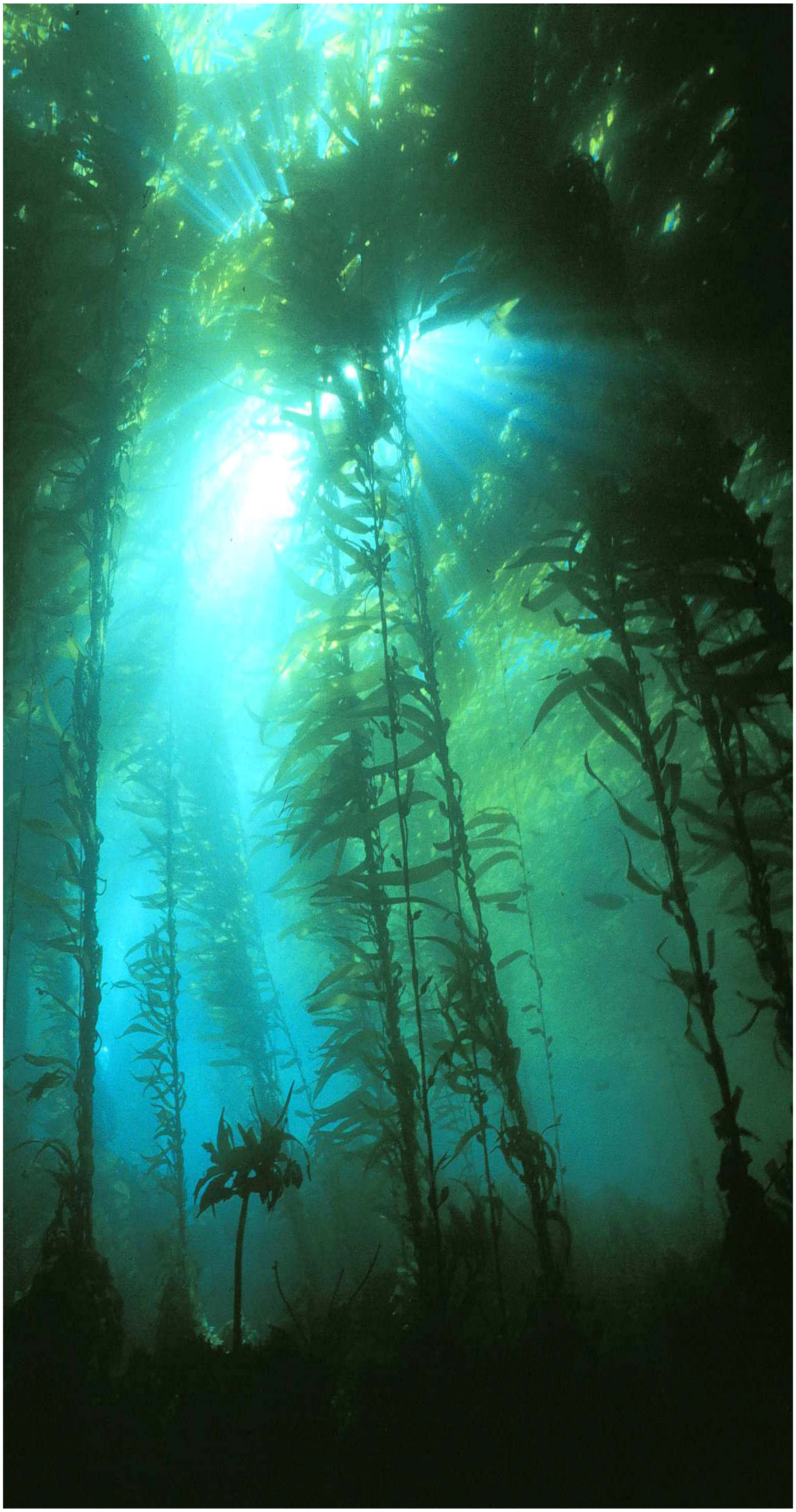


Status of the Kelp Beds 2011

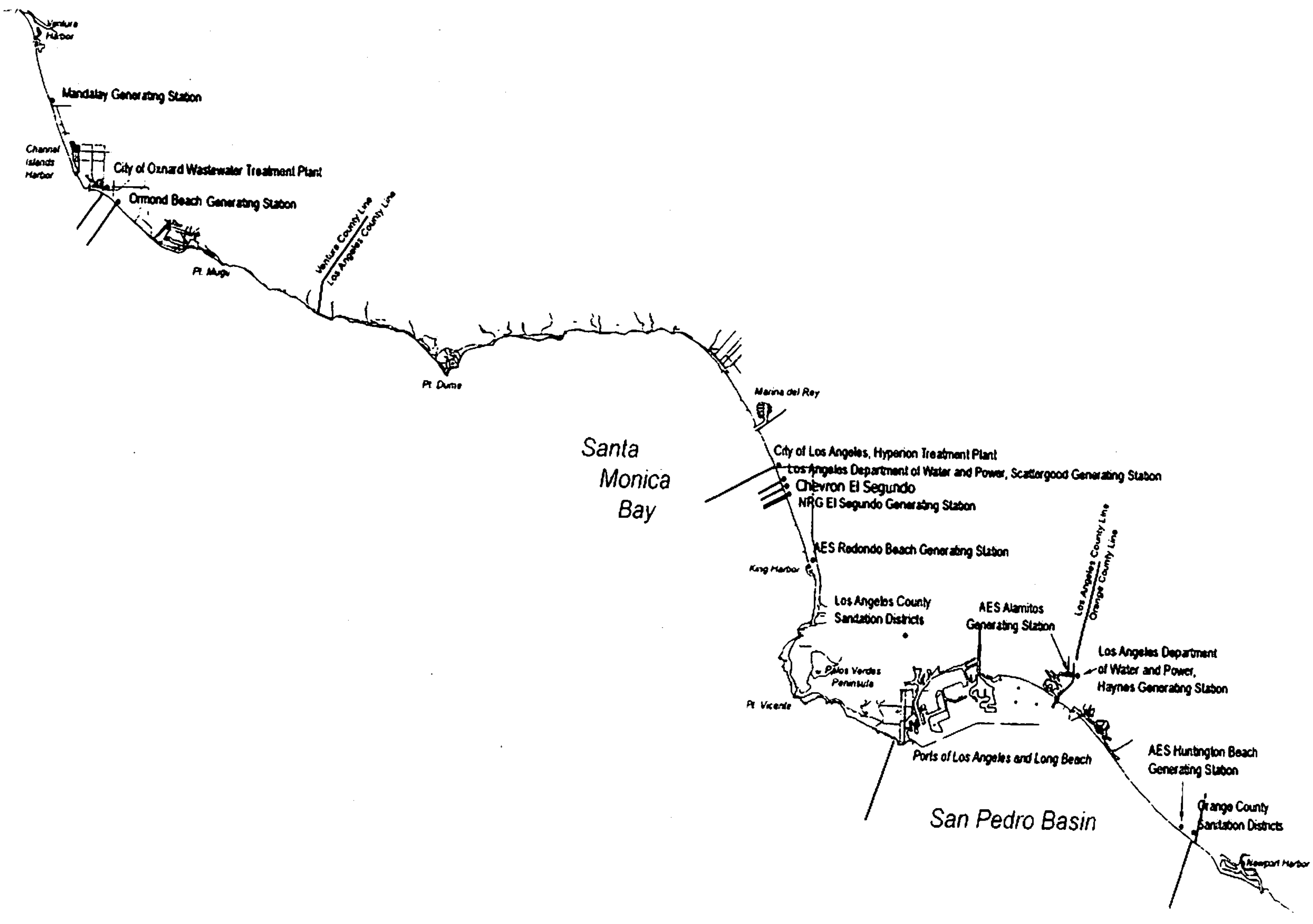
Ventura Los Angeles Orange Counties

Central Region Kelp Survey Consortium

June 2012

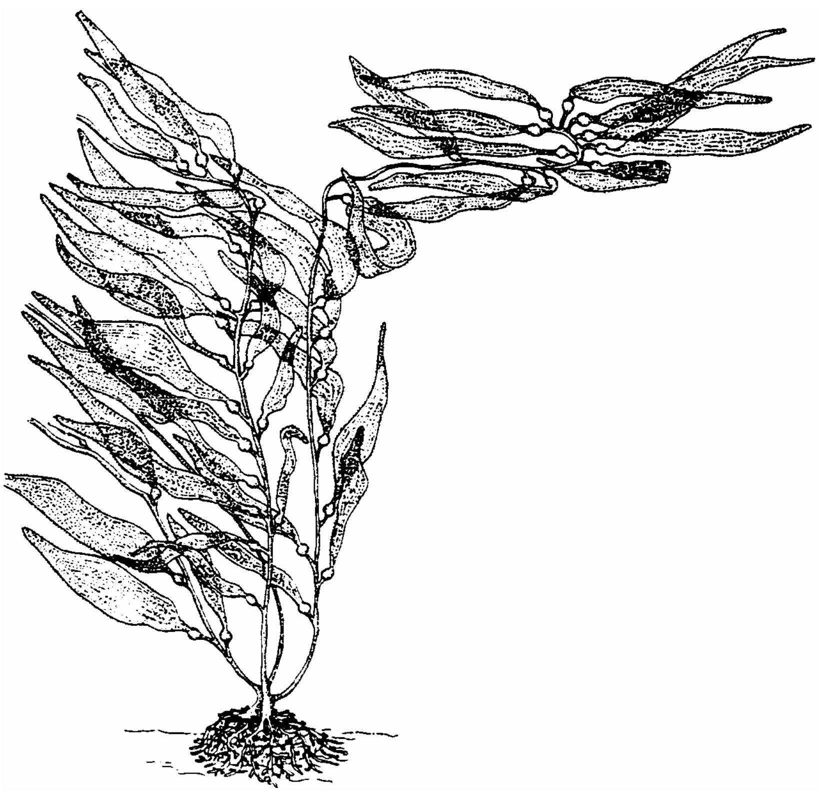
Prepared by:

MBC
Applied Environmental Sciences
Costa Mesa, California



Ventura Harbor
Mandalay Generating Station
Channel Islands Harbor
City of Oxnard Wastewater Treatment Plant
Ormond Beach Generating Station
Pt. Mugu
Ventura County Line
Los Angeles County Line
Pt. Dume
Marina del Rey
Santa Monica Bay
City of Los Angeles, Hyperion Treatment Plant
Los Angeles Department of Water and Power, Scattergood Generating Station
Chevron El Segundo
NRG El Segundo Generating Station
AES Redondo Beach Generating Station
King Harbor
Los Angeles County Sanitation Districts
AES Alamitos Generating Station
Los Angeles County Line
Orange County Line
Los Angeles Department of Water and Power, Haynes Generating Station
Palos Verdes Peninsula
Pt. Vicente
Ports of Los Angeles and Long Beach
AES Huntington Beach Generating Station
San Pedro Basin
Orange County Sanitation Districts
Newport Harbor

Status of the Kelp Beds 2011



Ventura
Los Angeles
Orange
Counties

Central Region Kelp Survey Consortium

June 2012

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STATUS OF THE KELP BEDS 2011
VENTURA, LOS ANGELES, AND ORANGE COUNTIES

CENTRAL REGION KELP SURVEY CONSORTIUM
JUNE 2012

EXECUTIVE SUMMARY

Foreword. Continuing favorable environmental factors contributed to the maintenance of giant kelp offshore of the Central Region in 2011 with a total of 4.795 km^2 of giant kelp in the region, a very slight reduction from the 5.008 km^2 recorded in 2010. The 2011 giant kelp study demonstrated that oceanographic environmental factors during a prolonged La Niña such as the availability of nutrients (or lack thereof) continued to control the fate of the kelp beds in 2011. There was no evidence to suggest that any of the region's various dischargers had any perceptible influence on the persistence of the region's giant kelp beds.

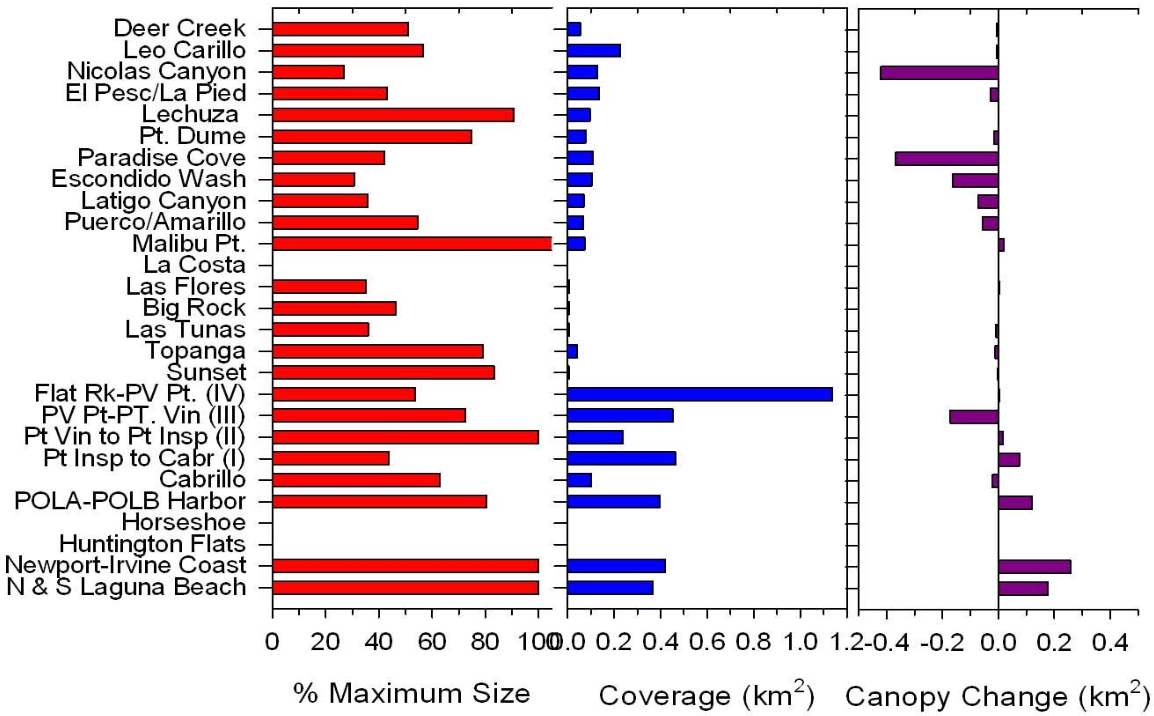
Giant kelp beds have been mapped annually in Ventura, Los Angeles, and Orange Counties for the Central Region Kelp Survey Consortium since 2003, when it was formed as a result of regulations from the Los Angeles Regional Water Quality Control Board (LARWQCB). When combined with a similar organization, the Region Nine Kelp Survey Consortium formed as a result of similar requirements from the San Diego Regional Water Quality Control Board SDRWQCB), the continuous and synoptic coverage of coastal kelp beds is provided for approximately 220 of the 270 miles of the Southern California Bight from the Ventura-Santa Barbara County line to the Mexican Border.

Aerial surveys of the giant kelp beds from the Santa Barbara-Ventura County line to Newport Harbor were conducted in 2011 by MBC *Applied Environmental Sciences* (MBC). The surveys in 2011 were conducted on 16 April, 1 August, 28 October, and 21 December 2011; one aerial survey has also been completed for the 2012 survey year on 6 April. Digital color and color infrared photos were taken of the entire Central Region Coastline during each survey. These photos were then processed and the kelp depicted on each photo was transferred to appropriate base maps to facilitate intra-annual comparisons and for ease of analysis.

Giant Kelp Survey Results 2011. Results of the 2011 CRKSC survey estimates that the maximum measured kelp canopy decreased from 5.008 km^2 square kilometers (km2) in 2010 to 4.795 km^2 (Graph). The number of kelp beds displaying canopy have remained markedly similar and with the addition of two more beds in 2009 in Orange County, the total number of beds monitored for the Central Region is 27 historic or extant kelp beds. The total amount of kelp present has been relatively large since 2007 peaking in 2009 with almost 6.5 km^2 (which was greater than during any past CRKSC survey and of any past synoptic surveys when all areas were surveyed) conducted since 1989.

The large-scale changes to the kelp beds noted are typically responses to ENSO (El Niño or La Niña) events, while the finer-scale variation observed in prior years indicates there still remains variation due to multi-decadal effects/regime changes within a region that we can not yet accurately predict with our current knowledge. In spite of this uncertainty in our predictive ability, the kelp beds of the Central Region in 2011 maintained kelp beds with only minor decreases from the previous year, indicating the resiliency observed during the past nine monitoring years.

As far as the greatest extent of canopy coverage during the quarterly surveys, 2011 was typical in that the December survey depicted most of the region's kelp beds (with the exception of most of the Palos Verdes beds and the Irvine Coast and Laguna Beach beds) at their greatest extent (Appendix A). Throughout the entire study area, kelp canopy coverage decreased but not uniformly, with distribution of kelp among the region's 27 kelp beds (only 24 are extant beds, as three, Sunset, Horseshoe, and Huntington Flats, have been missing for decades) varying widely. The five CRKSC beds comprising Fish and Game (F&G) Bed No.17 lost about 25% of their area and the six beds comprising F&G Bed No.16 decreasing by almost 50%. The six



Graph: Central Region kelp canopy percent of maximum size during nine year's monitoring, present coverage, and positive and negative canopy change.

CRKSC beds of F&G Bed No. 15 decreased, but as the beds that comprised it were very small, little change was noted, decreasing only about 20%. F&G Bed No. 14 decreased with the Palos Verdes Beds IV and Bed III decreasing about 10%; F&G Bed No. 13 (encompassing the shoreline from Point Vicente to the Los Angeles Harbor Breakwater) actually increased about 10%. In total, the Palos Verdes kelp beds decreased by about 5% in 2011 from that recorded in 2010. F&G Bed No. 12 from Newport to past-Laguna Beach grew greatly (as they continued to reclaim territory lost during El Niños of the 1980s and 1990s) again pointing out differences a few miles of coastline with varying oceanographic regimes can have on the extant kelp resources.

Conclusion 2011. The giant kelp survey of 2011 continued to demonstrate that kelp bed dynamics in the Central Region are controlled by the large scale oceanographic environment. None of the kelp beds in the region reacted contrary to what was observed region wide. There was no evidence of any adverse effects on the giant kelp resources from any of the region's dischargers. The remarkable recovery of the kelp beds over the past six years could be augmented in 2012 as nutrients appear to be replete in the region, but El Niño neutral conditions are forecast for the remainder of the year.

STATUS OF THE KELP BEDS 2011
VENTURA, LOS ANGELES, AND ORANGE COUNTIES
CENTRAL REGION KELP SURVEY CONSORTIUM

June 2012

INTRODUCTION

Giant kelp (*Macrocystis pyrifera*) beds have been mapped annually off Ventura, Los Angeles, and Orange Counties for the Central Region Kelp Survey Consortium (CRKSC) since 2003. The CRKSC program is based on the Region Nine Kelp Survey Consortium, which began in 1983 and covers the kelp beds off Orange and San Diego Counties. In 1983, the San Diego Regional Water Quality Control Board (SDRWQCB) initiated a kelp bed monitoring program for ocean dischargers within Orange and San Diego counties as a result of a series of meetings to discuss the design and implementation of a regional kelp bed monitoring program. It was agreed among the funding participants and the SDRWQCB that the monitoring program would be methodologically based upon aerial kelp surveys that had been conducted by Dr. Wheeler J. North since 1967. In 2003, dischargers in the Ventura, Los Angeles, and part of Orange Counties formed the Central Region Kelp Survey Consortium. Combined, the Region Nine and Central Region monitoring programs provide continuous and synoptic coverage of kelp beds along approximately 220 of the 270 miles of the southern California mainland coast from the Ventura-Santa Barbara County line to the Mexican Border. A map showing the geographical range and the ocean dischargers located within the CRKSC region is shown in Figure 1.

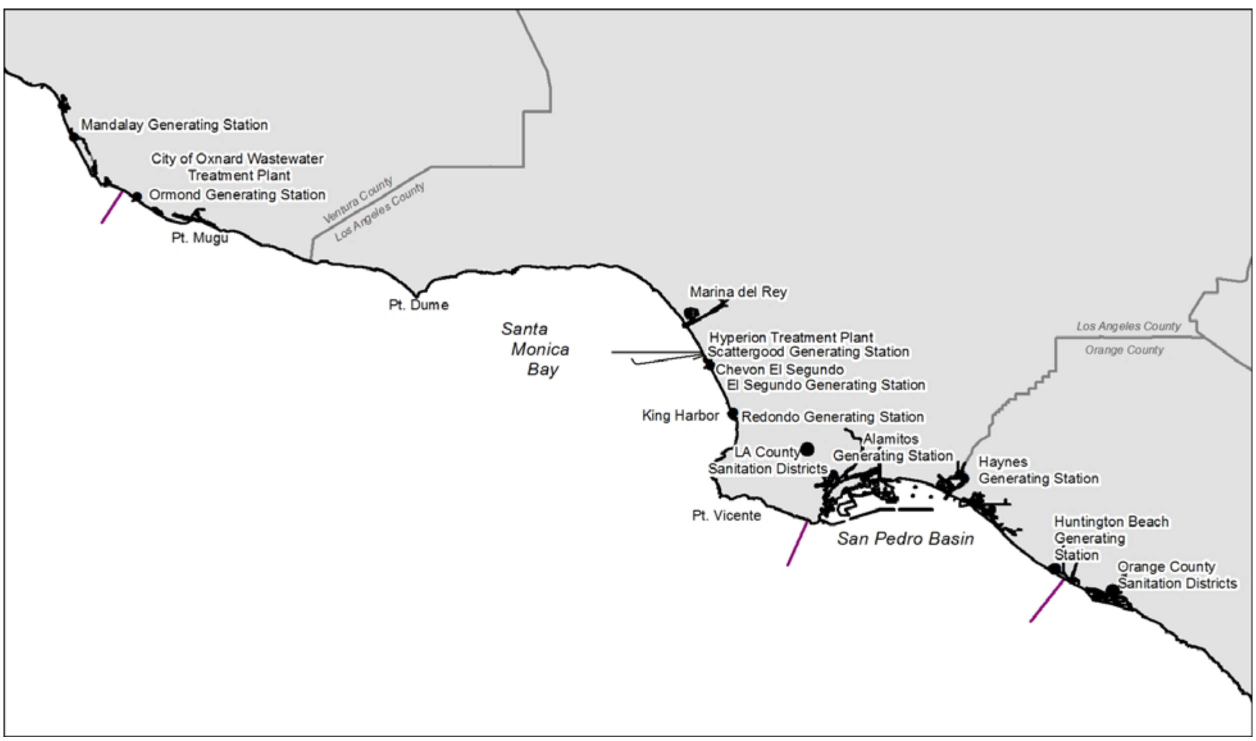


Figure 1. Ocean dischargers located within the Central Region Kelp Survey Consortium program area.

