
Sed. on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom Characteristics

CONDITION OF MACROCYSTIS BED

Date 2/4/16
Location IMPERIAL BCH
Time 7:30 PM
Wind/Direction 10 K
Current NO
Weather CLEAR
UW Visibility 15 FT
Swell Ht/Period 1-2 FT / W WND

'SIDE OBSERVATIONS

60 FT

Kelp Canopy LAT/LONG: 34757 10.167

Extent 1/2 MI x 1/2 MILE
Density DENSE LOOKS GOOD
Tissue color 90% DARK 10 LIGHT
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other

CHGE @ 2 FT

Disease
Encrustaceans 10 %
Apical blades NO TIPS TATTERED
Sediment on blades NO
Remarks

MAC

Subsurface 2-4 METER FROND LENGTHS

34,142/9 09,229

117.9 32.34

TANK ... ENCOUNTERED ... ATTACHED

UNDERWATER OBSERVATIONS

Midwater

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustaceans
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Remarks

Community

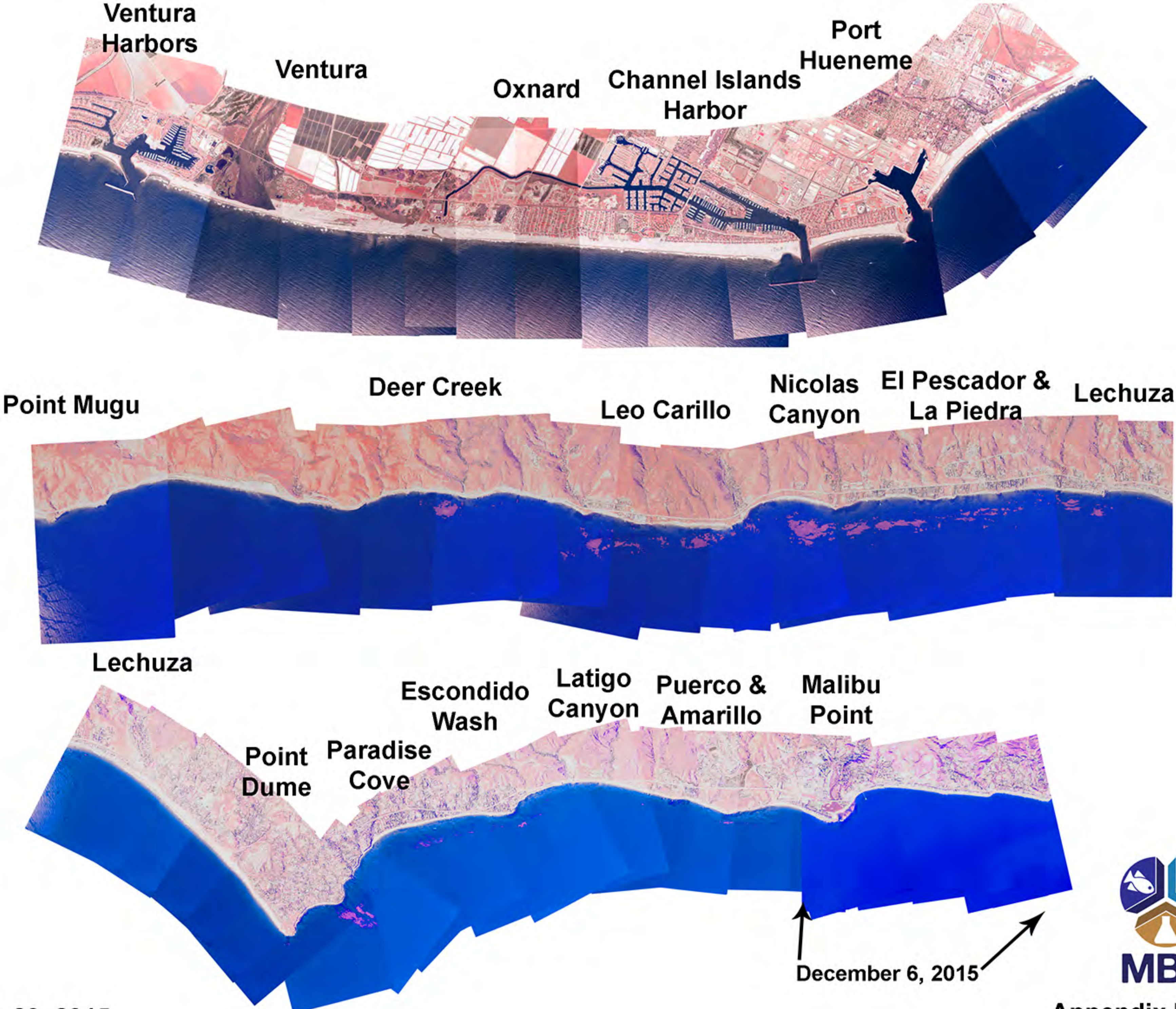
Litter
Turf algae
Turf invert.
Shrub algae
Large invert.
Fishes
Disease
Sed. on rocks
Urchin status