LIFE HISTORY OF GIANT KELP

Kelp consists of a number of species of brown algae of which 10 are typically found from the Mexican Border to Point Conception (the Southern California Bight). 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 southern and central California coast, giant kelp (*Macrocystis pyrifera*) is the largest species colonizing rocky (and in some cases sandy) subtidal habitats. 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, Foster and Schiel 1985, Dayton 1985). Darwin (1860) noted the resemblance of the three-dimensional structure of kelp stands to that of terrestrial forests. Probably because of its imposing physical presence, it has attracted numerous researchers so that a sizable literature on *Macrocystis* biology and ecology began a century ago, with much effort spent 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 50 to 75 ft and can be found at depths of 90 ft. In conditions of unusually good water clarity, giant kelp may even thrive to depths of 150 ft.

Giant kelp forms beds wherever suitable substrate occurs, typically on rocky subtidal reefs. Such substrate must usually be free of continuous sediment intrusion. Giant kelp beds can form in sandy bottom habitats where individuals will attach to worm tubes, given that the area is protected from direct swells as is seen along portions of the Santa Barbara coastline. Like 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 kelp growth. Greater water clarity normally occurs at the offshore islands, and as a result, giant kelp is commonly found growing in depths exceeding 100 ft. Along the mainland coast, high productivity, terrestrial inputs and continental shelf mixing result in greater turbidity and hence lower light levels as through attenuation. Consequently, kelp generally does not grow deeper than 60 ft along the coastal shelf, although exceptional conditions in San Diego produce impressively large beds that can grow vigorously beyond 100 ft.

Giant kelp has a complex life cycle and undergoes a heteromorphic alternation of generation, where the phenotypic expression of each generation does not resemble the generation before or after it (Figure 2). 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. Within three weeks, the zoospores mature into microscopic male and female gametophytes. This second generation does not resemble the sporophyte. Sperm and eggs are released into the water column where fertilization occurs. Dispersal distance can be greater during this phase compared to the zoospore stage. The life cycle is completed when a fertilized egg settles and develops into the adult sporophyte stage. Successful completion of the life cycle relies on the persistence of favorable conditions throughout the process.

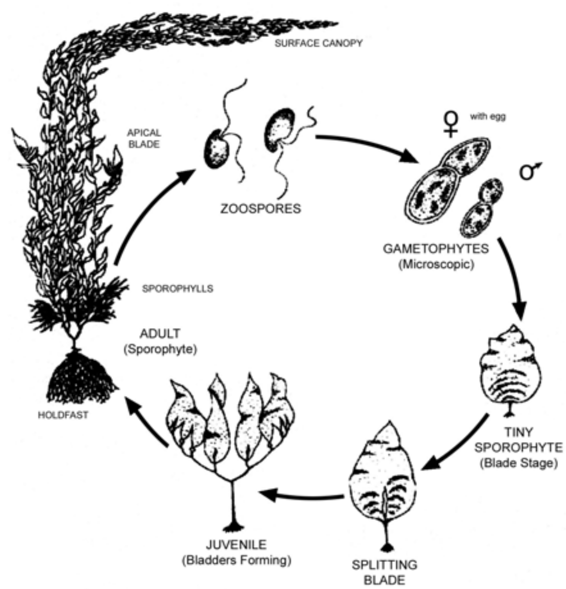


Figure 2. Kelp life cycle.

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 fish (Carr 1989) and invertebrates (Duggins et al. 1990). Stands of kelp can also affect flow characteristics in the nearshore zone, thus enhancing recruitment (Duggins et al. 1990), which further acts to increase animal biomass in the vicinity. For these reasons, giant kelp is also of great importance to sport and commercial fisheries.

FACTORS AFFECTING KELP GROWTH

Giant kelp bed size and health is known to be highly variable but there has been a downward trend from the inception of surveying in 1911 and the end of the century. During this period kelp beds declined at most coastal and island sites in the SCB. A comprehensive historical review of kelp beds in the SCB (Neushul 1981) found that an approximately one-third loss of kelp bed cover had occurred since 1911 when compared to a 25-year mean. A statewide survey in 1989 (Ecoscan 1990) estimated Southern California kelp forests to total 103.6 km^2(10,360 ha) (Tarpley and Glantz 1992), a 25% reduction from that reported by Crandall (138 km^2) in 1911 (from Neushul 1981). The accuracy of Crandall's measurements have been questioned (Neushul 1981) because it was not an aerial survey and measurement errors may have resulted from using a rowboat to compute the perimeter, particularly on very large beds. Estimates of these potential errors have ranged from 10 to as much as 25%, however, the resultant total of the worst case (33 km^2) would still be impressively large (Table 1). In defense of Crandall's estimates, the total regional area was probably larger in 1928 than Crandall measured based on the size of just the Palos Verdes beds from aerial photos which North measured at 9.912 km^2 in 1964 (SWRCB 1964) as compared to the 8.678 km^2 that Crandall measured in 1911 (suggesting even larger losses have occurred overtime). Unfortunately, the survey did not include the remainder of the Central Region so no definitive regional total was available.

The next complete survey of the region was not undertaken until 1955 which indicated the beds had decreased greatly from that recorded in 1911; exceptionally good conditions in 1967 resulted in a total of 7.861 km^2.The most significant losses during this period were that of Sunset Kelp (which was almost 1 km^2 in 1911, but was very small by 1955 and has remained small or completely missing through the intervening years) and the Palos Verdes beds which began decreasing greatly sometime after 1945. Those beds had decreased to 3.6 km^2 by 1947, and 1.5 km^2 by 1953. By 1967, a total of almost 8 km^2 for the entire region's beds indicated slight improvements, but Palos Verdes kelp beds south of Point Vincente were missing, but south of Point Vincente they totaled almost 1.0 km^2. By 1974, the Palos Verde beds had decreased to 0.015 km^2. Restoration activities began in 1974 by the Kelp Habitat Improvement Project, and in 1975 those beds began increasing and totaled 4.5 km^2 during the exceptionally good 1989 year. The impetus provided by the 1989 La Niña also resulted in almost 6 km^2 of kelp canopy in the region, but kelp totals decreased to about one half this during the subsequent two decades. In 2009, favorable conditions again increased canopy totals to about 6.5 km^2, larger than it had been since 1967 (Table 2). As these measurements indicate most of the beds remain smaller than those of a century ago, we attempt herein to determine what environmental factors have changed in the intervening years to cause such large declines.

Many factors determine whether giant kelp will recruit successfully, form a bed in a given area, and persist. These include the obvious factors such as available habitat, adequate light, nutrient availability, exposure to currents, prevailing swells, storms, predator-prey interactions, and the presence of herbivores. We also know that there are less obvious but potentially more far reaching effects in both time and scope such as the El Niño Southern Oscillation (ENSO) (referring to global climatic changes and effects), decadal regime shifts or climate shifts/variation (Miller et al. 1994, Breaker and Flora 2009), the Pacific Decadal Oscillation (PDO) which refers to events that are Pacific wide and decades long in nature, and the El Niño/La Niña events (which refer to more local effects resulting in warming or cooling of the waters along the South and North American western coast).

Light. Giant kelp needs adequate light to photosynthesize. Turbidity resulting from natural (e.g. phytoplankton blooms, sediment resuspension, etc.) or anthropogenic sources reduces light penetration and impacts photosynthesis. Phytoplankton blooms are typical in the spring and fall due to the supply of nutrients into the inshore waters from upwelling, but blooms of phytoplankton can also sufficiently occlude

Table 1. Historical canopy coverage in km² of Ventura, Los Angeles, and Orange County kelp beds to Newport Beach, from 1911 to 2000. Values represent an estimate of coverage utilizing varying methods over the years. Data for years 1959, 1963, 1971, and 1976 appear in Appendix B.

	Canopy Area (km²)												
Kelp Bed	1911	1928	1945	1955	1967	1972	1975	1977	1980	1984	1989	1999	2000
1 Deer Creek	ND	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
2 Leo Carillo	2.515	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
3 Nicolas Canyon	1.258	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
4 El Pesc/La Pied	0.252	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
5 Lechuza	0.126	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
Total 1-5 (F&G 17)	4.151a	ND	ND	3.010	4.144	2.589	1.606	1.579	ND	ND	0.914	0.530	ND
6 Pt. Dume	0.686	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
7 Paradise Cove	1.372	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
8 Escondido Wash	0.583	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
9 Latigo Canyon	0.446	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
10 Puerco/Amarillo	0.343	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
11 Malibu Pt.	ND	ND	ND	p	p	p	p	p	ND	ND	p	p	ND
Total 6-11 (F&G 16)	3.430a	ND	ND	2.140	2.538	1.813	1.502	1.528	ND	ND	0.220	0.033	ND
12 La Costa	0.021	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
13 Las Flores	0.014	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
14 Big Rock	0.017	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
15 Las Tunas	0.017	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
16 Topanga	0.017	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
17 Sunset	0.960	ND	ND	p	p	ND	p	p	ND	ND	p	p	ND
Total 12-17 (F&G 15)	1.355a	ND	ND	0.020	0.026	ND	0.026	0.000	ND	ND	0.045	0.000	ND
18 Flat Rk-PV Pt. (IV)	p	ND	ND	p	p	ND	p	p	0.940	0.655	p	p	p
19 PV Pt-PT. Vin (III)	p	ND	ND	p	p	ND	p	p	0.215	0.692	p	p	p
Total 18-19 F&G 14	5.536	ND	ND	0.820	1.062	ND	0.009	0.026	1.155	1.347	3.312	0.737	0.648
20 Pt Vin to Pt Insp (II)	p	ND	ND	p	p	ND	p	p	0.190	0.171	p	p	p
21 Pt Insp to Cabr (I)	p	ND	ND	p	p	ND	p	p	1.052	1.342	p	p	p
22 Cabrillo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0001	0.0001	ND
Total 20-22 F&G 13	3.142	ND	ND	0.080	0.000	ND	0.259	0.104	1.342	1.513	1.248	0.530	0.582
Total 18-22 PV	8.678a	9.912a	5.591a	0.900	1.062	ND	0.268	0.130	2.497	2.860	4.560c	1.267	1.230
23 POLA-POLB Harbor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24 Horseshoe	ND	1.94b	ND	ND	ND	ND	ND	ND	ND	ND	tr	0.0001	tr
25 Huntington Flats	ND	ND	ND	ND	-	-	-	-	-	-	tr	-	-
26 Newport-Irvine Coast	0.580	ND	ND	ND	0.086	0.100	0.160	0.160	0.148	0.008	0.010	-	-
27 N & S Laguna Beach	tr	ND	ND	0.680	0.005	0.021	0.006	0.120	0.072	0.053	0.187	-	0.003
TOTAL	18.194d	11.852d	5.591	6.750	7.861	4.512d	3.568	3.517	2.681d	2.893d	5.935	1.829	1.233

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; **green** = neutral year

a = 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 from Neushul (1981); 1967, 1972, 1975, 1977 from Hodder and Mel (1978); Ecoscan (1990) and Wilson (1989), North (2000); Veisze et al. (2004).

light that they negatively impact kelp health. Phytoplankton blooms were probably responsible for a large decrease in canopy coverage in 2005 that continued into 2006 due to a substantial, region-wide bloom.

Shading effects on kelp recruitment are well documented by Dean et al. (1989). Several, consecutive years of large giant kelp canopy can result in recruitment failure due to shading. Recruitment failures are typically manifested in the areal canopy years later as the older plants reach senescence and

Table 2. Historical canopy coverage in km² of Ventura, Los Angeles, and Orange County kelp beds to Newport Beach, from 2002 to 2011. Values represent an estimate of coverage utilizing varying methods over the years. Areal estimates for 2003-2011 were derived from infrared aerial photographs.

	Canopy Area (km²)									
Kelp Bed	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1 Deer Creek	ND	0.089	0.107	0.053	0.026	0.046	0.074	0.105	0.062	0.055
2 Leo Carillo	ND	0.318	0.399	0.171	0.150	0.145	0.207	0.255	0.232	0.226
3 Nicolas Canyon	ND	0.308	0.362	0.195	0.038	0.473	0.268	0.433	0.291	0.130
4 El Pesc/La Pied	ND	0.243	0.314	0.141	0.063	0.255	0.173	0.238	0.164	0.136
5 Lechuza	ND	0.105	0.104	0.041	0.022	0.106	0.075	0.105	0.096	0.096
Total 1-5 (F&G 17)	ND	1.063	1.286	0.600	0.298	1.025	0.797	1.136	0.844	0.642
6 Pt. Dume	ND	0.012	0.029	0.028	0.053	0.065	0.070	0.104	0.094	0.078
7 Paradise Cove	ND	0.162	0.258	0.035	0.036	0.100	0.223	0.244	0.259	0.109
8 Escondido Wash	ND	0.214	0.250	0.078	-	0.339	0.278	0.321	0.267	0.104
9 Latigo Canyon	ND	0.125	0.161	0.032	0.007	0.186	0.124	0.195	0.142	0.070
10 Puerco/Amarillo	ND	0.074	0.051	0.039	0.055	0.095	0.064	0.115	0.126	0.069
11 Malibu Pt.	ND	0.011	0.013	0.008	0.008	0.016	0.011	0.012	0.066	0.074
Total 6-11 (F&G 16)	ND	0.598	0.762	0.220	0.158	0.801	0.769	0.991	0.954	0.504
12 La Costa	ND	0.001	0.002	-	-	-	-	0.001	0.001	-
13 Las Flores	ND	0.009	0.023	0.004	-	0.005	0.001	0.005	0.005	0.008
14 Big Rock	ND	0.005	0.014	0.002	0.001	0.004	0.002	0.005	0.006	0.007
15 Las Tunas	ND	0.003	0.018	0.004	-	0.008	0.005	0.019	0.015	0.007
16 Topanga	ND	0.0002	0.002	0.0001	-	-	0.0009	0.002	0.052	0.041
17 Sunset	ND	-	-	-	-	-	-	0.004	0.008	0.007
Total 12-17 (F&G 15)	ND	0.017	0.059	0.010	0.001	0.017	0.009	0.035	0.087	0.069
18 Flat Rk-PV Pt. (IV)	1.400	0.196	0.245	0.204	0.859	1.151	1.839	2.122	1.136	1.139
19 PV Pt-PT. Vin (III)	0.028	0.045	0.040	0.056	0.135	0.074	0.300	0.570	0.624	0.452
Total 18-19 F&G 14	1.429	0.241	0.285	0.260	0.993	1.225	2.140	2.692	1.760	1.591
20 Pt Vin to Pt Insp (II)	0.039	0.059	0.023	0.034	0.082	0.034	0.108	0.163	0.222	0.238
21 Pt Insp to Cabr (I)	1.208	1.063	0.211	0.702	0.951	0.703	0.608	0.980	0.389	0.465
22 Cabrillo	ND	0.062	0.070	0.102	0.161	0.100	0.060	0.163	0.124	0.103
Total 20-22 F&G 13	1.247	1.184	0.304	0.838	1.194	0.837	0.776	1.306	0.734	0.805
Total 18-22 PV	2.676a	1.425	0.589	1.098	2.187	2.062	2.916	3.998	2.494	2.396
23 POLA-POLB Harbor	ND	ND	ND	0.147	0.494	0.118	0.213	0.151	0.277	0.397
24 Horseshoe	0.0001	-	-	-	-	-	-	-	-	-
25 Huntington Flats	-	-	-	-	-	-	-	-	-	-
26 Newport-Irvine Coast	tr	0.002	0.002	0.0004	0.023	0.054	0.089	0.095	0.161	0.419
27 N & S Laguna Beach	0.005	0.0006	0.008	-	-	0.001	0.028	0.063	0.191	0.368
TOTAL	2.676b	3.106	2.706	2.075	3.161	4.077	4.820	6.469	5.008	4.795

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; **green** = neutral

a = In another survey by LACSD in 2002 total area was estimated at 2.84 km^2
b = total is not inclusive of all beds in region

Sources: TMLandsat 7 (2002); MBC (2004-2010a, 2011).

break away from the holdfast. As amounts of rainfall/runoff were about average in 2011, and phytoplankton blooms were not persistent, the result was there were no serious deleterious effects on the kelp beds of the region.

Sedimentation. Several kelp forests have been impacted by sedimentation. The most notable are the Palos Verdes and Barn kelp forests. Palos Verdes kelp historically suffered extensive damage related to wastewater discharge prior to effluent improvements made in the 1970s and later, as well as shifting landscapes. Historically, sewage discharge included fine particulate matter that reduced light penetration while suspended and also buried rocky reef habitat when it settled (Hampton et al. 2002). Additional giant kelp habitat was lost due to landslides in the area such as the Portuguese Bend landslide (Kayen et al. 2002; Pondella 2012 pers. comm.). Sedimentation impacts to Barn kelp are less demonstrative, but the coincidental timing of terrestrial reshaping, storm wave activity, and the disappearance and reappearance of the once-persistent kelp forest is highly suggestive. Kuhn and Shepard (1984) detail the late-1970s extensive landscape modifications made in the Horno Canyon area that resulted in substantially accelerated erosion. Bence et al. (1989 MRC) reaffirmed the elevated sedimentation in the area after elevated rainfall during the 1978-1980 rainy seasons. The surface canopy at Barn kelp disappeared in 1980 and did not reappear until 1989 after a large storm in January 1988 resulted in anomalously high subtidal erosion (Dayton et al. 1989). While insufficient data exists to empirically test this theory, the timing of these events is striking and highly suggestive of sedimentation impacts at Barn kelp.

Nutrients. In addition to light, kelp also requires nitrates and other materials in solution to spur adequate growth (Jackson 1977, Haines and Wheeler, 1978, Dayton et al. 1999). Nutrient availability is known to be one of the primary limiting factors to algal growth (Jackson 1977, Zimmerman and Kremer 1984). Unlike terrestrial plants that absorb nutrients only though roots, kelp absorbs nutrients directly through its tissues. Nutrients are generally recycled in the environment through the continuous raining of accumulated organic matter from the shallow sunlit depths to deeper colder waters. Typically the concentration of nitrates increases with depth (Sverdrup et al. 1942). However, shallow waters at depths where kelp commonly occurs tend to have higher temperatures due to solar insolation, and are typically devoid of nutrients. This is due to the abundance of phytoplankton in the surface waters which compete for nutrients in surface waters where light penetration is good. This presents a physiological challenge for giant kelp, which must compete for nutrients and light. In typical, low nutrient conditions generally encountered during the summer, giant kelp will persist only if it can adequately translocate nitrates from below the thermocline through its tissues (Jackson 1977). If the thermocline is depressed (along with nutrients) below the level where kelp is found for an extended period of time, extirpation of the kelp will occur. For this reason, kelp thrives best during periods of upwelling, where deeper, nutrient-rich waters rise from depths where light levels are too low to permit nutrient stripping by phytoplankton.

Coastal upwelling events are usually wind-driven phenomena in southern California (such as periods of Santa Ana Winds) where surface friction from prevailing winds from the north creates a southward flow due to Ekman transport (Pond and Picard 1983). As the warmer surface layer is moved offshore, colder bottom water rises from the depths to take its place, especially at the continental margin or near submarine canyons, but in areas with persistent winds close to shore, smaller upwelling events occur in shallower waters. Upwelled waters are typically much colder than surface waters, so temperature tends to correlate with nutrient availability in coastal zones. Zimmerman and Kremer (1984) identified 1 μmol/L as a generally minimal nutrient threshold concentration to support giant kelp growth. Kamykowski and Zentara (1986) described a possibly stronger relationship between seawater density and nutrient concentration. Using this, Parnell et al. (2010) hindcasted the nutrient concentrations based on the seawater density and nutrient concentration relationship; however, this parameter is not typically available in the finer scales of a regional study. Studies demonstrating a correlation between the health of kelp beds and surface cooling events are numerous (e.g., Jackson 1977, Tegner et al. 1996, Dayton et al. 1999, and others) and surface temperature data are readily available from many locations. Upwelling in southern California generally occurs during the spring months, although canopy growth is also seen in late fall and winter when the nearshore water column is well mixed (Figure 3). Because of the strong correlation between temperature and kelp growth, episodic El Niño warm water events can have a severe negative impact on the health of kelp beds in the SCB. Surface temperatures above 17°C (64°F) generally indicate waters with very low nutrient content (North and Jones 1991). With roughly each one degree centigrade temperature drop (1.9°F), the availability of nitrates essentially doubles. Therefore, at a temperature of 12°C (54°F), 14 times more nutrients are theoretically available than at 16-17°C (62-64°F).

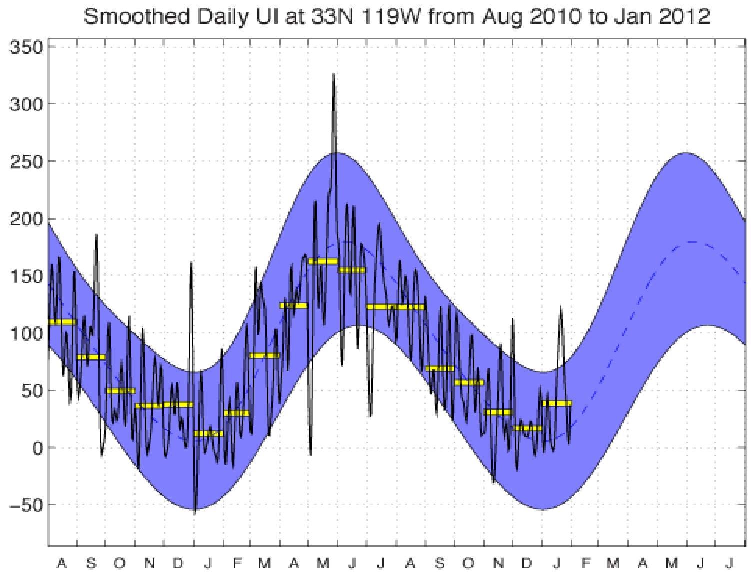


Figure 3. Upwelling Index 8-2010 to 1-2012.

Grazing. Kelp herbivores (such as urchins) can also affect the size and extent of giant kelp canopies. A reduction in natural predators will allow herbivores such as urchins to proliferate unchecked, resulting in overgrazing of kelp (North 1983, Wilson and Togstad 1983, Dayton 1985, Harrold and Reed 1985, Harrold and Pearse 1987, Murray and Bray 1993). These have been implicated in the wholesale loss of kelp beds at San Mateo Point, Palos Verdes, Imperial Beach, and have had large detrimental effects on many other kelp beds (North and Jones 1991). In southern California, sea urchin (*Strongylocentrotus* sp. and *Lytechinus pictus*) overgrazing by populations results in urchin barrens. The sustainability of urchin barrens requires immigration from other, non-barren sites as urchins sampled from barrens are nearly devoid of gonad material while those from kelp forests have much larger gonads (Tegner and Dayton (1991). Urchin barrens are documented in both time and space. The Palos Verdes kelp suffered persistent urchin overgrazing through the 1960s (Leighton et al. 1966). Clark et al. (1972) hypothesized that the elevated free amino acids discharged in the wastewater supported the area urchins even after the area had become denuded. Urchin barrens persist after the improvement of wastewater effluent and therefore their occurrence is not simply an effect of discharge, but additional factors likely trigger herbivore overgrazing (Foster and Schiel 2010). Tegner and Dayton (1991) concluded sea urchin overgrazing resulted from a reduction in drift algae biomass (typically as a result of adverse nutrient deficient periods) and elevated sea urchin recruitment. When drift algae biomass was sufficiently common, sea urchins remained in cracks and crevices in the reef. Tegner and Dayton (2000) hypothesized increased occurrence of urchin barrens was linked to fishing pressure on urchin predators, such as California sheephead (*Semicossyphus pulcher*). Many of these conclusions stem from work in Alaska where kelp forests lacking sea otters (*Enhydra lutris*) are heavily overgrazed while those with healthy otter populations are not. Tegner and Dayton (2000) inferred a relationship between urchin predator abundance and urchin overgrazing based on gut content studies, laboratory experiments, field observations of urchin behavior, and size-frequency distribution. Recent work by Hamilton et al. (2011) described the co-occurrence of low predator populations, high sea urchin density, and low giant kelp density as site-specific phenomena.

Storms. Storms can hinder or stimulate kelp growth, depending upon how large they are and how much energy they contain. Waves cause a back and forth motion in kelp; large swells increase the severity of this motion. The heightened drag force on the kelp resulting from large swells can break fronds or even break the holdfast free from its anchorage. As the fronds of giant kelp often entangle with other nearby giant kelp, the added drag of other loose giant kelp can overpower a more firmly attached neighbor and rip its holdfast free. As these accumulate, there is an increasing drag force on each neighbor causing them to be ripped free of their attachment to the bottom. Once dislodged, individuals often entangle with other nearby giant kelp, increasing the surface area susceptible to wave energy which can dislodge additional individuals. The resultant mass of entangled, loose giant kelp can drift through a kelp bed ripping out hundreds or thousands of giant kelp in the snowball effect that wash ashore or become a floating kelp paddy offshore (Dayton et al. 1984).

Of particular concern are storms that produce swell heights that exceed 4 m and that originate out of the west or southwest rather than the Gulf of Alaska (GOA). The Northeast Pacific wave climate changed in 1976-1977 to one where waves out of the west or southwest, similar to that occurring during El Niño events, occurred more frequently than before 1976 (Adams et al. 2008; Seymour 2011). Prior to 1976, the wave climate was dominated by energy generated in the GOA. The Southern California Bight coastline was largely protected from GOA-sourced waves via the island shadow effect (Pawka et al. 1984; Seymour et al. 1989). A shift south in the dominant trajectory minimized the island protection for the coastal area as more waves delivered their full energy to the Orange and San Diego Counties' coastline. This energy likely at times swamped all other physical and biological regulators of existing, persistent kelp forests (Reed et al. 2011) such as occurred during the 1982-1983 El Niño and the January 1988 storm (Seymour et al. 1989). These storms resulted in substantial damage to the coastal giant kelp forests including the complete removal of some forests (Dayton and Tegner 1984, Ebeling et al. 1985, Seymour et al. 1989). Even though large storms generally are devastating to the kelp bed resources, the two-fold factors of the 200-Year Great Storm of 1988 combined with the La Niña of 1989 produced kelp beds in areas that had been devoid of kelp for years, probably as the result of wave energy abrading the multi-layered invertebrate coverage (thereby eliminating competition for space) and exposure of bed rock for spore colonization (MBC 1990, Seymour et al. 1989, Appendix B).

ENSOs. Physical variables change, often resulting in dramatic shifts in kelp abundance and density over seasons, years, and between locations (Hodder and Mel 1978, Neushul 1981, North 1983, Jahn et al. 1998, Dayton et al. 1999). The manifestation of global El Niño and La Niña events are thought to be two extremes of a naturally occurring meteorological oscillation in atmospheric pressure gradient near the equatorial latitudes of the Pacific Ocean, termed the El Niño Southern Oscillation (ENSO). These oscillations generally occur on a scale of 2-7 years with the strongest effects often observed in the equatorial eastern Pacific (the west coasts of South and North America) (Bograd and Lynn 2003). El Niño conditions are commonly associated with warmer-than-average temperatures and a reduction in available nutrients in the upper water column as upwelling weakens resulting in poor kelp growth (Zimmerman and Robertson 1985, Dayton and Tegner 1989). Conversely, the onset of La Niña conditions, when surface waters are much colder than average, usually coincide with enhanced kelp growth as a result of the influx of nutrient-rich, colder bottom waters into the surface layer. It should be noted, however, that not all Central Pacific ENSOs result in Californian El Niños, or those that quantifiably alter local conditions. Californian El Niños in 1982-1983 and 1997-1998 lead to lower nutrient concentrations and increased wave energy striking the Southern California Bight coastline resulting in substantial damage to local giant kelp forests (Seymour et al. 1989; Edwards and Estes 2006). While ENSO events can elicit global effects, a given event may not necessarily produce local effects (Tsonis et al. 2005). Recently reported El Niño conditions in 2009-2010 resulted in no measurable response along the Southern California Bight (Bjorkstedt et al. 2010). Clearly, conditions labeled as El Niño or La Niña, encompass a wide gradient of southern California responses ranging from minor to catastrophic to giant kelp. Therefore, in certain years that are designated El Niño or La Niña years, there may not necessarily be locally poor or good kelp growth for the year.

Using several oceanographic models and looking at a variety of variables, a Multivariate ENSO Index has been compiled that uses these variables to parse cold water and warm water periods since the early 1870s (Figures 4 and 5). As depicted, it is clear that most of 2009 was a warm water period; however, as Tsonis et al. (2005) and Bjorkstedt et al. (2010) suggested, this may not necessarily cause local effects. The last two years are a prime example of this: while the ENSO index indicated that 2009 was a warm year, southern California kelp beds were larger than they had been in years, whereas the period from early 2010 to present has been a cold-water period, but many kelp beds were smaller in 2011 than in either 2010 or 2009, suggesting that due to the complicated giant kelp life cycle there may be a lag time before effects are fully matured.

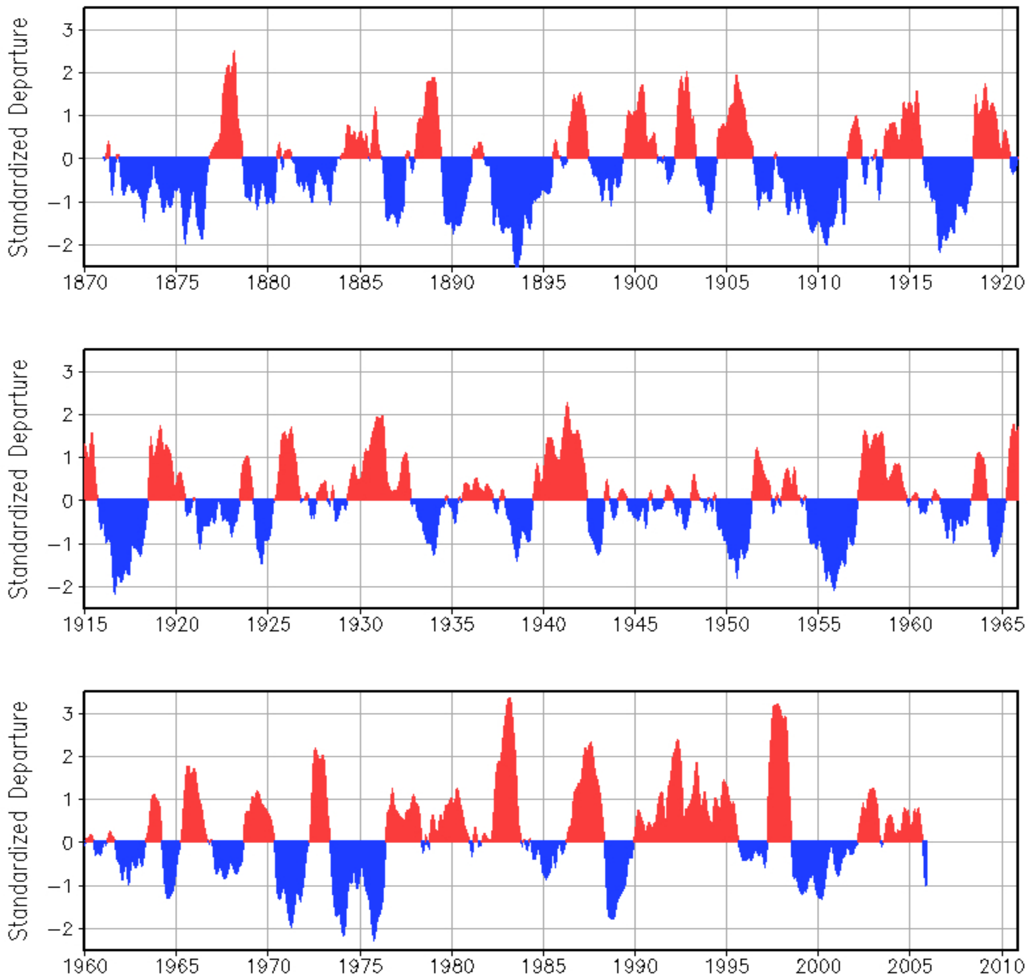


Figure 4. Multivariate ENSO Index from 1870 through 2006.

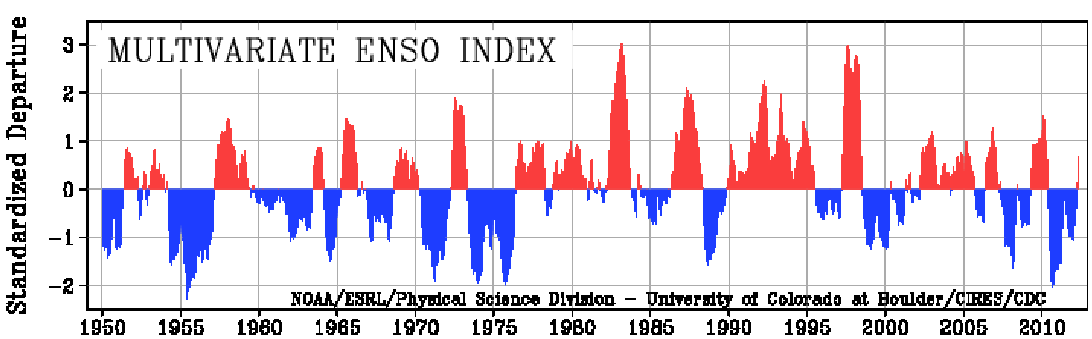


Figure 5. Multivariate ENSO Index from 1950 through 2011.

As ENSOs have been recurring events presumably for thousands of years, it was assumed in the long term that their effects have been neutral in regards to long-term maintenance of the kelp bed resources. However, a glance at the last approximately 50 years of the multivariate ENSO Index which tracks periods of SSTs at the equator above the mean (warm water events) and below the mean (cold water events) indicates that the 30 years between 1977 and 2007 were characterized by unrelenting warm spells. There were only two significant cold periods during the entire time period, whereas the previous 30 years were characterized by mostly cold-water events. Looking even further back to about 1872 to approximately 1918 (covering the period of Crandall's survey), it is clear that cold water events lasted longer and probably had a very favorable impact on the kelp beds of that era. The last five years have been characterized by two long La Niñas interspersed by one shorter El Niño.

Anthropogenic Effects. Because large-scale oceanographic cycles such as ENSO events are monitored closely, the ability of existing models to predict the onset of conditions that are either significantly warmer or colder than average increases every year as the profusion and quality of data increases. For this reason, it is far easier to correlate the variability of kelp bed abundance and health to natural physical phenomena than it is to relate it to anthropogenic causes. Anthropogenic effects on kelp beds have been documented, most notably the pollution-related loss of kelp beds offshore of Palos Verdes (from the late1950s through much of the 1970s) and Point Loma (in the mid-1990s) (SWQCB 1964, North 1968, Meistrell and Montagne 1983, Foster and Schiel 2010). It appears the cause of the loss of kelp at the Point Loma outfall was not related to the sewage, but probably the accompanying turbidity (North 2001, City of San Diego 1992a,b). Other factors have included unchecked runoff from coastal construction projects such as what appeared to have occurred during construction of Interstate 5 in the late-1960s (loss of Barn Kelp for several years); construction of homes at Salt Creek in the late-1970s which resulted in the loss of the large kelp bed (Salt Creek-Dana Point Kelp)(North and MBC 2001); the loss of the Huntington Flats kelp bed in the early-1930s; and the loss of the Horseshoe Kelp bed offshore of San Pedro Harbor in the late-1930s. The loss of the Horseshoe Kelp bed was probably from turbidity due to an increasing population and dumping of sediment from dredging of the Los Angeles and Long Beach Harbors, while the loss of the Huntington Flats kelp bed was probably a result of the construction of Anaheim Bay, Alamitos Bay, and the Long Beach breakwaters increasing turbidity in the area.

Climate Shifts. With evidence of five climate-regime shifts in the last century, anthropogenic effects would appear to be relatively insignificant compared to the changes the shifting oceanographic regime has wrought upon the marine biota. Consequences of these regime shifts take sometimes decades to appreciate. Contrary to what are generally assumed to be the responsible agents for the large-scale decreases in kelp in southern California (such as increasing urbanization, concurrent runoff, and discharges to the marine environment), there is now evidence that multi-decade-long physical oceanographic environmental changes have had a greater effect than previously believed. Low-frequency oceanographic regime shifts occurring on 20- to 40-year cycles result in sustained periods of comparatively high or low kelp canopy areas (Parnell et al. 2010). In the upper 200 m of the ocean, both density and temperature correlate well with nitrate concentrations (Kamykowski and Zentara 1986). A recent study looking at sea water density (which in itself may be a better indicator of the presence of nitrates/nutrients than temperature) over time appears to indicate that a major shift occurred in about 1977 during a period in which we assumed was just a strong El Niño (Parnell et al. 2010). Upon review of water density data collected since the 1950s incidental to fisheries management cruises by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and from Scripps Institution of Oceanography pier data, there is now evidence that nutrients were replete in the SCB for decades prior to the 1976-1977 regime or climate shift and in contrast have been more or less depleted since. The dramatic increases and decreases observed during El Niño and La Niña events in kelp bed canopies after the regime shift in the latter part of the 20th century was the result of them occurring during a period of depleted nutrients; kelp bed responses tp ENSOs were much more subdued during the period of replete conditions prior to the regime shift (Parnell et al. 2010). This change in the apparent intensity of the ENSO events is the result of a nutrient deficient regime with pulses of nutrients to sustain the beds only available during the rebound effects from ENSO events (La Niña). These regime shifts can come in the form of a gradual drift, smooth oscillations, or step like changes as noted in the 1976-1977 climate-regime shift and the later 1988-1989 shift (Miller et al. 1994, Miller and Schneider 2000). These far-reaching changes are usually decades in duration and can have profound effects on the local marine communities including large changes in abundance and biodiversity (Bakun 2004, Noakes and Beamish 2009). A regime shift reportedly occurred in the California Current circa 1999 (Petersen and Schwing 2003), but this has yet manifested as altered conditions in the Southern California Bight as all available metrics continue to indicate conditions consistent with the 1976-1977 shift (McGowan et al. 2003; Bograd and Lynn 2003; Pondella et al. in press). Initial understanding of the 1976-1977 shift centered on increased SST, but salinity also declined as the mixed layer deepened with a deeper thermocline (McGowan et al. 1998; McGowan et al. 2003; Bograd and Lynn 2003).The PDO and the Inter Decadal Oscillation (IDO) appear as potential long-term climate changes from a colder to warmer regime, or the reverse (Mantua et al. 1997, Power et al. 1999, Fiedler 2002, Verdon et al. 2004). Both the negative and positive PDO phases are well within the range observed for the 111-years included in the PDO series, many of which did not result in a corresponding giant kelp canopy area that would be predicted by a direct PDO:kelp growth relationship. As these effects dissipate, it was assumed that conditions become more or less normal; however, a closer look may reveal that the marine ecosystem has been fundamentally changed in a way that could portend serious consequences for the sustainability of the kelp bed resources. Increased recognition of the unique oceanography of the Southern California Bight identified a disconnect between the waters inshore of the Channel Islands and the California Current flowing seaward of the Channel Islands (Hickey 1992; Bograd and Lynn 2003). This disconnect may have limited the relevance of common climate indices derived from environmental data gathered across the Northeast Pacific Basin such as the Pacific Decadal Oscillation (PDO), North Pacific Gyre Oscillation (NPGO), Multivariate ENSO Index (MEI), etc. The PDO's minimal applicability to the Southern California Bight was best detailed by Di Lorenzo et al. (2008) and their conclusion that the PDO correlated with SST south of the 38°N while the NPGO correlated with several productivity measures. Cavanaugh et al. (2011) found the NPGO correlated with Santa Barbara Channel kelp forests, but only at a 3-year lag. No such relationship was identified with the PDO. However, large scale ENSO events and ENSO events of long duration do impact the region's kelp beds as can be elicited from the long-term MEI data compiled against the kelp canopy coverage.

Sediment Regimes. Changes in sediment regimes have also contributed to the disappearance of several kelp beds since the 1911 Crandall surveys. Large kelp beds once existed offshore of Point Dume, Sunset Beach, Crystal Cove, just south of San Onofre, Horno Canyon, Santa Margarita, and near the Mexican Border. As there are no known human-induced perturbations of these areas, it appears these beds have disappeared due to shifting sediments causing inundation of low lying reefs (or kelp was growing on the sand in some of these locations). Subtidal observations on the seafloor at the locations of these historically established kelp beds at Sunset Beach (offshore of Santa Monica), Crystal Cove, San Onofre, Santa Margarita, and the Mexican Border, indicate that no suitable hard substrate is found on the bottom for the re-establishment of these kelp beds (Curtis 2010, pers. comm.). Sub-bottom profiling revealed that hard substrate is buried by as much as one meter of sand at San Onofre and in the Barn Kelp area (Elwany 2007, pers. comm.).

DESCRIPTION OF THE CENTRAL REGION KELP BEDS

In the CRKSC program area, extending from the Santa Barbara-Ventura County line to Laguna Beach in Orange County, 27 existing or historic kelp beds were identified, three of which (Sunset kelp, Horseshoe kelp and Huntington Flats kelp) have been missing or greatly reduced since the first half of the 20th century (Appendix B). One kelp bed, Sunset kelp (near Santa Monica), has not been observed since the initiation of monitoring by the CRKSC in 2003, but was observed as a very small bed during the survey of Ecoscan (1990) and has only been observed since as kelp along the submerged breakwater at Santa Monica. The disappearance of these three kelp beds was likely the result of greater turbidity and sedimentation in these areas related to increased industrialization and population throughout southern California during World War II and into the late-1960s. Two other historic beds (Irvine Coast and Laguna Beach) have reappeared after absences of one to several decades resulting from a series of El Niño events extirpating the kelp from the area.

The continued loss of three of these five beds is likely the result of the loss of suitable substrate. Horseshoe kelp likely was buried during excavations of the harbor in the 1940s and 1950s and dumping of the sediment at that location, and the burial of suitable substrate by natural sedimentation processes (as has been observed at several other historic kelp bed sites removed from population centers) at Sunset kelp (a competing theory is that the Sunset kelp beds may have grown on sand, but there is no documentation). The loss of the Huntington Flats kelp bed was probably the result of increased turbidity in the area due to the extension of the Long Beach breakwater, and the dredging of Alamitos and Sunset-Huntington Harbors. CRKSC monitoring began following a strong cold-water La Niña event in 1999. This had followed the largest El Niño warm water event on record in 1997-1998. Due to the stimulus provided by La Niña conditions, 22 of the 24 kelp beds that were known to support kelp in the last half of the 20th century all supported a surface canopy during that period. All five missing beds had substantial canopies prior to 1950.