Remarks

Bottom characteristics

APPENDIX E

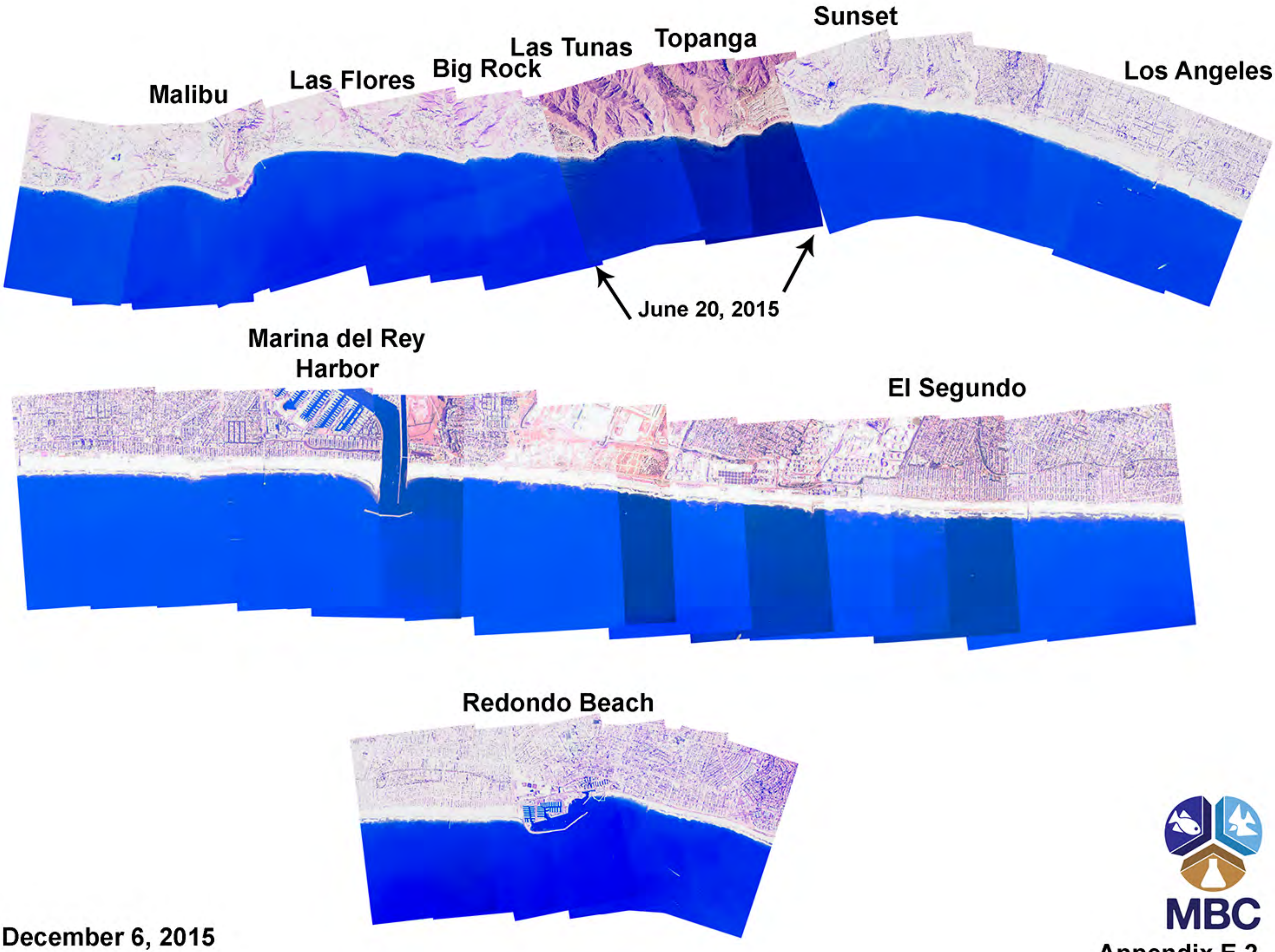
Kelp Canopy Aerial Photographs