The California Department of Fish and Game recognizes nine administrative kelp bed lease areas in the region: Fish and Game Kelp Beds 9-19 (Figure 6). Administrative kelp bed areas in California waters are numbered and defined by compass bearings from known landmarks, and have applicable commercial

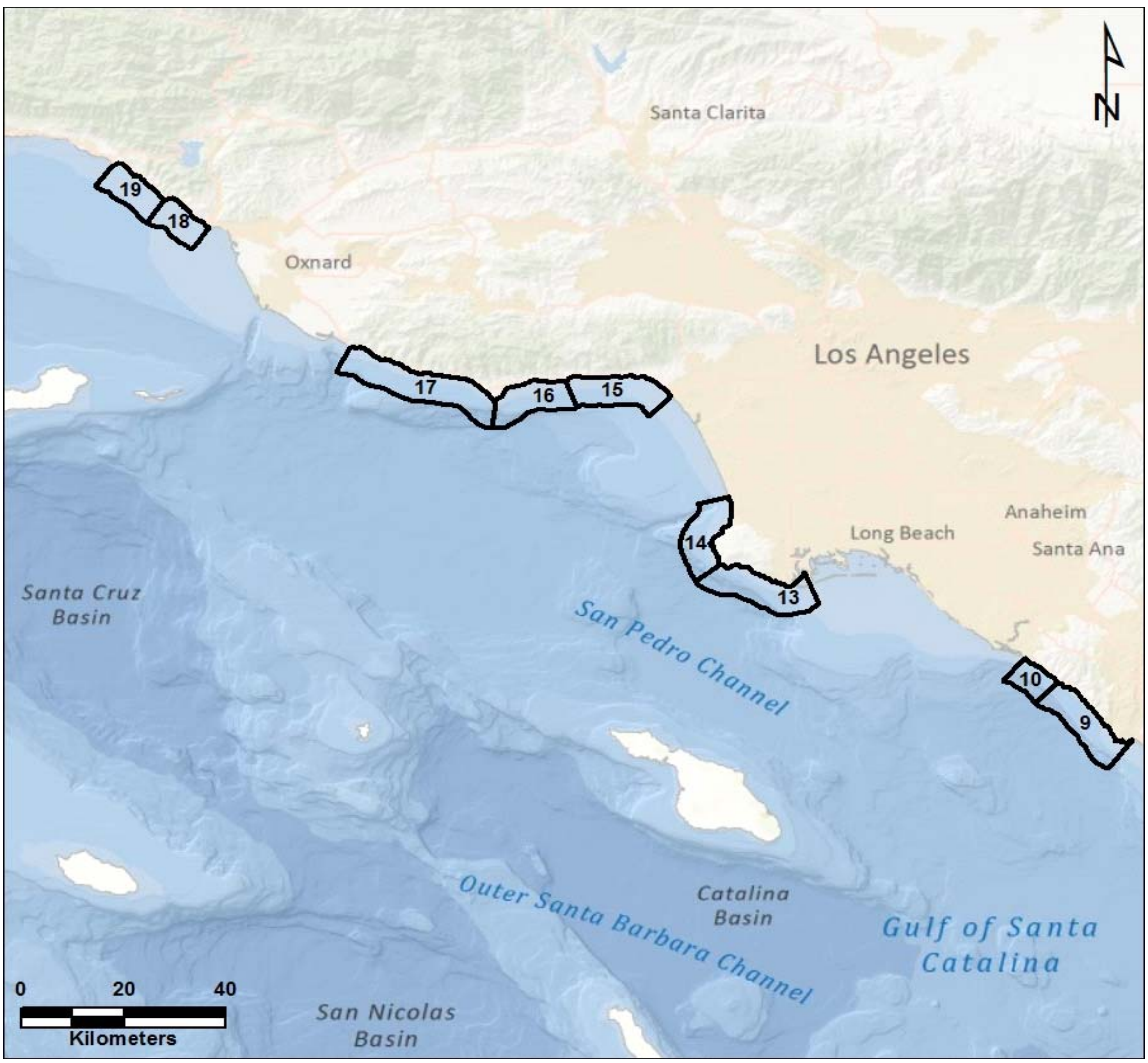


Figure 6. California Department of Fish and Game administrative beds in the CRKSC study area.

regulations (see CCR, Title 14, §165 and 165.5). The entire California coastline, including the Channel Islands, is divided up into numbered administrative kelp beds, although not all areas contain kelp beds. 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. In the CRKSC study area, there are nine administrative kelp beds: four are open, three are leasable, and two are closed (Bed No. 15 in northern Santa Monica Bay, and Bed No. 10, located between Abalone Point and the Newport Bay south jetty) (Figure 6).

Giant kelp was first harvested along the California coast during the early 1900s. Since 1917, kelp harvesting has been managed by the CDF&G 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 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 mi^2 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 Fish and Game Kelp Bed designations, making it difficult to determine if specific sub-areas of the much larger Fish and Game Kelp Bed lease areas are responding atypically compared to the other beds in the area. For example, Fish and Game Kelp Bed (lease area) No. 17 encompasses over 10 kilometers of coastline. Therefore, we have determined natural breaks in the beds (as noted by either Crandall (1912) or Ecoscan (1990)) and assigned names that describe the location based on nearby canyon names, prominent features, or names in use locally. Therefore, the area designated as Fish and Game Kelp Bed 17 includes five kelp beds in the CRKSC program (Appendix A).

In general, the nearshore bottom sediment north of the Deer Creek kelp bed, the northernmost kelp bed under study, is composed predominantly of sandy substrate with virtually no hard bottom at depths conducive to kelp growth. Therefore, no substantial kelp beds are found north of Deer Creek in the areas offshore of Ventura Harbor, the City of Oxnard, the Mandalay Generating Station, Channel Islands Harbor, Ormond Beach Generating Station, and from Port Hueneme south to Point Mugu. There are, however, small kelp stands that form along the breakwaters of both the Channel Islands Harbor breakwater and the Port Hueneme breakwater. Just south of Point Mugu, small kelp beds have occasionally been noted but have not been observed during the current monitoring program.

South of Deer Creek, kelp beds are more or less continuous to Sunset kelp in Santa Monica Bay. Another large gap in kelp cover exists from Sunset kelp south to Malaga Cove at the northern edge of the Palos Verdes Peninsula, again because sandy bottom dominates this stretch of coastline. Therefore, no measurable kelp stands exist offshore of Santa Monica, Marina del Rey Harbor, the City of Los Angeles Bureau of Sanitation Hyperion Treatment Plant, Scattergood Generating Station, Chevron El Segundo Refinery, El Segundo Generating Station, Manhattan Beach, Hermosa Beach, the Redondo Beach Generating Station, King Harbor, or Torrance Beach. While no natural hard substrate exists for the attachment of kelp along this coastal stretch, individual subsurface giant kelp are often seen at the Marina del Rey and King Harbor breakwaters and at the entrance to King Harbor.

Rocky substrate becomes prevalent offshore of the Palos Verdes Peninsula, which typically supports large kelp beds from Malaga Cove to Point Fermin and Cabrillo Beach, and within and along the inner and outer Los Angeles and Long Beach Harbor breakwaters. Kelp beds were also historically present in the first half of the 20th century offshore of San Pedro at Horseshoe kelp growing near the 66-ft (11-fathom) isobath. South, past Alamitos Bay and Huntington Harbour, sand predominates in the nearshore area with the exception of groins at the entrance to Bolsa Chica Wetlands and Huntington Flats, a low-lying reef in the shallow inshore area at the north end of the cliffs off Huntington Beach. This area also supported a kelp bed in the early part of the 20th century. As sandy bottom with no hard substrate continues downcoast to Newport Harbor, there is no suitable habitat for kelp along the coast from

Huntington Flats past the Huntington Beach Generating Station and the Orange County Sanitation District outfalls until reaching Newport Harbor and south. Small stands of kelp occur along the Newport Harbor breakwater, particularly along the inside edge of the upcoast jetty. Continuing downcoast, rocky substrate is present out to the 40 to 60 ft contour lines and typically there are small but nearly contiguous kelp beds from Newport Harbor to the sandy beach areas just north of Abalone Point in Laguna Beach. Beyond that, substrate (and typically kelp) is present at reefs fringing pocket beaches to Heisler Park in Laguna, with a gap at Main Beach and then good substrate out to the 50 ft contour for kelp continuing for at least a mile past Main Beach where CRKSC coverage ends and Region Nine coverage continues down to the Mexican Border.

HISTORICAL KELP SURVEYS (1911-2010)

In 1911, a mapping expedition of canopy-forming kelps for 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 to this day (Crandall 1912). Using this methodology, most of the kelp beds in the CRKSC area were mapped (Appendix B). The ability to accurately map kelp beds such as the Point Loma kelp bed would require numerous triangulations using a sextant, compass, and the need to row a boat to enough locations to have some confidence in the quality of the data. It is likely that relatively few points were taken in order to depict the kelp bed. Most of the discussion on the quality of the data appears to focus on the ability to measure the size of the kelp beds printed on the maps, but not whether the maps were accurate depictions of the kelp beds. The latter is a valid point and the answer is unlikely to be elicited readily. Given this ambiguity, the Crandall estimates should be viewed qualitatively rather than as quantitative estimates comparable to aerial survey data taken since the 1920s. However, the data is a very good approximation to use as our baseline as anecdotal reports from area stakeholders reported by Cameron (1915) indicate kelp beds in 1912 were in fairly poor condition at the time of his survey from that seen in previous years. Although the historical ENSO index suggests that the previous five years had been favorable to the kelp (Figure 4), the PDO (another environmental metric that has historical data extending back to that period) is in agreement with Cameron's statement. While 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 in 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 2.53 square nautical miles (Nm^2 [8.68 kilometers^2]) Crandall reported (all of his measurements were in square nautical miles) to be very similar to his measurement of 2.42 Nm^2, but likely did not include much of Malaga Cove). Due to the large sizes reported by Crandall, Neushul (1981) assumed there was a scaling error and re-measured the maps which produced a value that was 10% less than Crandall's original measurement. However, Neushul (1981) wrote that his measurements resulted in 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, the original maps of Palos Verdes by Crandall (1912) were re-measured by MBC using computer-aided spatial estimation software (including Malaga Cove) and found the area (2.57 Nm^2) to be slightly greater but very similar to that reported by Crandall (2.53 Nm^2). Therefore, the actual size of the beds that Crandall reported was probably relatively accurate since the areal survey extent and configuration reported had been confirmed from contemporary charts (Hodder and Mel 1978, Neushul 1981). Some of these beds have since grown to the sizes similar to or larger than those noted by Crandall (1912), confirming that the physical dimensions of the beds he reported were probable. This suggests that the ability to accurately measure the beds on the charts in 1911 were similar to that available to North in 1964 and Neushul in 1981.

Seemingly confirming suspicions that Crandall's measurements were not accurate, the Imperial Beach kelp bed south of San Diego measured 0.984 km^2 in 1911, and never again was measured to be larger than about 0.727 km^2 (occurring in 1987). However, at the end of 2007, Imperial Beach kelp bed measured 1.493 km^2 (MBC 2011b), almost 50% greater than what Crandall measured, lending further credence to Cameron's (1915) statement that beds were in poor condition compared to earlier years. It therefore follows that the Palos Verdes and other kelp beds of the Central Region prior to 1911 were likely much larger than they are today. Because the error we derive between Crandall's estimate of the physical dimensions of the beds and ours is only about 1.5%, we incorporate Crandall's original measurements in our table (Table 1). Although we believe that Crandall's physical dimensions are relatively accurate, we take exception to the actual canopy sizes he records as all of his beds depict the encompassed areas as solid kelp, whereas all of the kelp beds we have been monitoring for the past 40 years have many interstitial voids. This factor probably reduces the overall canopy estimate by at least 10% and possibly more. However, there is no uncertainty that between 1911 and the mid-1970s, kelp beds declined at most coastal and island sites in southern California. Current measurements indicate most of the beds remain smaller than those of a century ago (Tables 1 and 2).

MATERIALS AND METHODS

KELP DATA COLLECTION

Beginning in the 1960s, the surface area of coastal kelp beds was monitored by aerial photography by the late Dr. Wheeler J. North of the California Institute of Technology, and later by MBC using a methodology that provided a consistent approach to determining kelp bed size. MBC has conducted the surveying for Region Nine since its inception in 1983 and began conducting surveys for the Central Region Kelp Consortium in 2003.

Direct downward-looking photographs of the kelp beds were taken from an aircraft modified to facilitate aerial photography. MBC conducted quarterly overflights of the coastline for the Consortium from the Santa Barbara/Ventura County boundary to Laguna Beach, Orange County. 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 successful flights. 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 five feet and tide less than +1.0' MLLW, and
- Sun angle greater than 30 degrees nadir.

KELP DATA ANALYSIS

All photographs were reviewed after each overflight and the canopy surface area of each kelp bed was ranked in size by comparison to historical bed size, excluding El Niños and La Niñas. The ranking ranged from 1 for well below average, 2 for below average, 2.5 for average, 3 for above average, and 4 for

Table 3. Rankings assigned to the 2011 aerial photograph surveys of the Ventura, Los Angeles County, and Orange County kelp beds, and rankings assigned to a April 2012 aerial survey. 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. A ranking of 2.5 would represent the average status.

	2011	2011	2011	2011	2012
Kelp Beds	16 Apr 11	01 Aug 11	28 Oct 11	21 Dec 11	April
Channel Islands	1.0	2.0	2.5	**3.0**	2.5
Port Hueneme	2.5	**3.0**	2.5	2.5	3.0
Deer Creek	2.0	2.5	3.0	**3.5**	3.0
Leo Carillo	2.5	3.0	3.0	**3.5**	3.0
Nicolas Canyon	2.5	2.5	2.5	**3.0**	3.0
El Pescador/La Piedra	2.5	2.5	2.5	**3.0**	3.0
Lechuza Kelp	2.5	2.5	2.5	**3.0**	2.5
Point Dume	1.5	2.5	2.5	**3.0**	3.0
Paradise Cove	1.5	2.5	2.5	**3.0**	3.0
Escondido Wash	1.5	2.0	2.5	**3.0**	3.0
Latigo canyon	1.5	2.0	2.5	**3.0**	3.0
Puerco/Amarillo	1.5	2.0	2.5	**3.0**	3.0
Malibu Pt.	1.5	2.5	2.0	**3.0**	3.0
La Costa	-	-	-	-	-
Las Flores	1.5	1.0	1.0	**2.5**	2.0
Big Rock	-	-	1.0	**2.0**	2.0
Las Tunas	1.0	1.5	1.5	**3.0**	3.0
Topanga	1.0	2.5	2.5	**3.0**	3.0
Sunset	-	0.5	0.5	**0.5**	0.5
Marina Del Rey	-	-	1*	**2.5**	2.0
Redondo Breakwater	-	1.5	3.0	**2.5**	2.0
Malaga Cove - PV Point (IV)	3.0	3.5	4.0	**4.0**	3.5
PV Point - Point Vicente (III)	3.0	3.5	4.0	**4.0**	4.0
Point Vicente - Inspiration Point (II)	2.5	4.0	4.0	**4.0**	4.0
Inspiration Point - Point Fermin (I)	2.0	4.0	4.0	**4.0**	2.5
Cabrillo	2.0	3.5	3.0	**3.0**	2.0
LB/LA Harbor and Breakwaters	2.0	3.0	**3.5**	3.0	3.0
Horseshoe Kelp	-	-	-	-	-
Huntington Flats	-	-	-	-	-
Newport Harbor	3.0	2.5	3.5	**3.5**	3.0
Corona Del Mar	3.0	3.0	3.0	**4.0**	3.0
North Laguna Beach	3.5	3.5	3.5	**4.0**	3.0

Notes: * = Red tide present
Ranking values: 0.5 = trace or very small amt 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

well above average (Table 3). 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 canopy in each distinct kelp bed (as designated by the Consortium) was calculated.

All slides were individually digitized, and the slides from one of the four surveys that showed the greatest areal coverage were digitally assembled into a composite photo-mosaic that provides a regional view of whole kelp bed areas. The assembly was done using Adobe Photoshop CS2 to combine photos for the photomosaic. The Photoshop mosaics were then transferred to GIS (ArcGIS 9.2) to geo-reference them to place into the specific Fish and Game shape file. Each mosaic was geo-referenced to at least three prominent features on the map and converted to UTM or other acceptable coordinate system and ultimately converted to a geo-referenced TIFF file. Surface canopy areas was calculated using the Hawth's Analysis Tools (Version 3.27), an extension to the GIS program (SpatialEcology.com). The kelp beds from the photos were then layered on standard base maps to facilitate inter-annual comparisons.

ENVIRONMENTAL DATA

Data from shore and buoy stations 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 Point Dume, Santa Monica Pier, and Newport Pier. At these locations, automated samplers measure conductivity, temperature, and fluorometry every 1 to 4 minutes. These data are made available in real time via the Southern California Coastal Ocean Observation System (SCCOOS) website (www.sccoos.org).

Water temperature data from two Los Angeles County Sanitation District monitoring stations offshore Palos Verdes Peninsula (Stations PV TM and PV TN),

Sea and swell height data from CDIP data buoys located at Santa Monica Bay and San Pedro. Wave direction, height, and period are available in real time via the CDIP website (cdip.ucsd.edu).

RESULTS

WATER TEMPERATURES AND NUTRIENTS

Sea surface temperatures (SSTs) from five separate monitoring stations (from Point Dume, the Santa Monica Pier, two stations offshore of Palos Verdes Peninsula, and Newport Pier) were used to determine the theoretical availability of nutrients in the region. The average early morning SST for the month at each station is correlated with the amount of nitrate that is theoretically available for uptake by kelp (in micrograms-per-gram per-hour) (Haines and Wheeler 1978, and Gerard 1982). The value for each month is summed (12 monthly values) for the indexed year (July 1 to June 30) (Table 4). For example, a month with an average temperature of 14.5°C has a nutrient quotient value (NQ) of 4 while a temperature of 12°C has a value of 14. This method allows for an inter-annual comparison between nutrients available to kelp during any given year, making it possible to pinpoint those years with theoretically high or low nutrient availability and to establish possible temporal trends. Low annual values (below 30) indicate below-average nutrient availability during the year which probably has adversely stressed the kelp, while values above 30 indicate average to above average and probably sufficient nutrients available to sustain growth. While there appears to be convincing evidence that seawater density can also be used as a surrogate, and in some cases predict nutrient availability possibly better than temperature, long-term measurements on smaller scales than the Southern California Bight are not readily available. Temperature measurements in the marine environment, however, have been ongoing for decades in many areas along the coast resulting in a readily available resource that can predict nutrient availability. It should be noted that the kelp life cycle is a very long process which means good nutrient availability during a period will have a lag effect, and poor nutrient may also lag before results are observed visually in terms of canopy coverage or lack thereof.

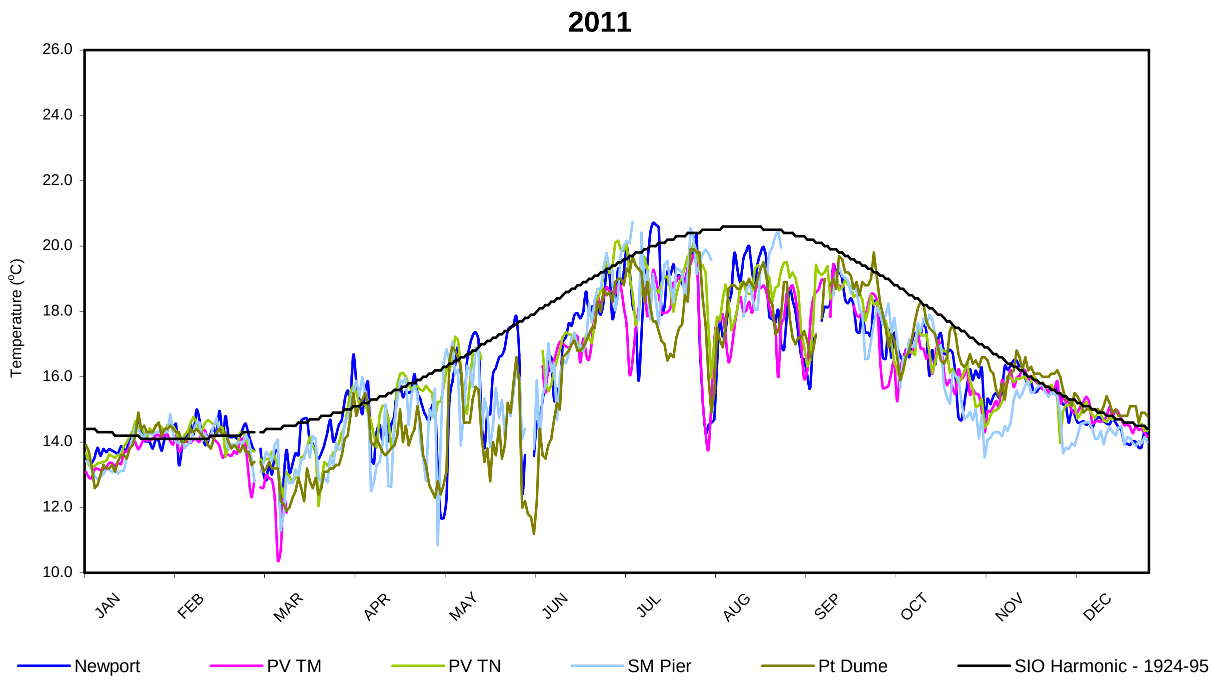
It is apparent that all of the temperature regimes across the Central Region were in relative agreement indicating that most of 2011 temperatures were well below the average through most of the year consistent with NOAA El Niño Watch data indicating a continuing La Niña throughout all of 2011 (Figure 7). From January through February, temperatures were slightly warmer than the long-term mean in the north and south, becoming very cool and well below the mean from March through October. November and December were near average and stayed about average through February before becoming cool again through mid-April 2012.Temperatures were warmer-than-average at Point Dume

Table 4. Seasonal kelp nutritional index based on weighting values given to monthly temperature data derived from Point Dume (PD), Santa Monica Pier (SMP), Palos Verdes TN &TM, and Newport Pier† (NP). The weighting values are derived from nitrate versus temperature data from North and Jones (1991), and nitrate uptake rates from Haines and Wheeler (1978), and Gerard (1982). The season begins 1 July and ends 31 June. Years in Red denote warm-water years, Blue cold-water years, both colors are transition years, based on NOAA Multivariate ENSO Index (MEI), May 2012.

Number of months falling into indicated temperature range (Weighting Factor)	Temp. Range	Site	Season 2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
14	12.01-13.00°C	PD	-	-	-		-	-	-	1	1	-
		SMP	-	-	-	1	-	-	1	-	-	-
		PVN	-	-	-	-	-	-	-	-	-	-
		PVM	-	-	-	-	-	-	-	-	1	-
		NP	-	-	-	-	-	-	-	-	-	1
8	13.01-14.00°C	PD	-	-	-	-	-	-	-	3	2	1
		SMP	-	2	1	2	-	2	1	-	3	2
		PVN	-	-	-	-	-	-	-	-	2	-
		PVM	-	-	-	-	-	-	-	-	4	-
		NP	1	-	-	-	-	2	-	-	2	-
4	14.01-15.00°C	PD	-	-	-	-	-	-	-	3	4	2
		SMP	3	1	2	3	4	3	3	5	3	4
		PVN	-	-	-	-	-	-	-	-	2	2
		PVM	-	-	-	-	-	-	-	-	3	3
		NP	2	2	1	3	4	3	4	3	3	4
2	15.01-16.00°C	PD	-	-	-	-	-	-	-	4	3	1
		SMP	4	1	2	-	2	1	1	1	1	-
		PVN	-	-	-	-	-	-	-	-	2	1
		PVM	-	-	-	-	-	-	-	-	2	1
		NP	3	2	3	1	1	-	2	3	3	1
1	16.01-17.00°C	PD	-	-	-	-	-	-	-	-	-	2
		SMP	1	2	2	3	-	1	1	1	2	1
		PVN	-	-	-	-	-	-	-	-	3	1
		PVM	-	-	-	-	-	-	-	-	1	1
		NP	2	2	1	-	-	1	3	1	1	2
Season	NQ	PD	-	-	-	-	-	-	-	58	52	29*
		SMP	21	24	22	31	20	31	23	23	40	34*
		PVN	-	-	-	-	-	-	-	-	31	11*
		PVM	-	-	-	-	-	-	-	-	63	15*
		NP	24	14	11	22	18	29	23	19	35	34*

PD = Point Dume, SMP = Santa Monica Pier, PVN = Palos Verdes "TN", PVM = Palos Verdes "TM", NP = Newport Pier.