June 20, 2015

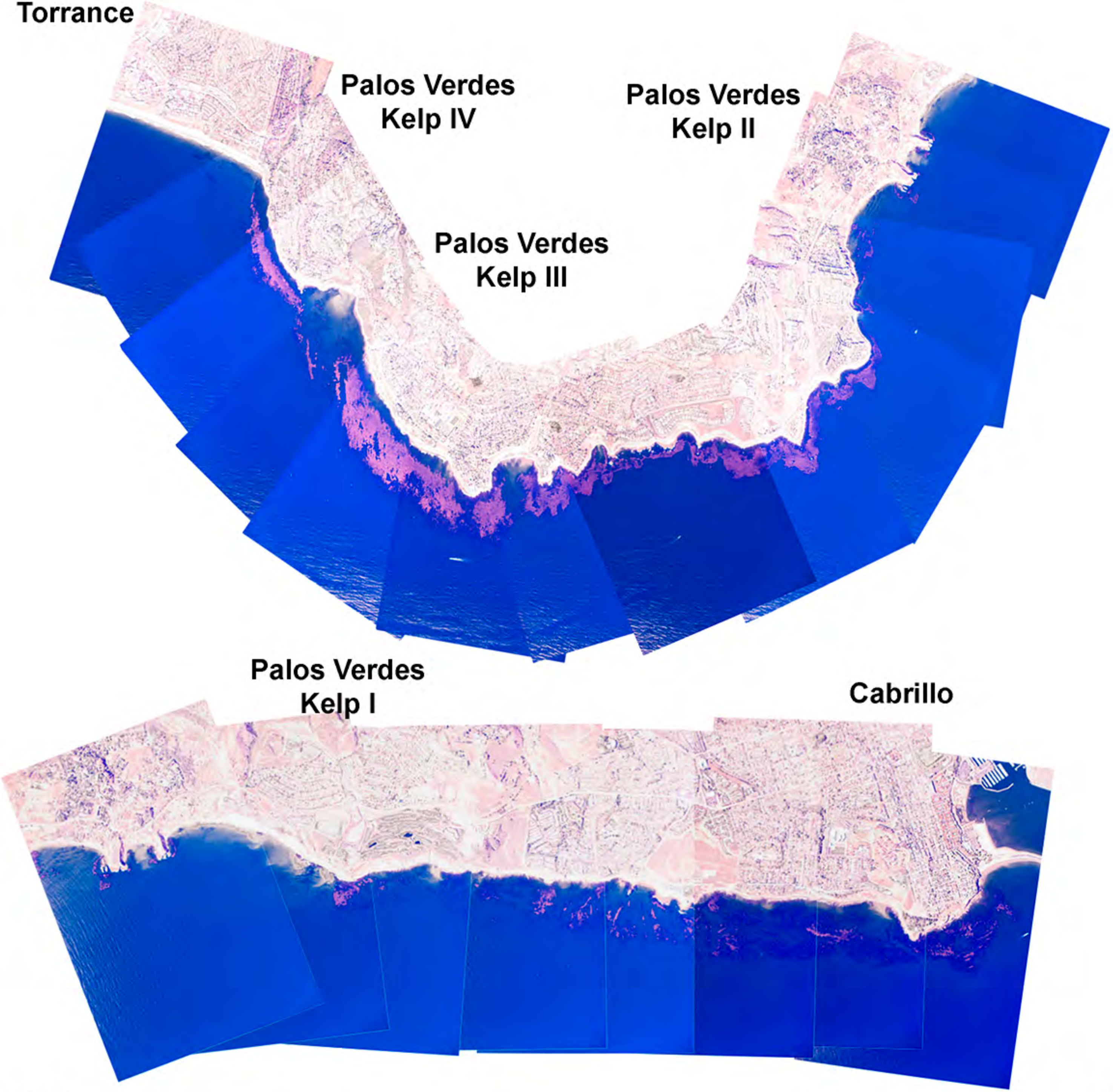
MBC

Appendix E.1



MBC

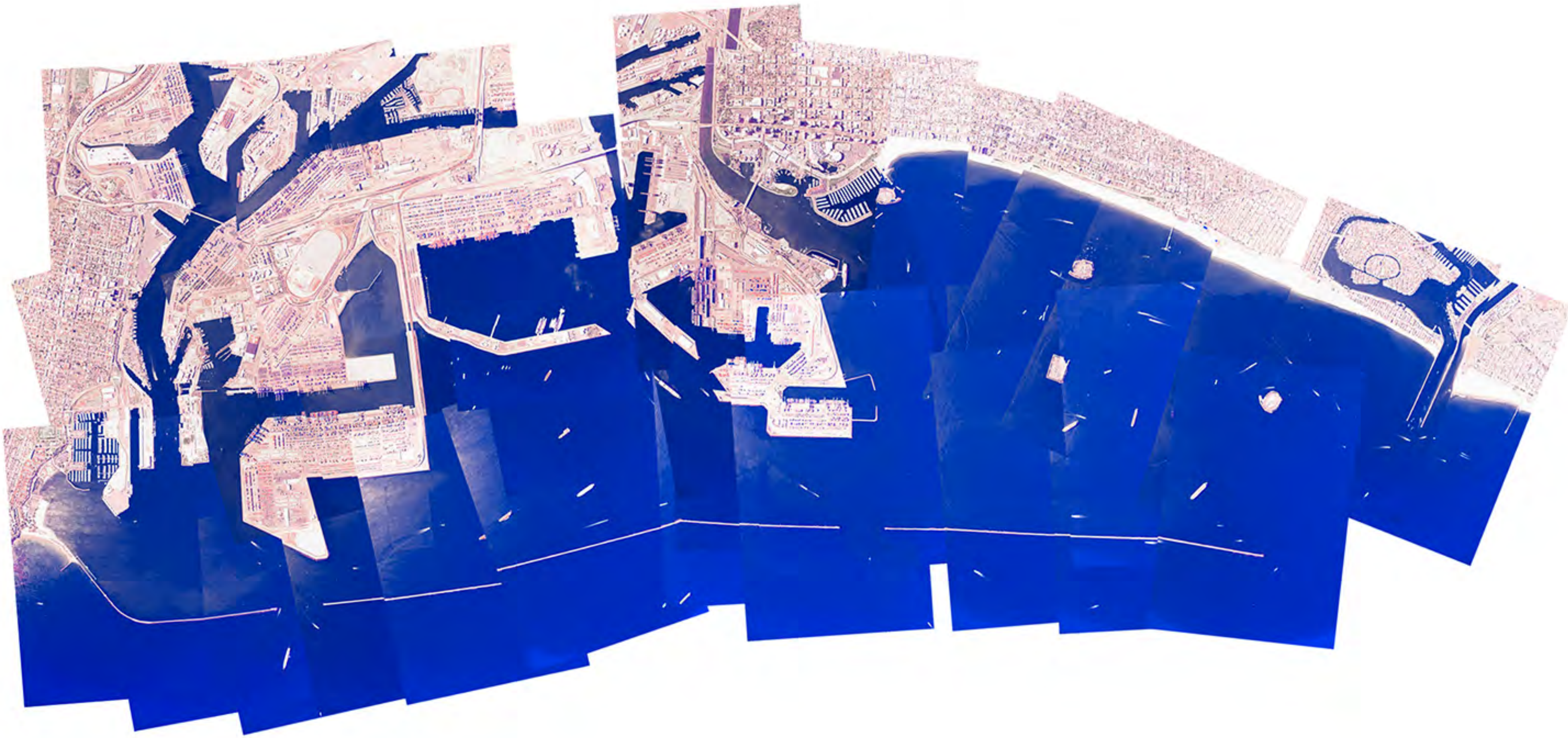