* Data available only through mid-May 2012



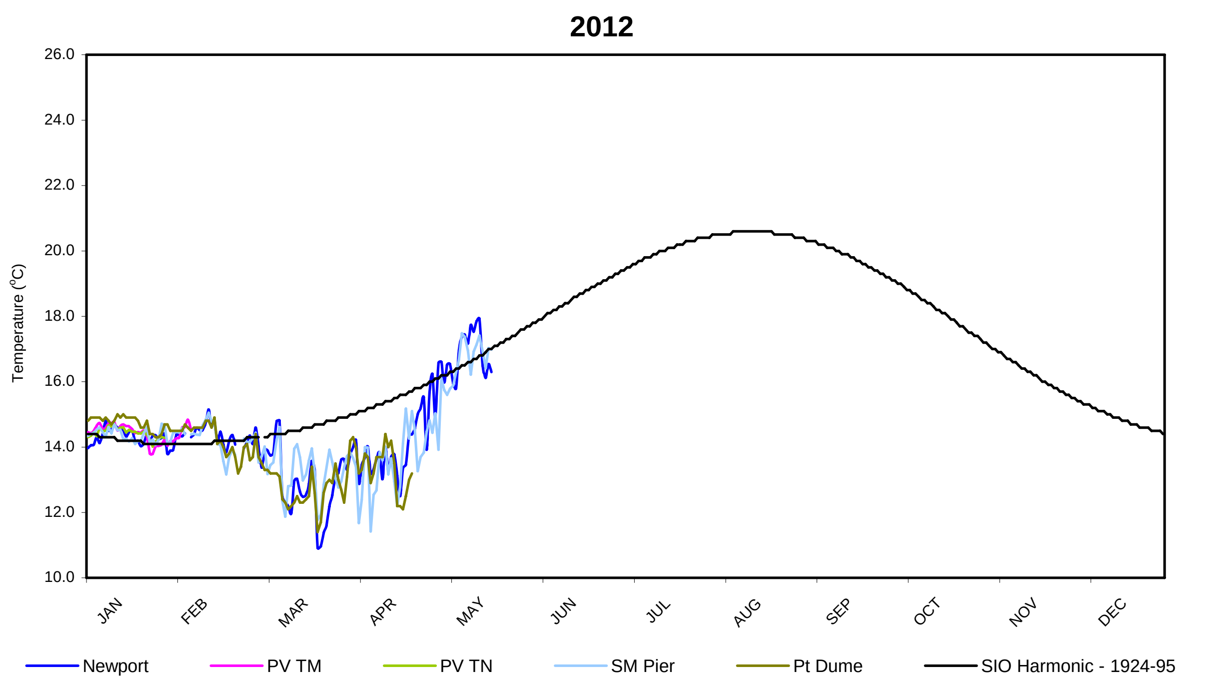
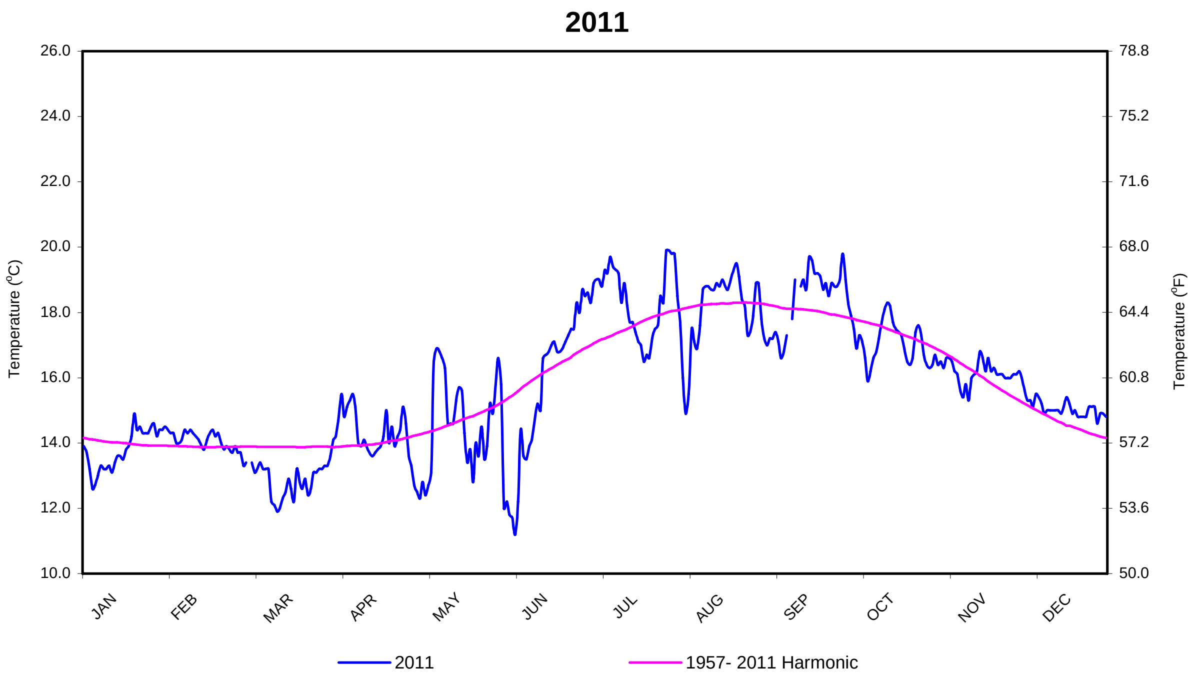


Figure 7. Daily sea surface temperatures (SST) for five stations for the Central Region for 2011 and through May 2012.

through most of 2011 (Figure 8), but average temperatures at Point Dume are typically much cooler than the rest of the Central Region; the temperature pattern stayed similar to that of the region (Figure 7). Temperatures at Santa Monica Pier followed the same pattern with mostly cooler-than-average temperatures throughout the year, with the deviations mentioned for the region (Figure 9). Further south along the coast, at Palos Verdes TN station (Figure 10) and at the Palos Verdes TM station, temperatures



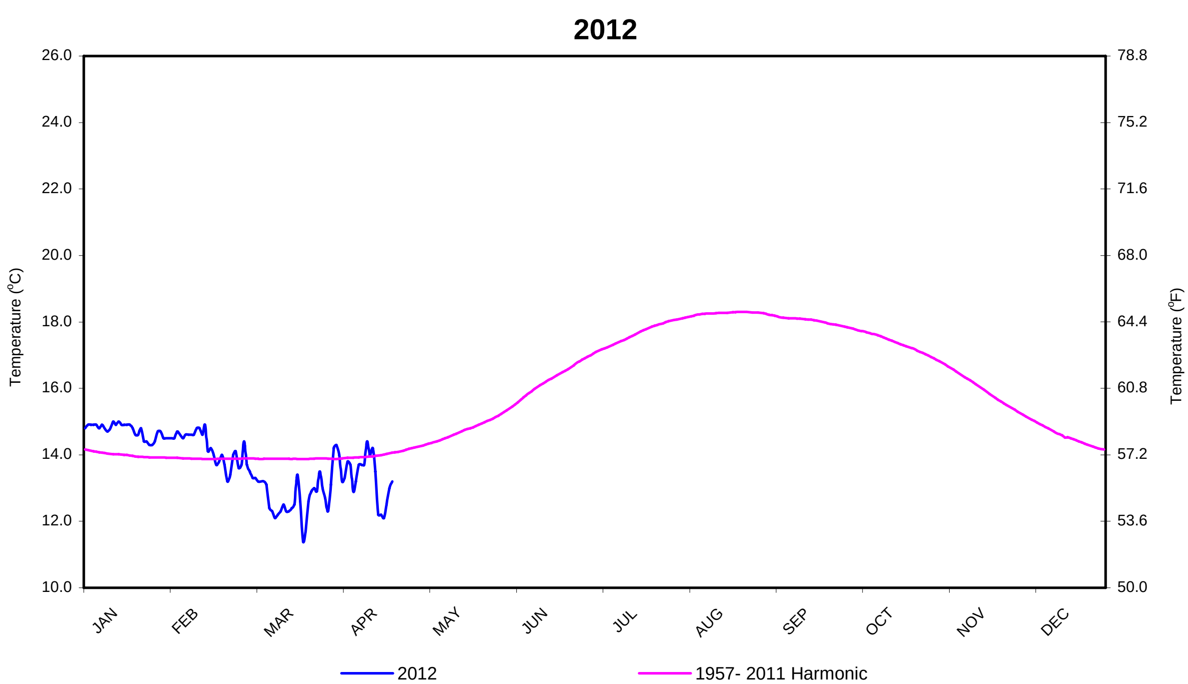
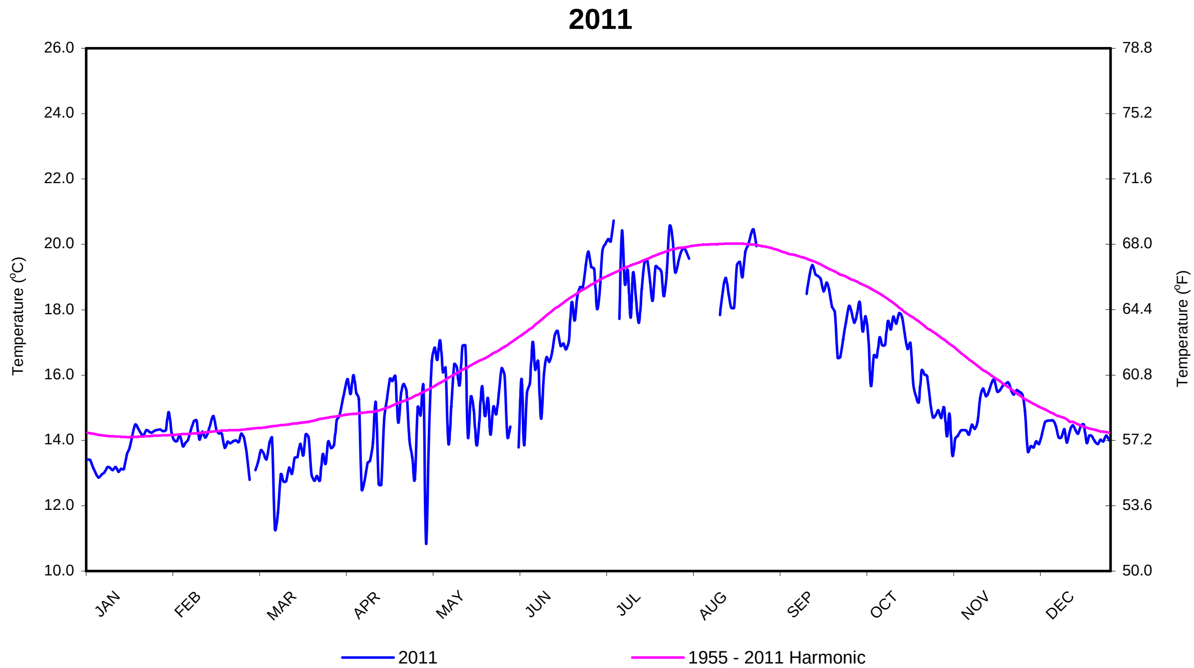


Figure 8. Daily sea surface temperatures (SST) at Point Dume for 2011 and through mid-April 2012.



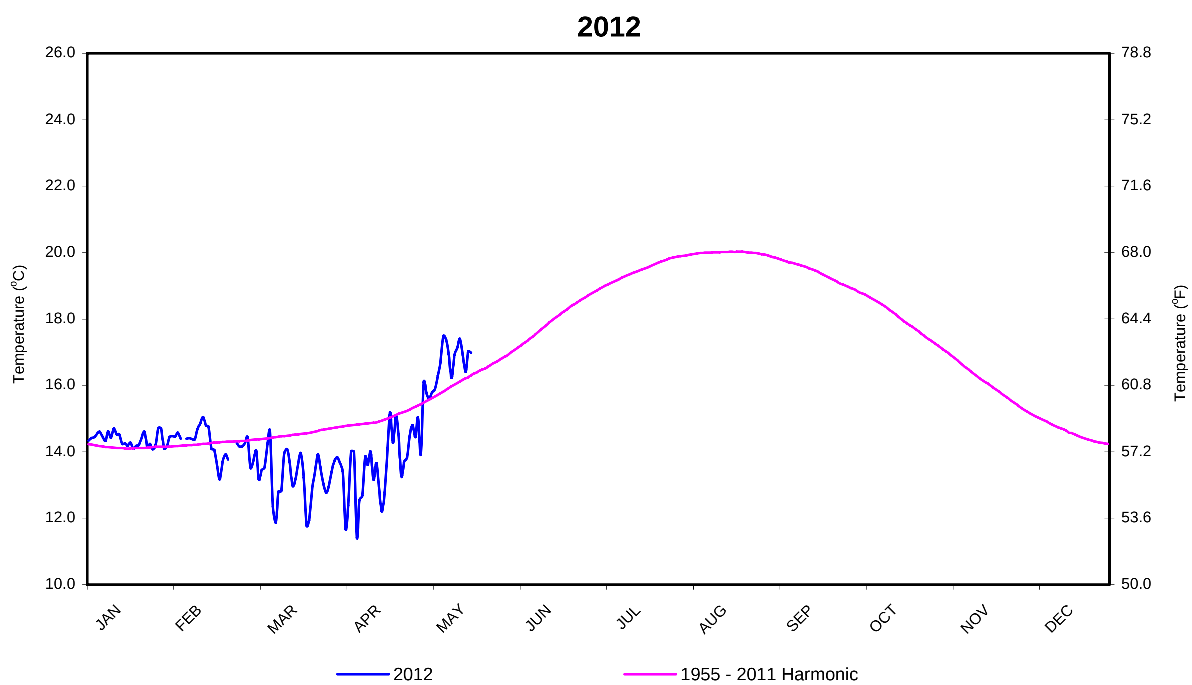
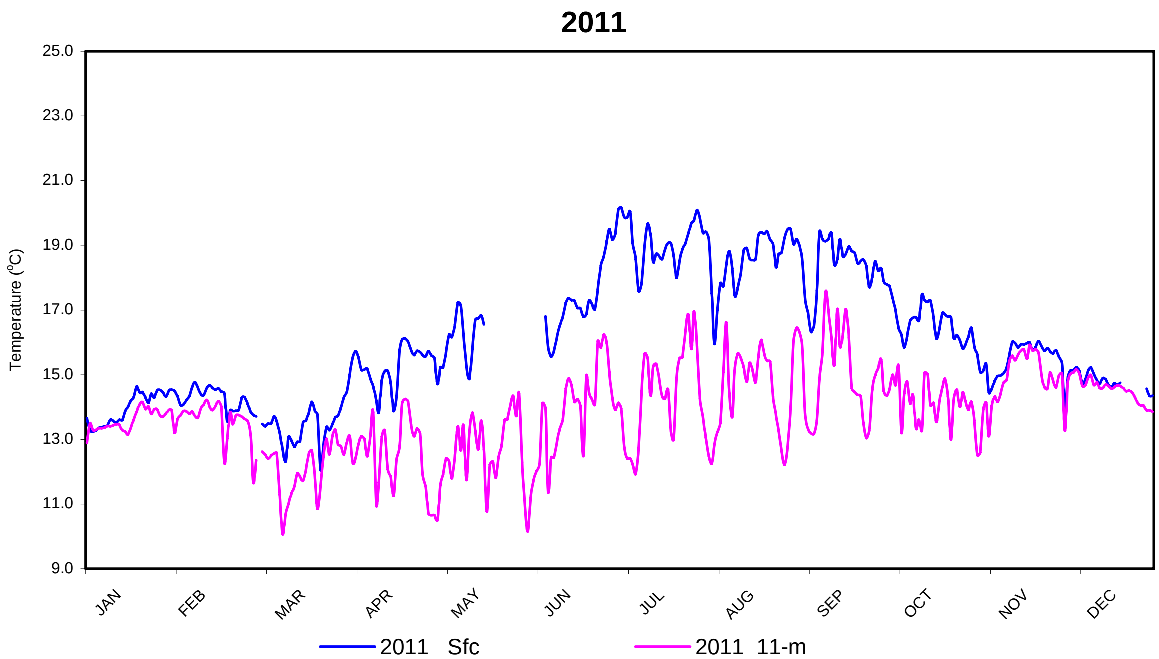


Figure 9. Daily sea surface temperatures (SST) at Santa Monica Pier for 2011 and through May 2012.

were notably cooler at the TM station than at the TN station, but temperatures at the 11-m depth station were very cool indicating ample nutrients below the thermocline throughout most of the year. At the southern portion of the Central Region range at Newport Pier (Figure12) temperatures were very similar with average SSTs in the beginning of the year, but becoming cooler through October before becoming average during the last two months of the year. The beginning of 2012 started with warmer but average



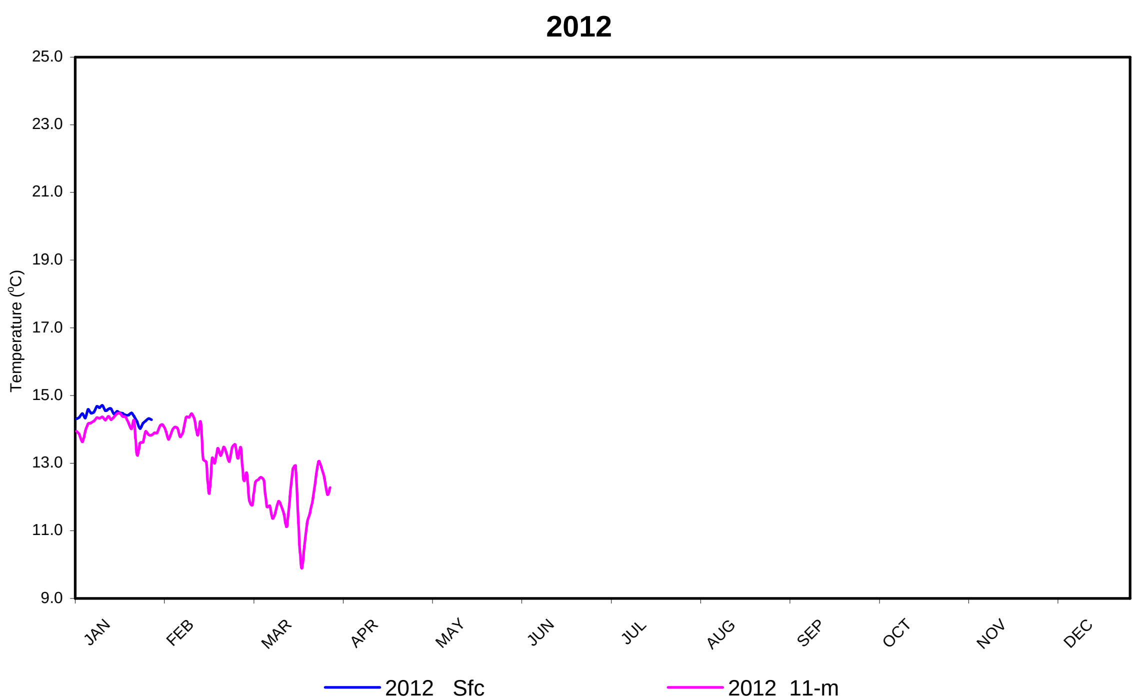
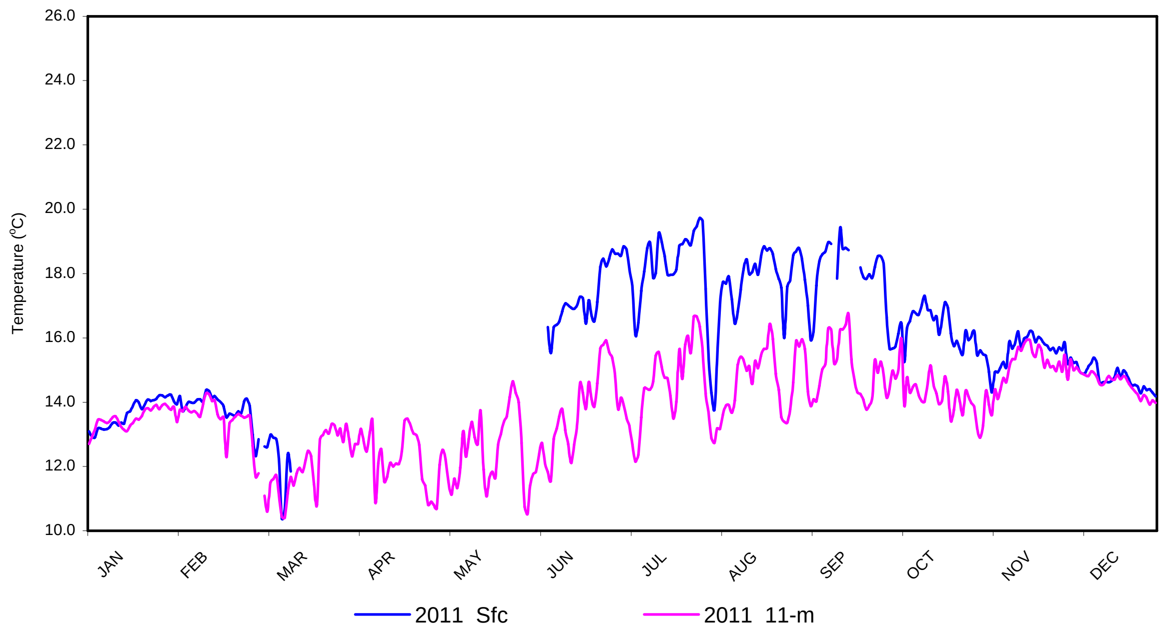