Appendix E.2



June 20, 2015

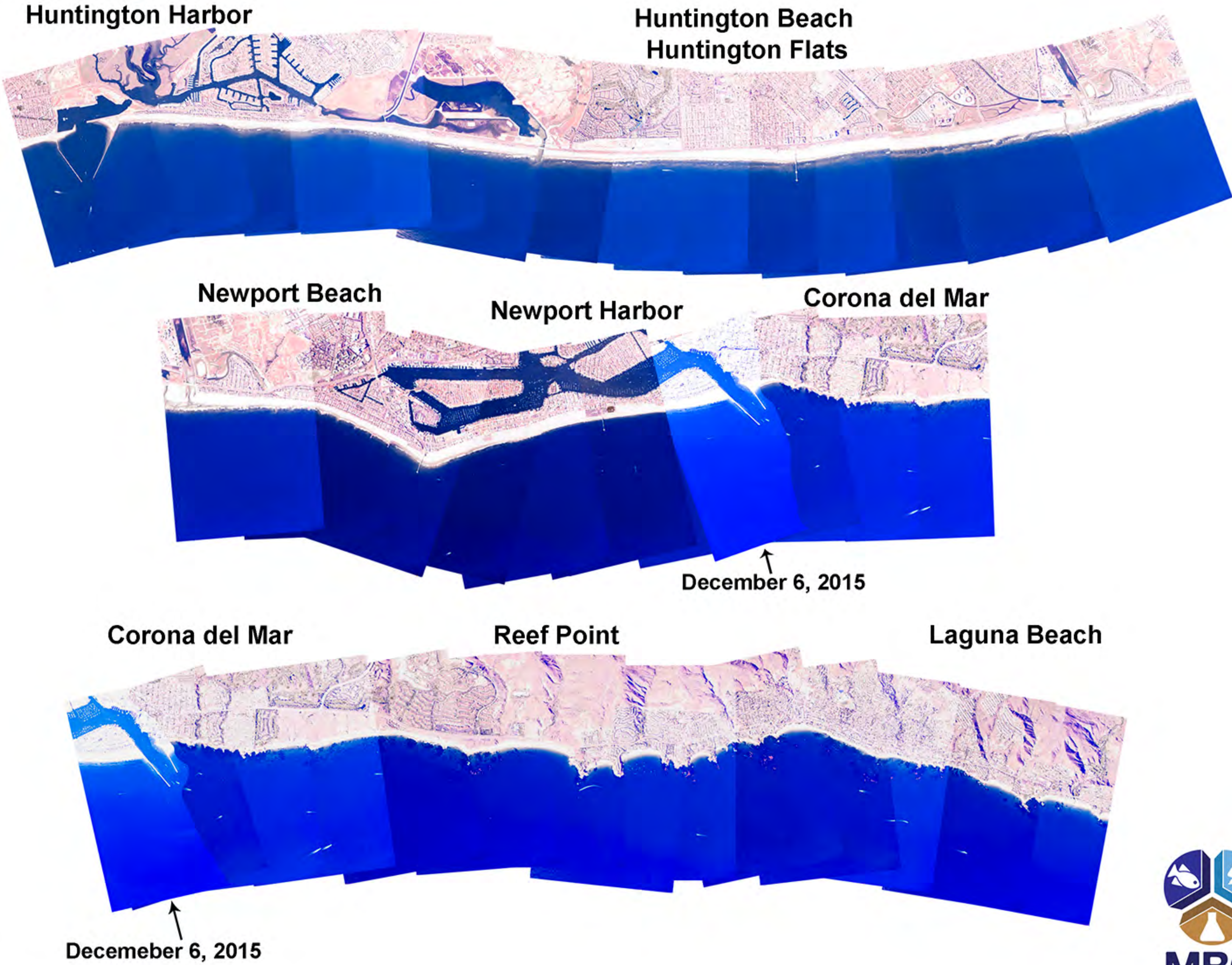
Appendix E.3

POLA/POLB Harbors



June 20, 2015

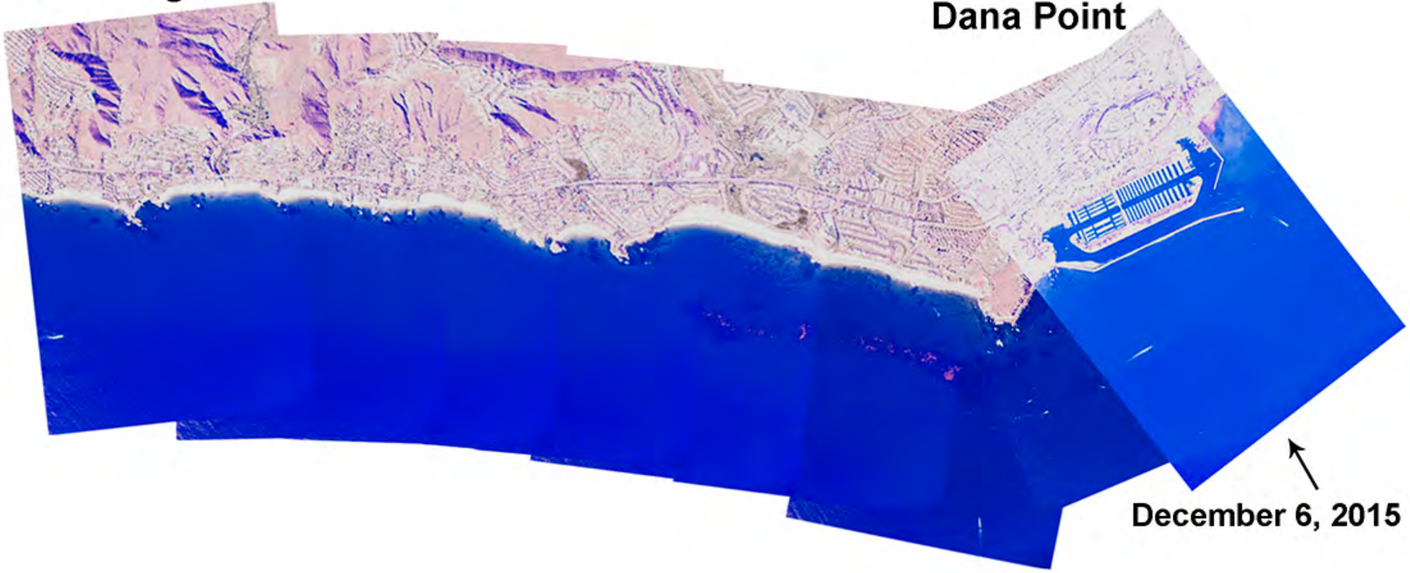
Appendix E.4

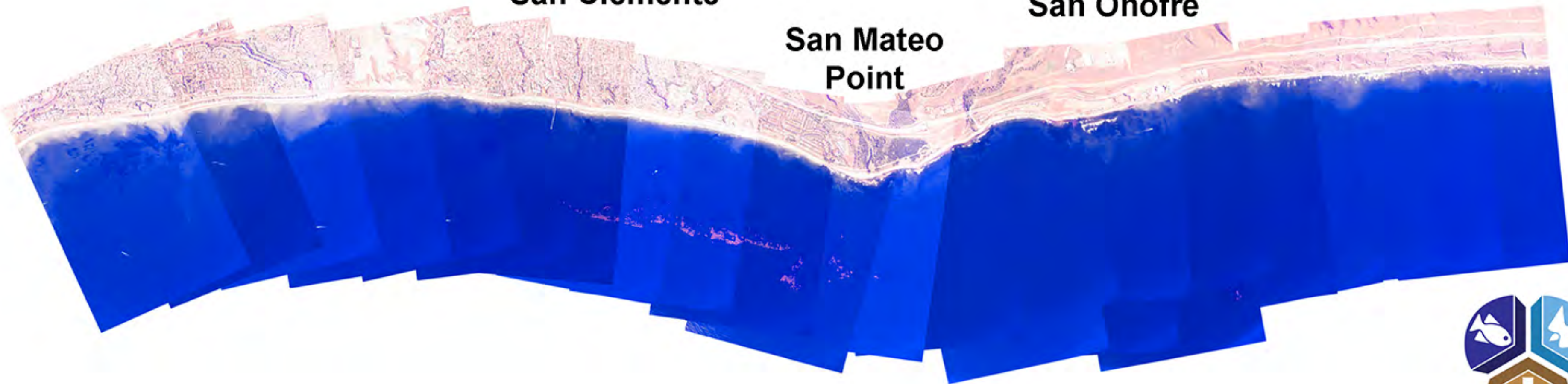


June 20, 2015