Figure 10. Daily sea surface temperatures (SST) at Station TN offshore Palos Verdes for 2011 and through March 2012.

temperatures at most monitoring stations. Due to persistent overcast skies, the June survey was not conducted until August. At that time, following several months of probably adequate nutrients from April to



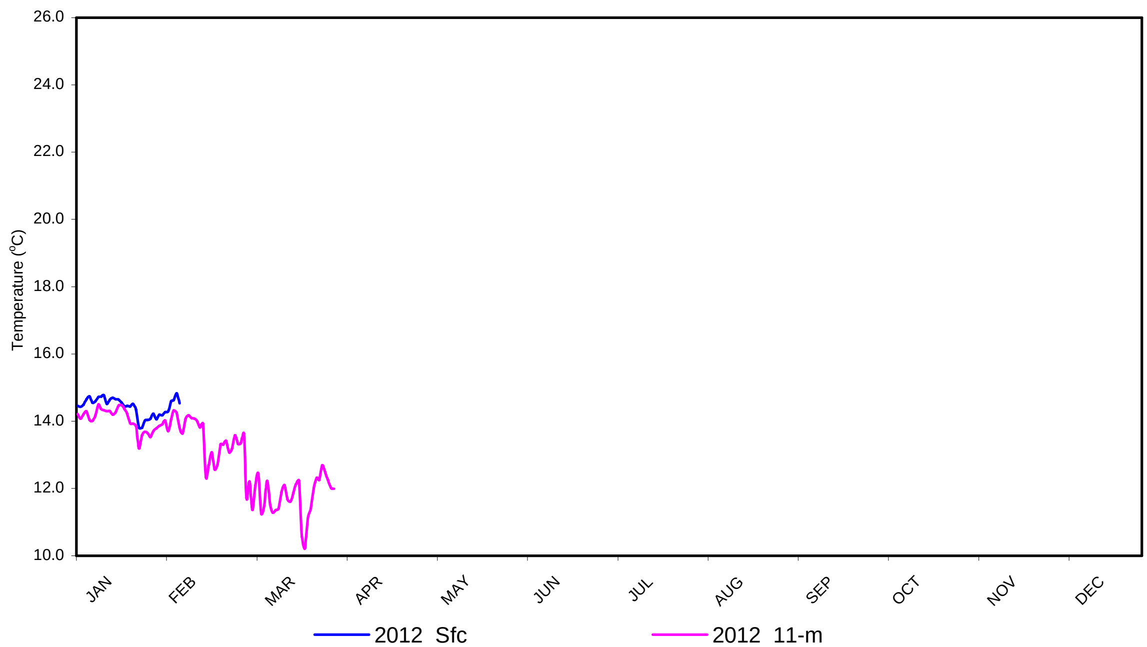
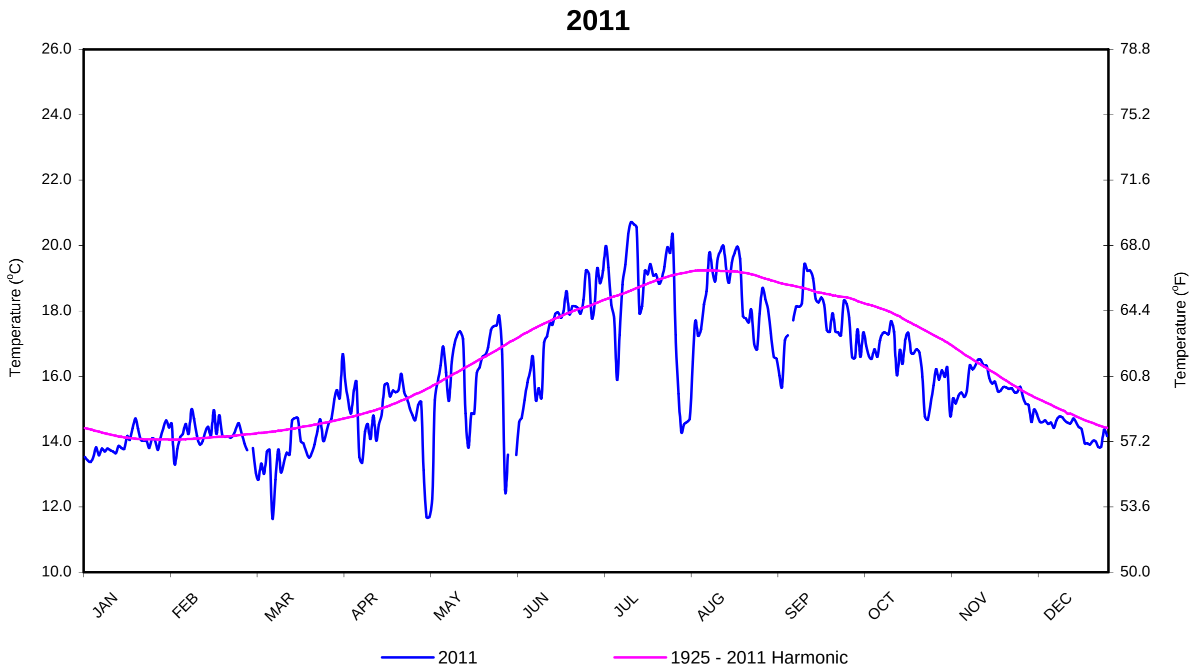


Figure 11. Daily sea surface temperatures (SST) at Station TM offshore Palos Verdes for 2011 and through March 2012.

August, it was again apparent that the kelp beds were responding to differing temperature regimes in the various locales of the Central Region as the beds responded differently to what appeared to be similar temperature regimes. There was a disconnect between temperature and kelp canopy sizes in the northern portion of the range with beds from Deer Creek through Topanga displaying much reduced canopies



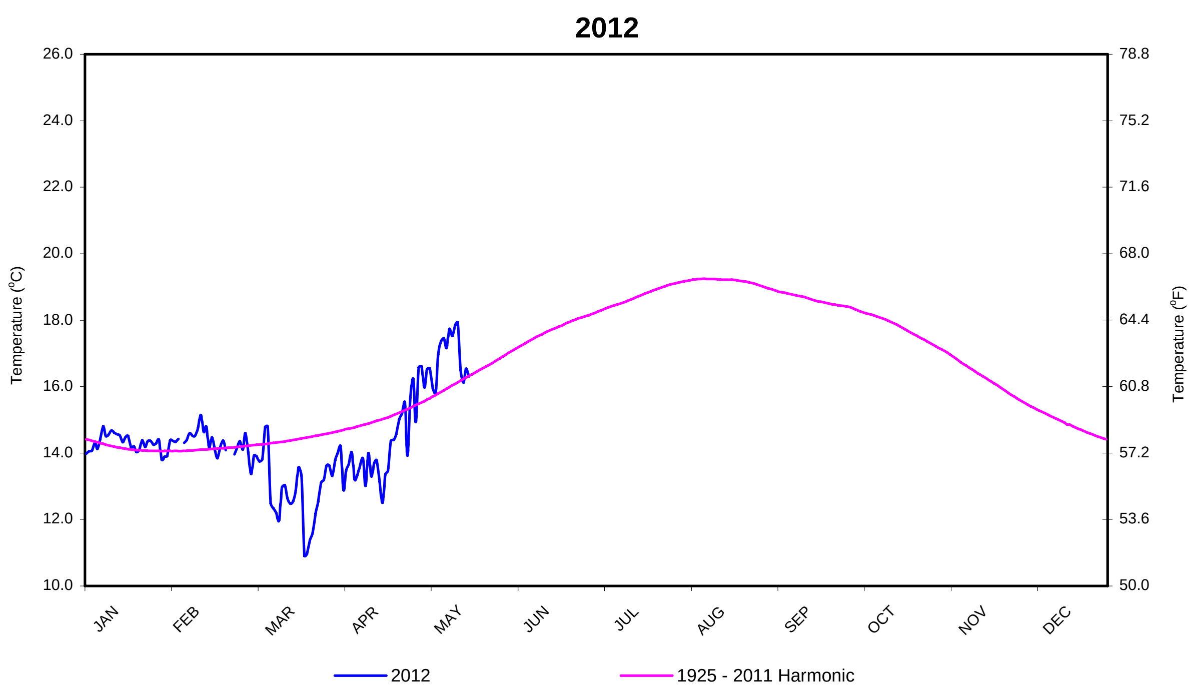


Figure 12. Daily sea surface temperatures (SST) at Newport Pier for 2011 and through March 2012.

indicating either poor nutrient conditions or other adverse events adversely affecting the kelp beds. Again, warmer temperatures in the summer months should have resulted in diminishing kelp canopies, but instead most beds in the region increased by August and were even better by October. With the advent of cooler ocean temperatures in the last few months of 2011, most beds increased to their maximum for the year by the December survey. In the southern portion of the range, kelp responded similarly but decreases were muted, and increases were more robust resulting in several of the southern beds having strong increases over the previous year (Table 2). The December survey indicated that overall decreases observed in 2011 were mixed across the Central Region, with the average bed loss in the northern portion to Topanga averaging about 35%, while Palos Verdes I and II decreased by only 10% and III and IV increased by an equal percentage. The beds from Los Angeles Harbor to Laguna Beach nearly doubled in size since last year with the Laguna Beach beds more robust than they have been since 1955 (Tables 1 and 2).

The 2011-2012 season nutrient quotient at Point Dume was 29, Santa Monica Pier was 34, and it was 34 at Newport Pier (above average) indicating that nutrients were average to above average disparate locations across the Central Region. At times a rather large disparity is seen between nutrient quotients across the region, which is in part due to variability in local oceanographic regimes between the beds near Point Dume at the northern end of the range, Santa Monica Bay in the middle, and those to the south between Santa Monica Bay and Newport Beach. This variability is driven by prevailing flow characteristics and bathymetric features which probably result in periodic upwelling along the rocky shores of the coastline, particularly from Deer Creek to Point Dume and along the Palos Verdes Peninsula. To illustrate this, two new SST sampling stations, situated at opposite ends of the Palos Verdes Peninsula, had nutrient quotients of 31 (TN) and 63 (TM) for the 2010-2011 nutrient year and only 11 (TN) and 15 (TM) through February 2012 (for the nutrient year beginning in July 2011 and continuing through June 2012), indicating that nutrients may have been lacking in the Palos Verdes beds during this period (Figures 10 and 11, Table 4). By the April 2012 aerial survey, most of the beds in the northern and southern portions had maintained most of their canopy from that observed in December 2011 when Central Region kelp beds were greatest in extent for the year. By August 2011 only slight decreases or increases were noted in the northern section survey, while three of the Palos Verdes beds (I, II, and III) reached their greatest extent for 2011 during the August survey. The November survey generally depicted beds that were similar or slightly larger than observed during the March survey. By the end of the year (December 31), most beds reached their greatest extent for the year, with the Palos Verdes beds still large but having decreased since the August survey. Overall, major nutrient pulses for the five temperature stations were recorded across the region synoptically as can be seen in Figure 7, only the degree of nutrient availability was different.

WAVE HEIGHTS

Typical swell sizes and directions were observed through most of 2011, with swells generally approaching the region from the south and west (Figure 13). High-energy waves that negatively impact the southern California coastline usually are low frequency, high amplitude waves approaching from the west. Swell conditions were relatively benign during the typical stormy period from early January through May 2011, with a few storms in January and March with peak waves slightly over 3 m in height; the remainder of the year seas were relatively mild. In mid Central Region, seas were greater than 3 m on only two occasions, one in February (3.0 m) and March (3.4 m), as evidenced by buoy wave heights recorded at the Scripps Coastal Data Information Program (CDIP) Buoy 028 in Santa Monica Bay (Figure 14; CDIP 2012). Offshore of San Pedro (CDIP Buoy 092) high waves were similarly recorded in late-February slightly over 3 m and just under 3 m about one week later; another larger swell (3.1 m in height) reached the Palos Verdes area in late-May (Figure 15) as recorded at Santa Monica Bay. These events were

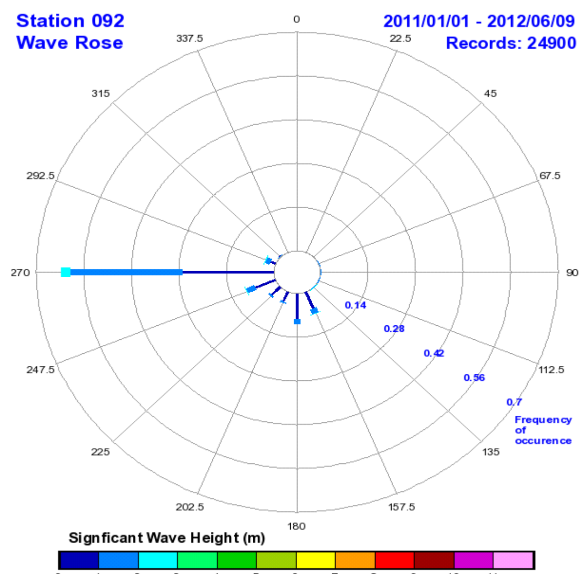


Figure 13. Wave Rose significant wave direction San Pedro, CA from 2011 through June 2012.

followed by a relatively calm period until February and March of 2012 when large waves again impacted the coastline (Figures 14 and 15). Therefore, wave and swell intensity probably contributed only slightly to any stresses upon the giant kelp resources in 2011, while any effects would have been mitigated by what appears to have been ample nutrients during the peak wave periods and for most of the summer.

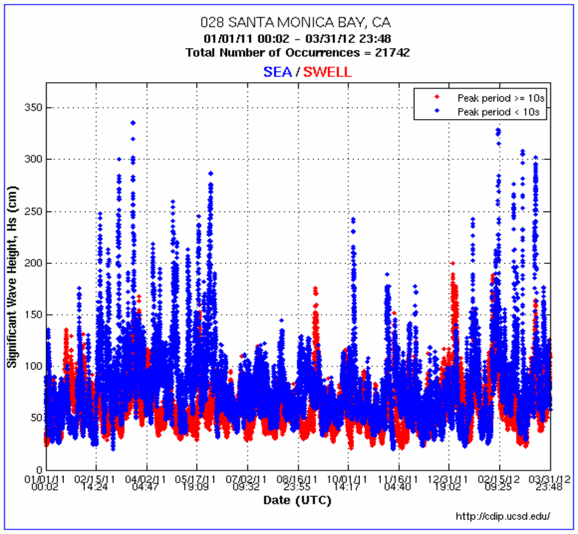


Figure 14. Significant wave heights offshore San Pedro, CA. 1 January 2011 through 31 March 2012.

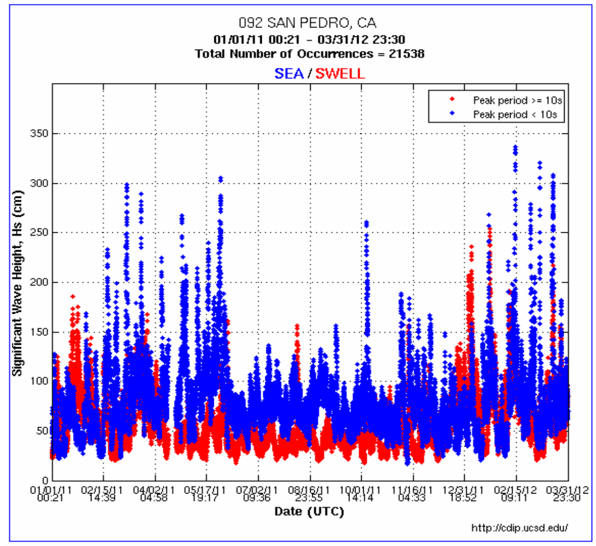


Figure 15. Significant wave heights offshore Santa Monica, CA. 1 January 2011 through 31 March 2012.

RAINFALL AND WATER CLARITY

Water clarity was relatively good in 2011. Typically, periods of sustained high turbidity result from rainfall; during the 2011/2012 rain year, rainfall was near the long-term average at LAX of 14.46 inches with less than 13 inches of rainfall at Los Angeles Airport, and slightly over 12 inches at Long Beach (Figure 16, NOAA National Climate Data Center [www.ncdc.noaa.gov]). There were periods when the rivers and streams ran strongly and nearshore waters were turbid and there were periods of algal blooms; however, they did not persist for sustained periods in the region during 2011 (SCCOOS web site 2012). Monitoring efforts show that these dense blooms are caused primarily by phytoplankton, such as the dinoflagellate *Lingulodinium polyedrum* (SCCOOS 2012). Cell counts indicated a population increase from an average of 7,000 cells/liter to 200,000 cells/liter in the patches, and a ten-fold increase in the chlorophyll content from the average value of 2 $mg/m^{3.}$ This species has been associated with previous red tides in southern California, and blooms of that magnitude (chlorophyll greater than 20 mg/m^3) have occurred in five years out of the last twenty-five years. Another potential problem is the diatom *Pseudo-nitzschia* spp. which has been implicated in domoic acid poisoning.

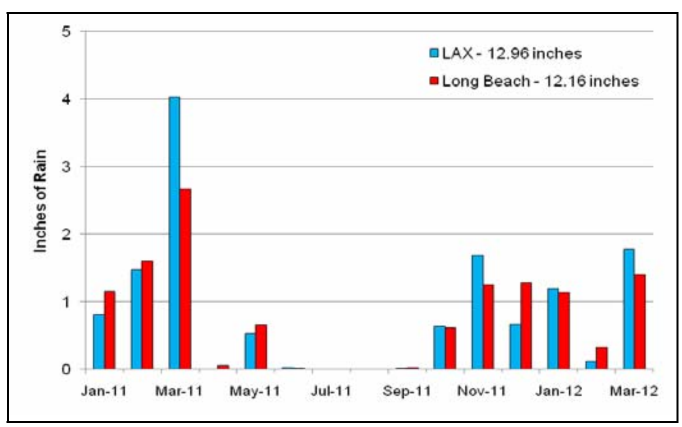


Figure 16. Rainfall for the LAX and Long Beach areas January 2011 through March 2012. Long-term averages for Los Angeles and Long Beach are 14.46 inches and 12.94 inches, respectively.

A harmless, green foam has also been observed on the beaches of southern California. Researchers at Scripps Institution of Oceanography identified this as

Tetraselmis, a microscopic green algae. This green flagellate is about 10 micrometers in size and has been found in concentrations as dense as 15 X 10^6 cells per liter of seawater (SCCOOS 2012). Concentrations at over 0.35 X 10^6 cells per liter (Shipe 2006, pers. comm.) can effectively exclude light from all but the shallowest depths, which prohibits photosynthetic activity at depth and was probably responsible for a portion of the severe impacts on the kelp bed resources observed in 2006 (Gallegos and Jordan 2002, Gallegos and Bergstrom 2005). Although the concentrations of these phytoplankton could have greatly reduced light availability on the bottom in 2011 and thereby decreased photosynthetic opportunities, their duration offshore in 2011 was not sufficient to have adversely affected the health of the Central Region kelp beds.

2011 QUARTERLY OVERFLIGHT SUMMARY

Aerial surveys were flown on 16 April, 1 August, 28 October, and 21 December 2011. One survey was completed for the 2012 survey year on 6 April 2012 (Appendix C).

Flight conditions were generally good during all the surveys. Reasonable attempts were made to conduct one aerial overflight within each of the four quarters in the year. The March survey was conducted about two weeks late due to overcast conditions along the Southern California coast caused by the almost 3-year long La Niña over much of the spring and summer (Table 5). As the June survey was conducted about one and half months later than ideal, in consultation with the Consortium the remaining two surveys were earmarked to split the remaining time; therefore, there was no September survey scheduled. Instead it was scheduled for late-October with the last survey for the year being conducted as scheduled on 21 December 2011. Due to the effects of the La Niña, and based on the results of the surveys (with the exception of the April survey), maximum canopy coverage was not appreciably different between the last three surveys of the year; however, the flight of 21 December appeared to depict canopies as slightly larger than those of the August or October surveys. Most kelp beds decreased between the December 2010 survey and the April 2011 survey, but then increased through the remainder of the year and maintained canopies during summer with the cooler water temperatures due to the La Niña (Table 2).

Table 5. Synopsis* of status of planned aerial flights 2011.

Target Date	Mid-March	Status	Results
Planned Flight	16-Mar-11	Cancel	Overcast Entire Range
	19-Mar-11	Cancel	Overcast Entire Rnge
	29-Mar-11	Cancel	Partly Cloudy Entire Range
	14-Apr-11	Cancel	Overcast Partial Range
	15-Apr-11	Cancel	Overcast Entire range
	16-Apr-11	Flown	Generally Good Visibility Entire Range
Target Date	**Mid-June**	**Status**	**Results**
	15-Jun-11	Cancel	Overcast Entire range
	29-Jun-11	Cancel	Partly Cloudy Entire Range
	3-Jul-11	Cancel	Overcast Entire range
	14-Jul-11	Cancel	Overcast Partial range
	16-Jul-11	Cancel	Overcast Entire range
	1-Aug-11	Flown	Generally Good Visibility Entire Range
Target Date	**Mid-September**	**Status**	**Results**
New	**Mid-October**	split remaining month	
	23-Oct-11	Cancel	Partly Cloudy Entire Range
	25-Oct-11	Cancel	Partly Cloudy Entire Range
	28-Oct-11	Flown	Generally Good Visibility Entire Range
Target Date	**Mid-December**	**Status**	**Results**
	19-Dec-11	Cancel	Partly Cloudy Entire Range
	21-Dec-11	Flown	Generally Good Visibility Entire Range

* See Appendix C for Entire Flight Status Report

2011 KELP CANOPY SUMMARY

The following changes were documented in the 27 CRKSC kelp beds in 2011:

- 9 kelp beds increased in size
- 15 kelp beds decreased in size
- 1 kelp bed remained about the same size
- 3 kelp beds were not present in 2011 of which two have been absent for decades

Results of the 2011 CRKSC survey estimate that the maximum measured kelp canopy decreased from 5.008 km^2 in 2010 to 4.795 km^2 in 2011 (Table 2). The number of kelp beds displaying canopy has remained markedly similar during the past nine survey years, whereas kelp canopy size has varied throughout the period (Figure 17). Since 2009, two additional kelp beds have been monitored in Orange County, resulting in a total of 27 historic or extant kelp beds being monitored for the Consortium. The total amount of kelp present was intermediate of the nine CRKSC survey. The National Oceanic and Atmospheric Administration (NOAA) indicates that the 2011 year started with the cooler temperatures that prevailed in late 2010 with SSTs cooler than average through the end of May 2011, followed by a period of warmer temperatures (but below average) through June and July, becoming cooler in August and September, warmer in October, and cooler again through the remainder of the year (NOAA Climate Diagnostic Center, www.cdc.noaa.gov).