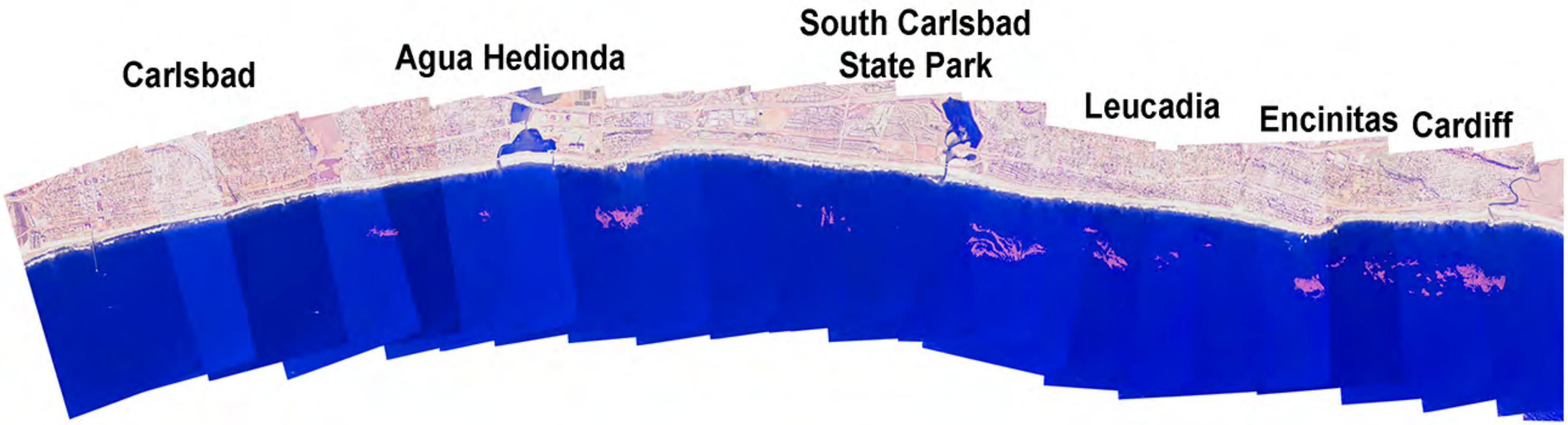
MBC

Appendix E.5


South Laguna
Dana Point
December 6, 2015

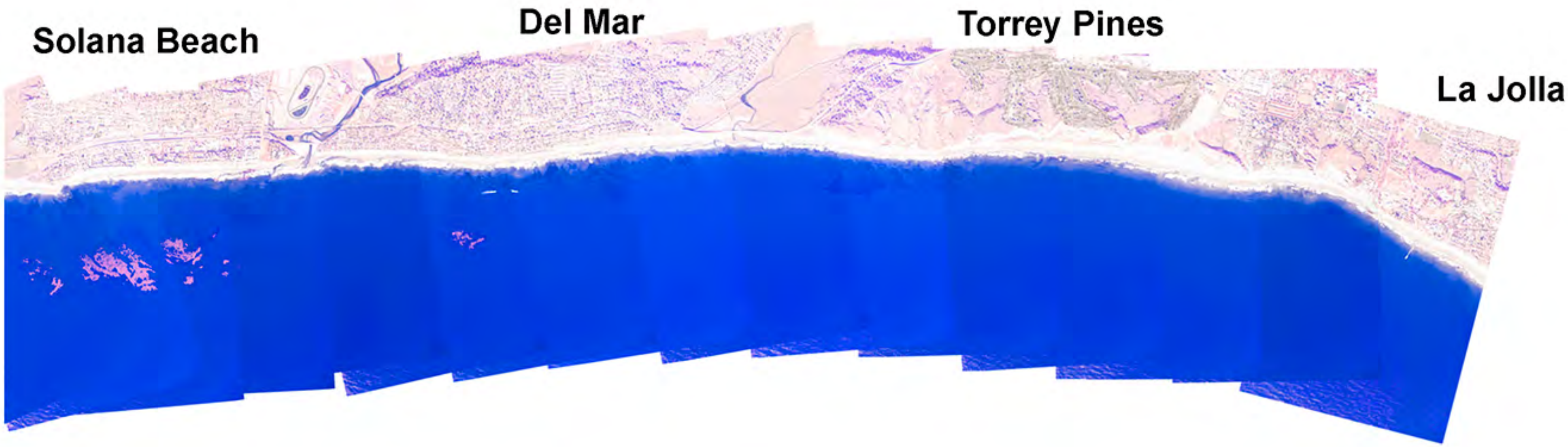

San Clemente
San Mateo Point
San Onofre

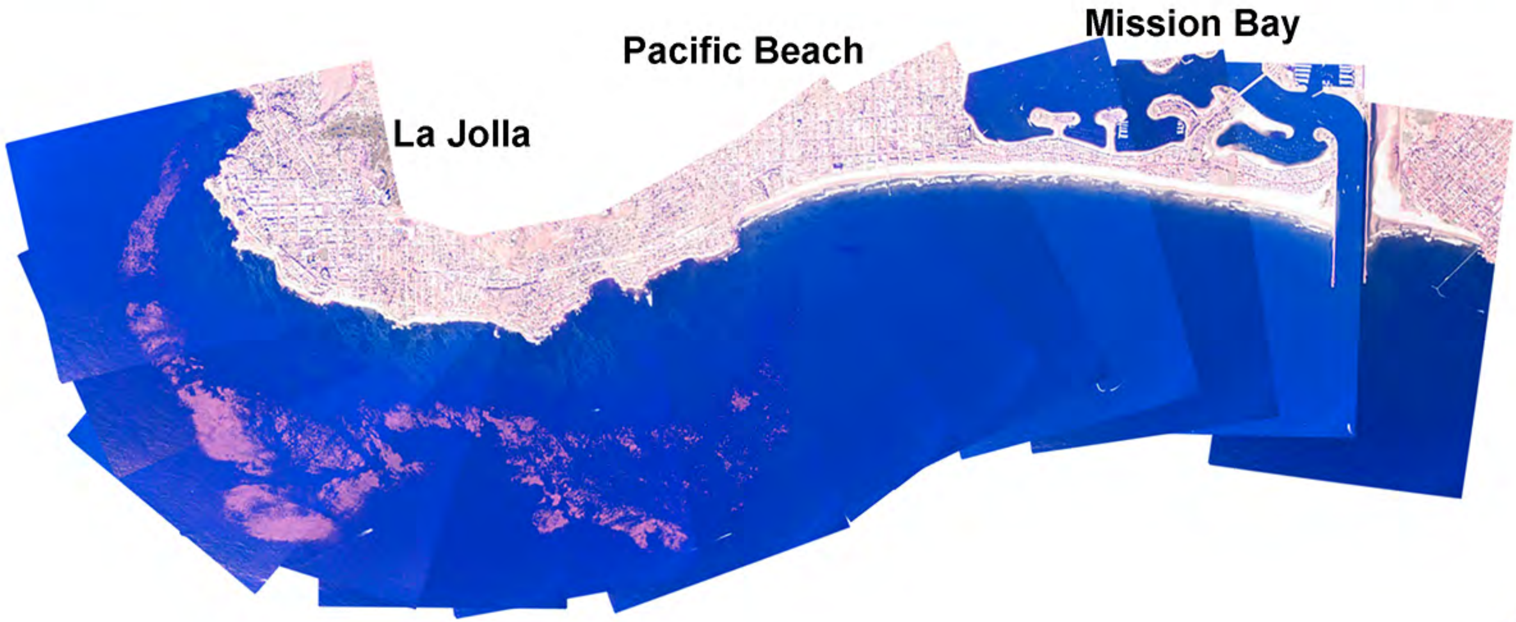
June 20, 2015



June 20, 2015