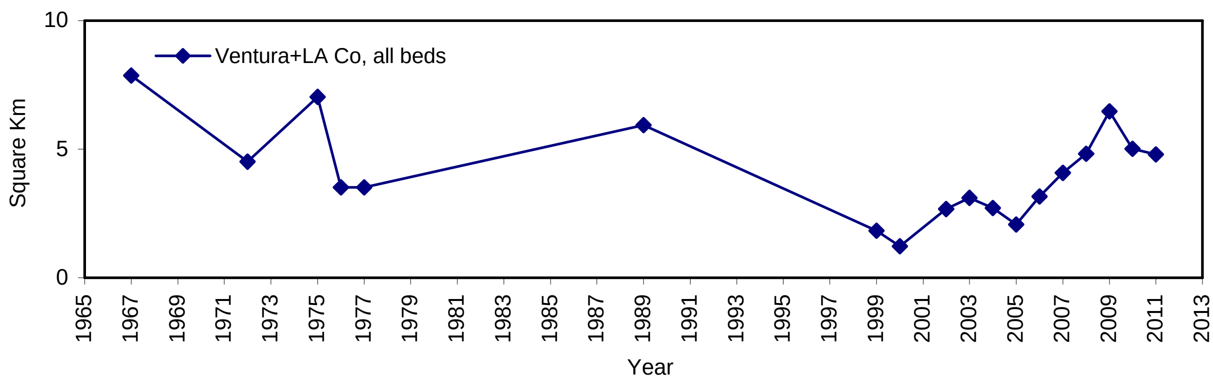


Figure 17. Combined canopy coverages at all kelp beds in Central Region from Ventura to Laguna Beach.

STATUS OF THE 27 KELP BEDS IN 2011

The following is a synopsis of the status of each individual bed during the 2011 survey year based upon the quarterly surveys. A note regarding errors found in previous reports: In the 2003 report, as in many other past reports (e.g., Neushul 1981), it was erroneously assumed that all measurements by Crandall (1912) were in square statute miles, when in fact he clearly labeled his report as square nautical miles, resulting in about a 30% increase in area from that reported in the table therein. Thus the kelp bed area recorded in 1911 was approximately 30% higher than what was reported in the CRKSC 2003 report. These areas were corrected and recalculated for the 2004 report from square nautical miles to square kilometers (MBC 2005). However, Crandall's depiction of the kelp beds he measured as solid uninterrupted expanses of kelp would bias his measurements in favor of larger kelp beds as his rowboat-based measurement on the perimeter of the kelp would not have been able to see the holes that we now know from aerial photographs are common in California kelp beds. Based on similarly based measurements of extant kelp beds from 2010, this error would have been at least 10% (possibly more) of the total bed size, indicating that his perimeter measurements of the kelp beds were accurate, but the actual kelp coverage of the area he reported was probably smaller than the actual beds (Hodder and Mel 1978, Neushal 1981). In addition, the measurements reported in the State Water Quality Control Board (1964) report on the effects of discharged waste on kelp were later erroneously also thought to have been in statute miles but were in fact in nautical miles. All of the historical data that came from that report have been recalculated to reflect an approximate 30% increase in area (Table 1).

Each kelp bed description below is a portion of what Fish and Game refers to as an administrative kelp bed lease area which can contain more than one giant kelp bed. The CRKSC program identifies these individual beds either using local names or geographical references for the name. By placing these beds under the Fish and Game numbered bed, a more direct comparison of the data in this report can be related to that obtained by Fish and Game. Some kelp stands exist outside of the Fish and Game Kelp

Beds, in which case a CRKSC designation has been assigned. Large declines and subsequent recoveries are common occurrences in the historical record (especially if we include all the quarterly surveys). Drastic reductions may simply be short-term fluctuations of little importance to the long-term welfare of the bed. If, however, the decline represents a persistent change or develops into a downward trend, more evaluation may be needed to clarify the cause and effect relations.

CRKSC NORTH (Ventura River Mouth to Point Mugu)

Ventura Harbor, Channel Islands Harbor to Point Mugu. A small amount of kelp was noted growing along the breakwaters of Ventura Harbor (0.0047 km^2), Channel Islands Harbor and at Port Hueneme (0.0056 km^2) in 2011. No kelp was noted offshore of either Mandalay or Ormond Beach Generating Stations. No kelp was noted downcoast of Port Hueneme until Deer Creek. The same pattern of no kelp growth, except along the breakwaters of Ventura Harbor, Channel Islands Harbor, and Port Hueneme, was also observed during the first survey of 2012.

FISH AND GAME KELP BED 17 (Point Mugu to Point Dume)

Fish and Game Kelp Bed 17 covers five distinct CRKSC kelp beds (Appendix A) that vary in coverage from the Deer Creek kelp bed to Lechuza kelp bed. Kelp bed surveys have been conducted in this area only about 10 times during the past century, and therefore large gaps exist in the historical record. This area totaled 4.151 km^2 in 1911, and was markedly similar to the survey in 1967 (4.144 km^2). Kelp coverage in this area began to decline after 1967 continuing through 1972, 1975, 1989, and 1999. At some point after the July survey of 1999, coinciding with the La Niña of 1999-2000, kelp began to increase again. In the 2003 survey, canopies covered 1.063 km^2, and increased slightly to 1.286 km^2 in 2004, 31% of the 1911 total. However, in 2005 this area declined to 0.600 km^2 and in 2006 a further reduction to 0.298 km^2 was recorded, a 76% reduction from the 2004 coverage. By December 2007 kelp bed canopy coverage again increased by more than 300% to 1.025 km^2 in this region. The December 2008 survey depicted healthy kelp beds, but with mixed results as several were reduced in size and others expanding resulting in a total regional coverage of only 0.797 km^2. Total coverage increased by the March 2009 overflight and most beds became larger still (1.136 km^2) by the June overflight (the best coverage since 2004) with beds decreasing in both the September and December overflights, but beginning a slight recovery by the March 2010 overflight. This recovery continued through December 2010 with a slight downward trend eventually producing good canopies, although smaller (0.844 km^2) than observed in mid-2009. Kelp bed canopy coverage was generally larger-than-average, but despite a continuing La Niña, they were lower in coverage than they had been during the proceeding few years with canopies in the region totaling 0.642 km^2 at their peak during 2011.

Deer Creek 2011. The Deer Creek kelp bed was not noted by Crandall (1912), suggesting it was missing or relatively small during that period. All subsequent surveys of Fish and Game Kelp Bed 17 encompassed the Deer Creek kelp bed, thus making it difficult to establish a long-term trend in canopy size for this specific bed. The bed was fairly large in 1989 (Ecoscan 1990), exceeding the 0.089 km^2 noted in the first CRKSC survey in 2003 (Table 2). The greatest areal coverage occurred in 2004 when it was measured at 0.107 km^2; it subsequently decreased the following year (2005) by one-half to 0.053 km^2, and again by one-half in 2006 to 0.026 km^2. The bed responded favorably to the 2007 nutrient regime and began increasing in canopy coverage, measuring 0.046 km^2 by the end of 2007. In 2008, the bed increased to 0.074 km^2, and in 2009 it increased again to 0.105 km^2, exhibiting the largest canopy seen at this location since 2004 (Table 2). In 2010, the bed decreased by about 40% to 0.062 km^2, but it was even smaller at the onset of 2010, so the bed actually made a good recovery by the December 2010 survey, but in spite of an ongoing La Niña in 2011, the bed declined to 0.055 km^2 . The Deer Creek kelp bed was compared to the average bed area per year (ABAPY) size of the northern and central portions of the Central Region kelp beds to determine whether it was responding synoptically with the beds from the same area. Kelp beds in the Palos Verdes portion of the Central Region were treated separately as they are typically larger beds and appear to react atypically from the other beds of the Central Region. The

Deer Creek kelp varied closely with the other beds in its region during the past nine years, and the ABAPY suggested it's response was in keeping with the other beds in the region (Figure 18).

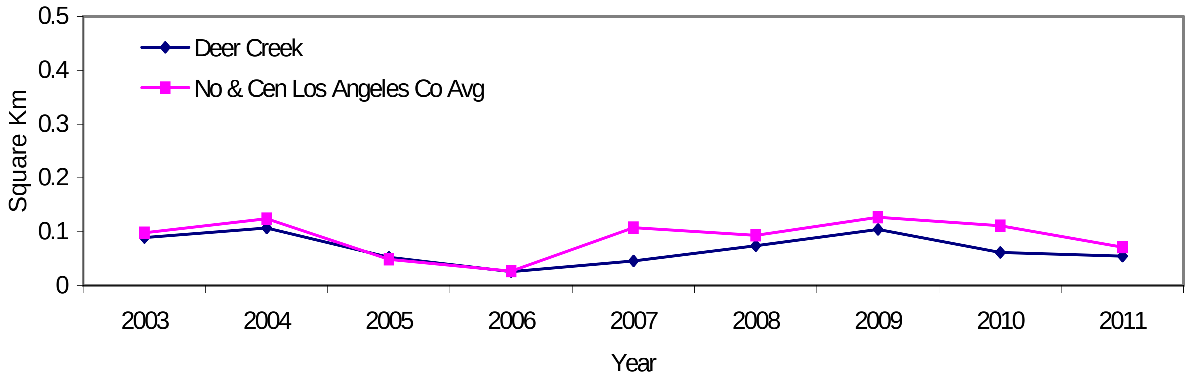


Figure 18. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Deer Creek for the years shown.

Leo Carillo 2011. Leo Carillo kelp is incorporated in Fish and Game Kelp Bed 17, and was included in the measurements of Crandall (1912). It was a very large bed in 1911 covering 2.5 km^2. By a 1967 survey, which pooled the area of the five beds in the region designated as Fish and Game Kelp Bed 17, it probably was still very large as the total area for the five beds was markedly similar to what Crandall measured in 1911. By 1972 a trend of decreasing bed sizes occurred as the total canopy coverage for the Fish and Game region decreased from over 4 km^2 in 1967 to 2.5 km^2 in 1972 and down to 1.5 km^2 by 1977. By 1989, the beds were much smaller as noted in overflight photographs taken by Ecoscan (1990). As the Ecoscan survey occurred during a period of exceptional nutrient availability (a very strong La Niña event), it appears likely that the very strong storms of 1983-84, and or the 1988 "Great Storm" may have contributed to the much smaller size that appeared during that survey. As they have not significantly recovered during the past 20 years, it also appears likely that either substrate was buried, or like many of the Santa Barbara kelp beds, the beds may have been growing on a sandy bottom. These beds all lie in the shadow of the Channel Islands, and the 1988 storm came from a direction that wiped out the Santa Barbara to Point Conception kelp beds, most of which were growing on sandy bottoms. It appears likely these beds to the north of Point Dume may have suffered a similar fate. In 1989 this bed was slightly larger than in the 2003 CRKSC survey when accurate areal measurements of this bed were first made and was similar in size to that seen in 2004 (0.399 km^2). The greatest areal extent of 2005 was 0.171 km^2, but it decreased the subsequent two years to about 0.150 km^2 by 2006 and to about 0.145 km^2 in 2007. In 2008, it responded favorably to increased nutrients in the area and began a recovery resulting in a kelp canopy coverage of 0.207 km^2 by the December 2008 aerial survey. Leo Carillo kelp bed was considerably larger in March 2009, but decreased thereafter before beginning a recovery to 0.232 km^2 by December 2010. There was a decrease by the April 2011 survey, but again the bed increased and stayed larger than average through the remainder of the year peaking in December at 0.226 km^2 (very similar to the past two years' totals). With the exception of the 2007 and 2008 years, Leo Carillo kelp has reacted synoptically with the kelp beds in the region; however, in 2011, it was less adversely affected then that of the ABAPY (Figure 19).

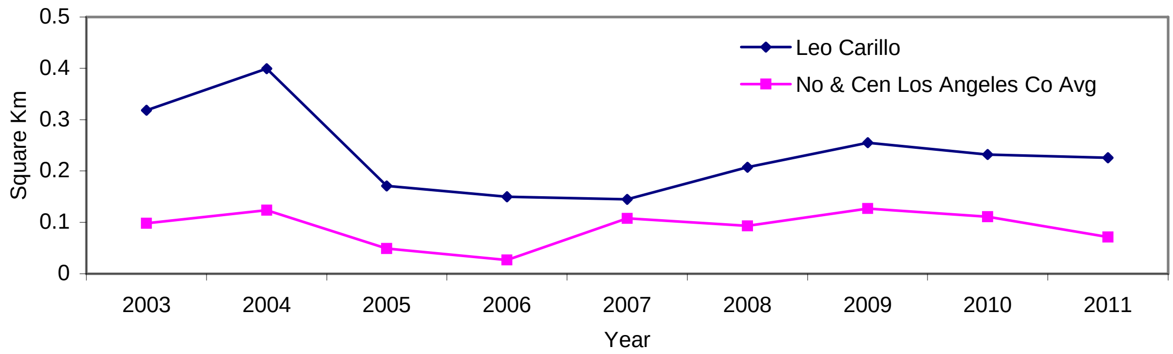


Figure 19. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Leo Carillo for the years shown.

Nicolas Canyon 2011. Crandall's (1912) measurements of the Nicolas Canyon kelp bed indicated it was a very large bed in 1911 at 1.26 km^2. By a 1967 survey which pooled the area of the five beds in the region Fish and Game designated as Fish and Game Kelp Bed 17, it probably was still very large as the total area for the five beds was markedly similar to what Crandall measured in 1911. Through surveys in the 1970s, the bed probably decreased greatly as noted by the decreasing total kelp canopy coverage of Fish and Game Kelp Bed 17 (Table 1). Aerial photographs of the bed by Ecoscan (1990) indicate that by 1989 this bed was much smaller than recorded previously (probably as a result of the agents discussed previously), and was of a similar size to that noted in 2003 (0.308 km^2) or 2004 (0.362 km^2). The bed attained a size of 0.195 km^2 in 2005, but was much smaller by December 2006 due to unfavorable conditions during the past two years only reaching a size of 0.038 km^2, an almost 90% reduction from 2004 (Table 2). The Nicolas Canyon kelp bed appears to have a natural break in the center of the bed, and the western-most half of the bed has continued to decrease in size while the eastern-most portion appears to have increased in size. In any case, the bed's response to the availability of nutrients resulted in more than a 10-fold increase in size in 2007; at 0.473 km^2, it was larger than in any of the CRKSC surveys since 2003.The bed responded atypically to the nutrient regime of 2008, decreasing to 0.268 km^2 while the beds just to the north increased during the same period. However, by June 2009, the bed had regained some of its former size and totaled 0.433 km^2. Less than ideal conditions during the remainder of the year resulted in the Nicolas Canyon kelp bed waning. Improved nutrient conditions in 2010 allowed it to regain a considerable coverage by December 2010 of 0.291 km^2. In spite of what should have been good nutrient conditions by December 2011, the Nicolas Canyon kelp bed decreased to less than half that recorded the previous year. The bed reacted more unfavorably than the ABAPY would indicate; Nicolas Canyon kelp bed is larger than the average bed in the region and appears to respond quicker to large stimuli such as when nutrients became more abundant in 2007 (Figure 20).

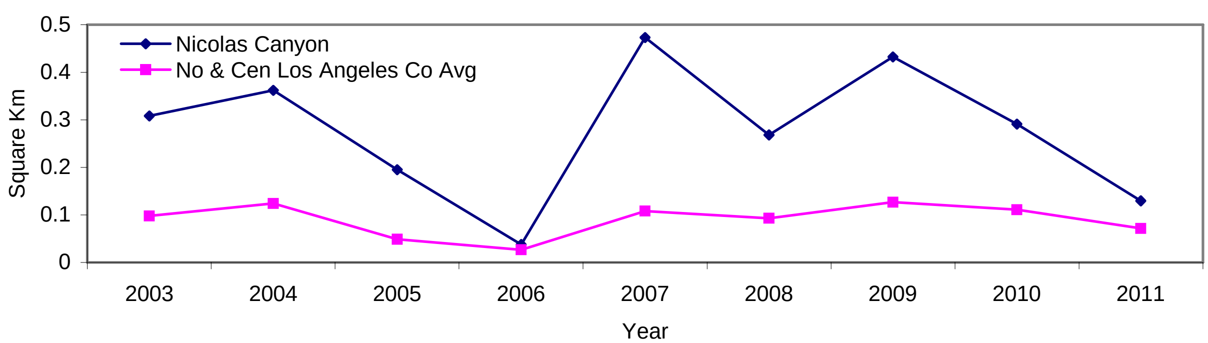


Figure 20. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Nicolas Canyon for the years shown.

El Pescador/La Piedra 2011. Maps by Crandall (1912) indicated that the El Pescador/La Piedra kelp bed was 0.252 km^2 in 1911. Aerial photographs of the bed by Ecoscan (1990) indicate that in 1989 this bed was slightly larger in size than that observed by Crandall, and based on the total for the five beds probably similar to that noted in 2003 (0.243 km^2) (MBC 2004). By 2004, the bed increased in canopy coverage to 0.314 km^2 (its maximum size in the CRKSC surveys), but by 2005 it was reduced to 0.141 km^2, a 55% reduction from that seen in 2004. The El Pescador/La Piedra kelp bed decreased by about one-half from that areal coverage and covered only 0.063 km^2 by the December 2006 survey. It then made a good recovery by 2007, quadrupling in size to 0.255 km^2. Again responding in lockstep with the Nicolas Canyon kelp bed, it also decreased during the 2008 period to 0.173 km^2 (December), but again was larger by June 2009 at 0.238 km^2. By December 2009, the bed had began to decrease, and despite resurgence during favorable portions of the year, it was reduced by December 2010 to 0.164 km^2 and 0.136 km^2 by December 2011. When comparing the El Pescador/La Piedra bed to the ABAPY, it was evident that it was larger than the average bed size but its response has mirrored that of the regional beds (Figure 21).

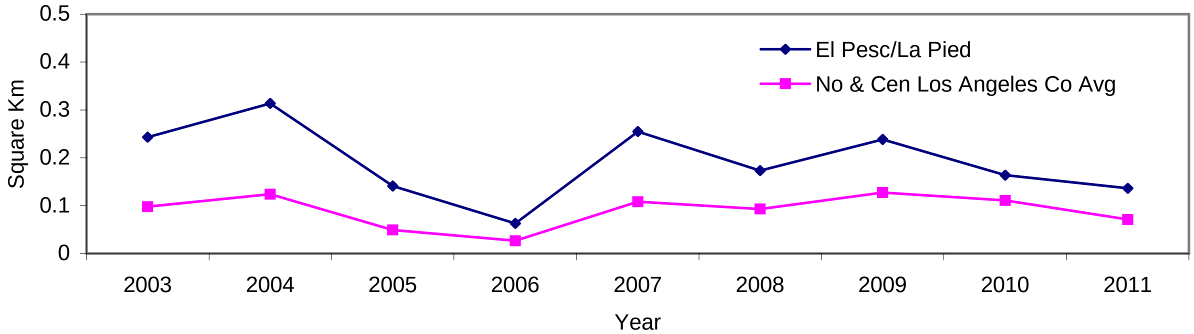


Figure 21. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off El Pesc/La Pied for the years shown.

Lechuza 2011. Lechuza kelp bed is the most downcoast bed included in Fish and Game Kelp Bed 17. Crandall (1912) identified this bed and measured its surface canopy at 0.126 km^2. In 1983, a survey in the vicinity of Lechuza kelp bed by Patton and Harman (1983) found reef structure rising 2 to 3 m above the surrounding sandy bottom, but no kelp growth was found (midst of a very strong El Niño). Visual inspection of Ecoscan (1990) images of the kelp bed suggest that in 1989 Lechuza kelp bed was present, but noticeably smaller than what was calculated in 2003 (0.105 km^2) and 2004 (0.104 km^2) (MBC 2004, 2005). In 2005, the largest canopy coverage observed was 0.041 km^2. During the fourth survey on 7 January 2006, the Lechuza kelp bed surface canopy had completely disappeared, likely as a result of the powerful breaking waves that hit the coastline between late-December 2005 and early-January 2006. By the last quarterly survey of 2006, a bed about 0.022 km^2 was present. Like the El Pescador/La Piedra beds, it too increased in size, totaling 0.106 km^2 during the 2007 survey year. This would appear to indicate that oceanographic conditions were advantageous to the kelp at Lechuza in 2007, but again in lockstep with its two companion beds to the north, this bed decreased to 0.075 km^2 by the December 2008 survey. Like its neighboring beds, it increased by the June 2009 survey to 0.0105 km^2. In 2010, the Lechuza kelp bed lost canopy early in the year but made a good recovery by December 2010, increasing to 0.096 km^2, a significant fraction of that observed in June of 2009. The 2011 year recorded the bed as moderately large and increasing slightly again by December 2011 to the same size as noted in 2010 of 0.096 km^2. The Lechuza kelp bed was almost exactly the size of the average bed in the region and its responses have been nearly identical to those of the average bed in the region (Figure 22).

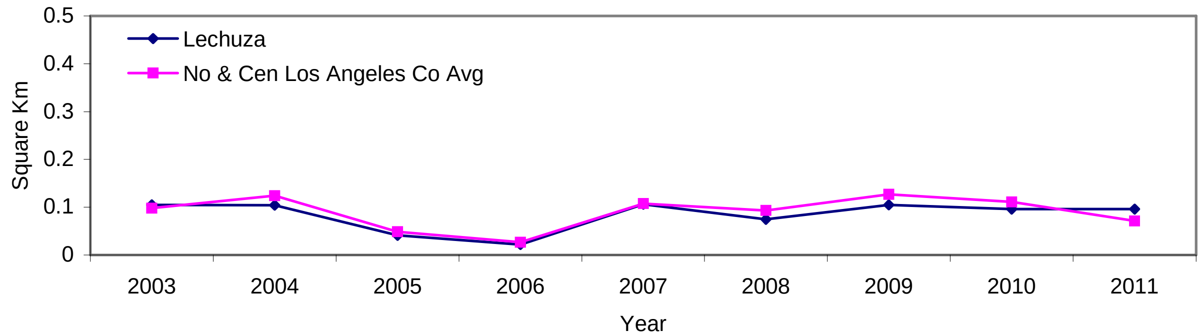


Figure 22. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Lechuza for the years shown.