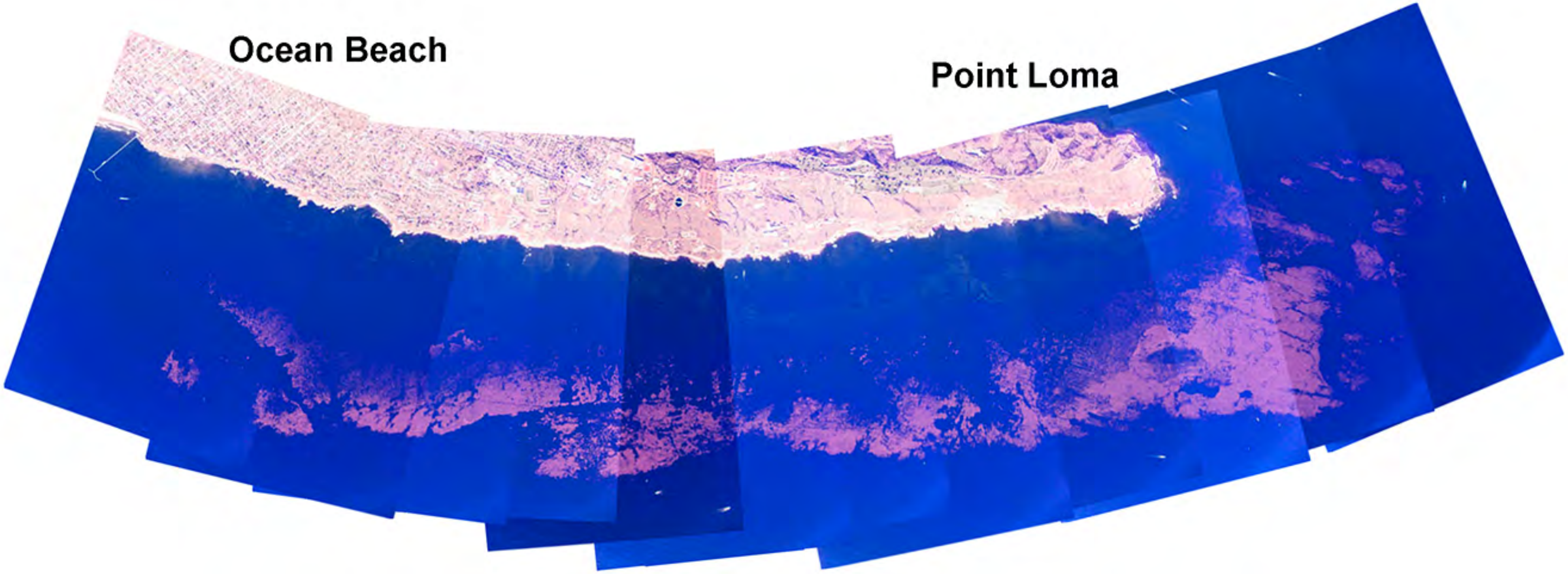
Appendix E.7





June 20, 2015

Appendix E.8



June 20, 2015

MBC

Appendix E.9