FISH AND GAME KELP BED 16 (Point Dume to Malibu Point)

Kelp canopy coverage in Fish and Game Kelp Bed 16 has varied considerably over time. CRKSC recognizes six individual beds in this region (Appendix A). From the historic data, the 1911 measurements of 3.4 km^2 decreased by about one third by 1955 (2.14 km^2), and then increased by 1967 to about 2.54 km^2, about 74% of the 1911 measurements (Crandall 1912). These beds were in a severe decline by the Ecoscan Survey of 1989 (0.220 km^2) and a decade later the affects of the severe 1997-1998 El Niño culminated in a coverage of only 0.03 km^2 for the six beds, by 1999. The beds had recovered by the first CRKSC survey of 2003 (although kelp canopy coverage was still much lower than recorded in the 1960s and 1970s), and the canopy area totaled 0.598 km^2. The beds continued to increase in 2004 and totaled 0.762 km^2 during their largest extent that year, presumably responding to relatively favorable environmental conditions in the early portion of that year (MBC 2005). With the exception of the Point Dume kelp bed, all of the other kelp beds in this area decreased in 2005 compared to 2004. However, in a continuing response to poor nutrient conditions, kelp canopy coverage decreased strikingly in 2006 to only 0.158 km^2. The beds again recovered strongly in 2007 to 0.801 km^2, and remained large in 2008, though with a slightly smaller coverage at 0.769 km^2, before increasing again by June 2009 to 0.991 km^2. The 2010 survey followed a mild El Niño in mid-to-late 2009 which reduced the kelp beds; however, they began to recover throughout 2010 reaching a sizeable fraction (96%) of their 2009 status and covered 0.954 km^2 by December. Although conditions appeared favorable, never-the-less, the most of the beds decreased by about half in 2011 to 0.504 km^2.

Point Dume 2011. Point Dume demarks the western boundary of Fish and Game Kelp Bed 16. Point Dume kelp bed was historically a sizable kelp bed, totaling 0.686 km^2 in 1911 (Crandall 1912). Since then, Point Dume kelp bed has decreased considerably in size. It appears from photographs taken during calm water periods that much of the area's hard substrate may be inundated by sand, as there is very little visible reef structure in any of the photos, suggesting that unknown large movements of sediments occurred (or a large storm event swept through and eliminated kelp growing on sand) sometime between the regime shift of 1977 and 1989. From aerial surveys by Ecoscan (1990) this kelp bed in 1989 was much smaller than it was in 1911, although it was larger than the 0.012 km^2 noted in the first CRKSC survey of 2003 and the 0.029 km^2 noted in early 2004 (Table 2). Reversing a trend seen at other more northern kelp beds of the Central Region, the Point Dume kelp bed appeared larger in the December 2006 survey and was measured to be 0.053 km^2, subsequently increasing only slightly in 2007 (0.065 km^2) and again a small increase was observed in 2008 (0.070 km^2). This trend continued and by June 2009, it totaled 0.104 km^2, the largest bed at this location since CRKSC monitoring began. Kelp canopy coverage in 2010 stayed poor at Point Dume through the November overflight and then began increasing slightly by the December 2010 survey to just under 0.094 km^2; the 2011 surveys indicated severe reductions in April but the bed began to increase during the remainder of the year but totaled slightly less at 0.078 km^2 than the results of the December 2010 survey. The Point Dume kelp bed was typically lower than the ABAPY, although it outperformed the ABAPY in 2006 and stayed in exact agreement from 2008 through 2011 (Figure 23).

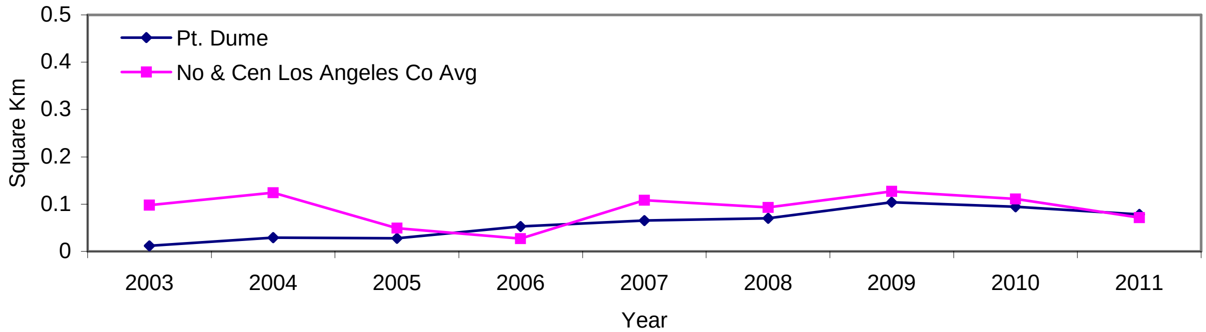


Figure 23. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Pt. Dume for the years shown.

Paradise Cove 2011. Paradise Cove kelp bed was a very large bed in 1911, covering 1.37 km^2 (Crandall 1912). The spur and groove topography in this area provides ample attachment for kelp growth. None-the-less, this bed declined considerably by a survey conducted in 1967, a slide that continued until the late 1970s (Table 1). While no areal measurements were made by MBC from the overflight surveys of Ecoscan (1990), the images from the survey suggest that in 1989 the coverage was less than during the first CRKSC survey in 2003. Coverage during 2003 was only 0.162 km^2, but it increased to 0.258 km^2 in 2004. Warm water and phytoplankton blooms combined in 2005 so that the greatest areal extent observed in 2005 occurred in the 22 June survey; it was calculated at 0.035 km^2 and it was only slightly larger at 0.036 km^2 in 2006, an 80% reduction from that recorded in 2004. Cooler waters with nutrients allowed the kelp bed area to increase to 0.100 km^2 in 2007, with further increases in coverage in 2008 to 0.223 km^2, and still further increases by June 2009 to 0.244 km^2. The cooling trend abated in later 2009 and affected the kelp bed adversely by the end of 2009. Paradise Cove kelp bed was still reduced in March 2010 but began a good recovery by the August survey which continued through November resulting in a fairly robust kelp bed covering 0.259 km^2 by the late December 2010 survey, the largest extent in the eight years of CRKSC monitoring. The Paradise Cove kelp bed was larger than average in 2003 and 2004, then decreased to the ABAPY from 2005 to 2007, and then became larger in 2008, and trended upward while the ABAPY trended downward in 2010 (Figure 24).

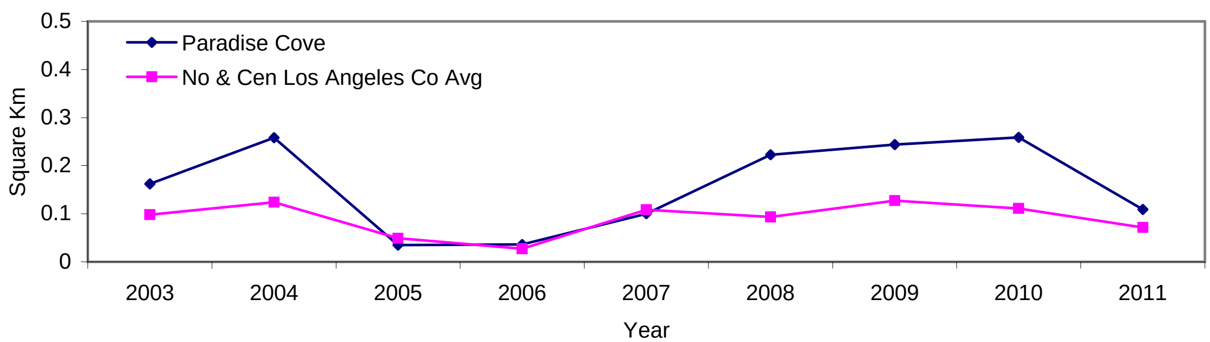


Figure 24. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Paradise Cove for the years shown.

Escondido Wash 2011. Escondido Wash kelp bed is usually one of the denser beds of Fish and Game Kelp Bed 16, totaling 0.583 km^2 in 1911 (Crandall 1912). Since then, Escondido Wash kelp bed has decreased in size, although not to the extent seen in many of the nearby kelp beds. From aerial surveys conducted in 1967, the total for the region was about 75% of what Crandall (1912) recorded for the region, indicating that the bed was probably substantially larger than seen in recent years. In a survey of the entire California coastline by Ecoscan (1990), this kelp bed in 1989 was very small, noticeably less than in the CRKSC monitoring in 2003 (0.214 km^2) and 2004 (0.250 km^2) (MBC 2004, 2005). The 2005 maximum areal coverage was 0.078 km^2, a 69% reduction in surface canopy area from that seen in 2004. The surveys of the Escondido Wash kelp bed in 2006 did not record a canopy until just an unmeasurable trace of kelp was noted in the December 2006 survey. With the advent of the La Niña in 2007, kelp rebounded strongly and areal coverage was 0.339 km^2 in late 2007, but decreased somewhat to 0.278 km^2 by the December 2008 survey, before increasing to 0.321 km^2 by March 2009. Thereafter, the kelp bed began declining through the remainder of the year, but made a good recovery by the first survey of 2010, then waned somewhat until the December 2010 survey when the bed had rebounded to cover 0.267 km^2. The Escondido Wash kelp bed did not respond favorably to local nutrient conditions in 2011 and was much reduced by December 2011 (0.104 km^2). This bed is typically larger than the ABAPY, which mirrored the losses noted in 2005 and 2006, and again responding positively to stimuli, rebounded in 2007 through 2009, was slightly lower in 2010 with a steeper decline in 2011 than recorded for the ABAPY (Figure 25).

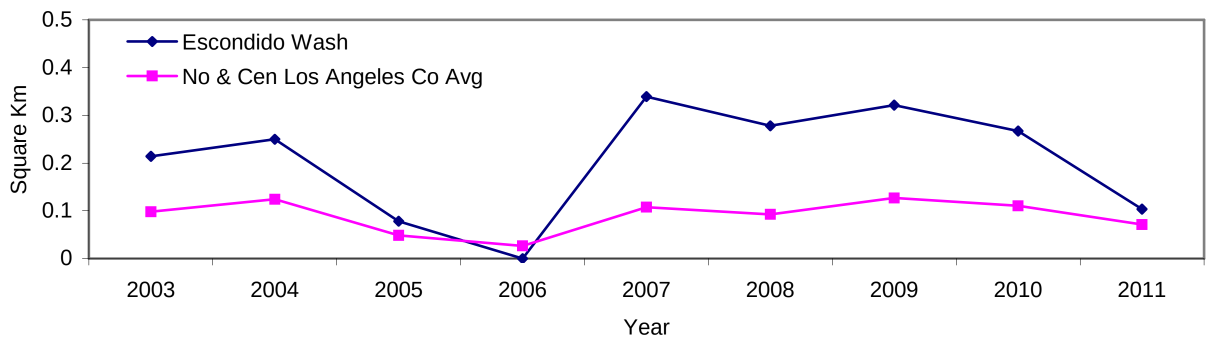


Figure 25. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Escondido Wash for the years shown.

Latigo Canyon 2011. Crandall's (1912) maps of 1911 were used to calculate that the Latigo Canyon kelp bed covered an area of 0.446 km^2 (Table 1). Aerial photographs of the bed by Ecoscan (1990) indicate that by 1989 this bed was much smaller than reported in Crandall (1912), and appeared to be considerably smaller than the size calculated in 2003 (0.125 km^2) or 2004 (0.161 km^2). In 2005, the bed only attained a size of 0.032 km^2, an 80% reduction from the previous year. The Latigo Canyon kelp bed continued to remain much smaller than it was in 2004, measuring only 0.007 km^2 on the December 2006 survey; however, by the end of 2007, the bed increased to 0.186 km^2. By December 2008, the bed had decreased to 0.124 km^2 but made a good recovery by March 2009 increasing to a coverage of 0.195 km^2, its largest size since the CRKSC monitoring began in 2003. The bed became smaller during the remainder of 2009, before recovering by the March 2010 survey. The August and November 2010 surveys recorded a bed that was somewhat reduced but still a substantial kelp bed becoming robust and covering 0.142 km^2 by the December 2010 survey. The continuing La Nina did not provide a local stimulus to the Latigo Canyon kelp bed and it too decreased to 0.070 km^2, about one half of the total in 2010. The Latigo Canyon kelp bed is very near the ABAPY for the region, but responded slightly better in 2007 to stimuli, while tracking relatively close to the ABAPY in 2008 and 2009, but with a steeper downward trend than the ABAPY in 2010, but right on track in 2011 (Figure 26).

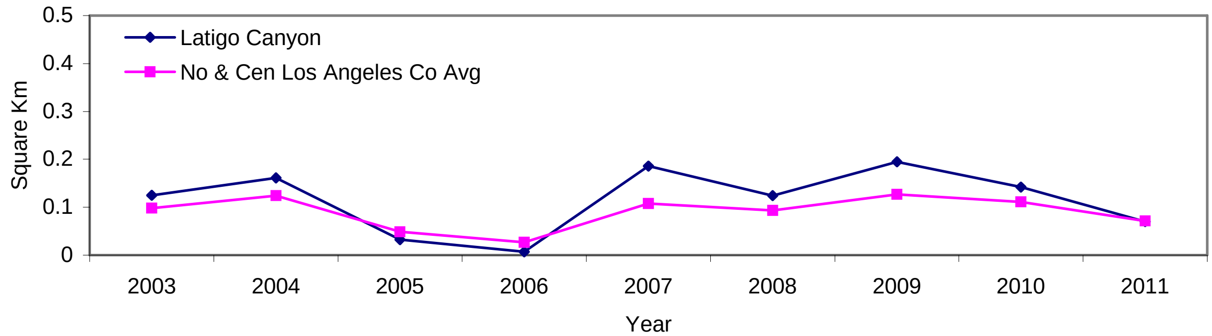


Figure 26. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Latigo Canyon for the years shown.

Puerco/Amarillo 2011. Surface canopy at Puerco/Amarillo kelp bed totaled 0.343 km^2 in 1911 (Crandall 1912). Since then, the Puerco/Amarillo kelp bed has decreased in size. From aerial surveys by Ecoscan (1990) in 1989 this kelp bed was considerably larger than in 2003 (0.074 km^2) and 2004 (0.051 km^2). The 2005 maximum areal coverage was 0.039 km^2; unlike its northern neighbors, it increased in 2006 to 0.055 km^2 and responded well to the advent of the La Niña in 2007 increasing to 0.095 km^2. The areal coverage of the Puerco/Amarillo kelp bed in the December 2008 survey was 0.064 km^2; the bed mirrored its neighbors by decreasing, suggesting nutrients were limiting in this region as compared to further north at Paradise Cove. By June 2009, the bed reached its largest size (0.115 km^2) since the CRKSC surveys began, but began to decrease shortly thereafter as it was noted as very poor in September with only slight increases by December 2009 (MBC 2010a, Table 3). In 2010, the kelp bed began to recover and by August was substantial, decreasing somewhat in November, but was again robust in December 2010, covering an area of 0.126 km^2, larger than any previous CRKSC survey. Nutrients, in spite of the long lasting La Niña, were apparently lacking in this region, as the bed decreased similarly to the Latigo Canyon bed directly north to 0.069 km^2. This bed has been typically slightly smaller than the ABAPY, although regional beds fared worse in 2006 than the Puerco/Amarillo bed, while the bed has trended synoptically with the ABAPY from 2007 through 2011 (Figure 27).

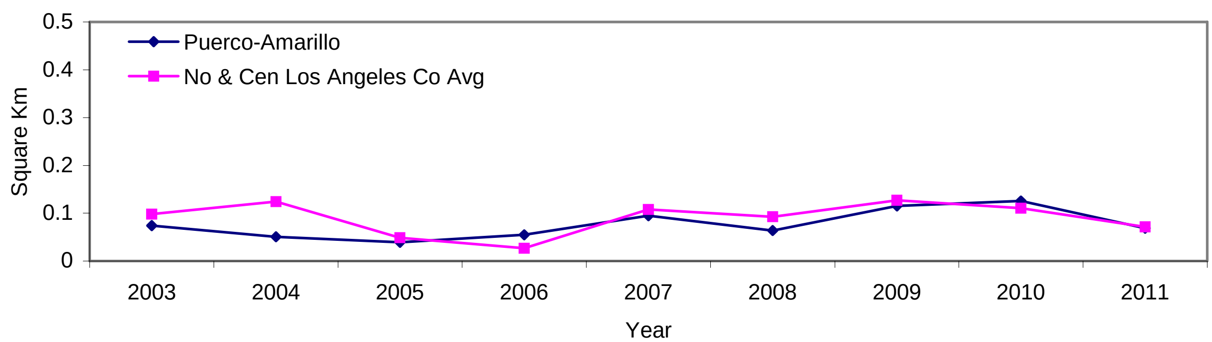


Figure 27. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Puerco/Amarillo for the years shown.

Malibu Point 2011. Malibu Point marks the eastern-most boundary of Fish and Game Kelp Bed 16. Crandall (1912) did not record kelp off Malibu Point either because it was very small or it was non-existent during his survey. A small amount of surface kelp was observed by Ecoscan (1990) similar to the size recorded from the 2003 CRKSC survey, when 0.011 km^2 was measured. The bed experienced a slight increase in 2004 to 0.013 km^2, although coverage decreased by 41% in 2005 when only 0.008 km^2 was observed. The Malibu Point kelp bed stayed exactly the same in 2006 at 0.008 km^2. Although the bed was still small (0.016 km^2) in 2007, it was the largest extent of kelp observed since CRKSC monitoring began in 2003. By the end of 2008, kelp had again decreased to 0.011 km^2 to the total area first observed in 2003; the bed stayed virtually the same in 2009 with a canopy coverage of 0.012 km^2. Ongoing kelp restoration projects apparently combined with favorable conditions by December 2010 resulting in the largest bed (0.066 km^2) at this location since the CRKSC began monitoring in 2003. Bucking the trend for all of the other beds of Fish and Game Bed 16, the Malibu Point kelp bed increased in 2011 to a slightly larger canopy of 0.074 km^2.The Malibu Point kelp bed was smaller than the ABAPY and did not appear to be greatly stimulated by any upwelling events that spiked the ABAPY upward in 2007 and 2008, and a substantial increase in kelp bed size in 2010 was not mirrored in the ABAPY, nor was the slight increase in 2011 (Figure 28).

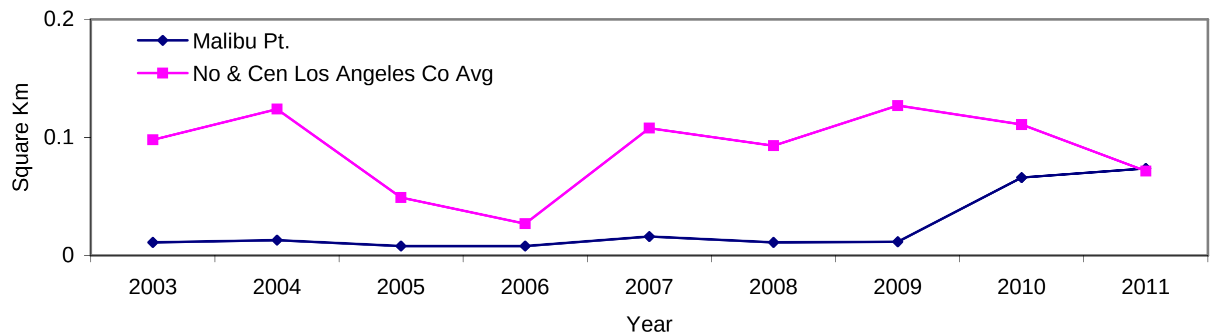


Figure 28. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Malibu Pt. for the years shown.

FISH AND GAME KELP BED 15 (Malibu Point to Santa Monica Pier)

The CRKSC recognizes six distinct kelp beds in Fish and Game Kelp Bed 15 from La Costa kelp to Sunset kelp (Appendix A). Most of these beds were fairly small in 1911, with the exception of Sunset kelp, which covered 0.960 km^2 and appeared to cover a similar area in the US Coast and Geodetic Survey Map of 1890 (Map 5100) suggesting the size of the bed Crandall noted was not an aberration. By 1955, the area encompassing Fish and Game Kelp Bed 15 was essentially only a remnant of that noted in the 1911 survey, with only 0.02 km^2 of kelp coverage reported. Presumably the construction of a breakwater offshore of the Santa Monica Pier in the 1930s, the surge in population along the coastline, and increased industrialization within the coastal communities resulted in greater turbidity from terrestrial run-off in that area, adversely impacting the local kelp beds. The beds in this area are much smaller than that reported by Crandall (1912). It is also possible that the bed at Sunset was similar to the kelp beds in Santa Barbara that grow on the sand and once extirpated, may not readily recolonize an area (unfortunately there is no evidence to support that theory). In 2004, the total area of Fish and Game Kelp Bed 15 was 0.059 km^2, less than 3% of that noted in 1911. However, in 2006 the total areal coverage in this region was further reduced to 0.001 km^2, which is much less than 1% of the 1911 value. The kelp beds in this region were very small in 2007, and three (La Costa, Topanga, and Sunset) were missing; however, their total size was larger (0.017 km^2) than recorded in 2006. Although the Topanga kelp bed reappeared as a very small bed in 2008, the total kelp coverage of the region decreased to 0.0009 km^2. Reversing this trend, all of the beds appeared in 2009 (the first time all beds were present since CRKSC monitoring began) and increased to a regional coverage of 0.035 km^2, increasing further in 2010 to 0.087 km^2. By the end of December 2011, the beds had decreased to a total of 0.069 km^2 and La Costa was missing.

La Costa 2011. La Costa kelp bed is the western-most bed in Fish and Game Kelp Bed 15. Crandall (1912) included this kelp bed in his measurements; however, it appeared to have been located further south than its present position. Historically, La Costa kelp bed was small with canopy coverage of only 0.021 km^2 (Crandall 1912). However, from all available reports, this kelp bed never came close to the same amount of coverage, at least not after 1955. From aerial surveys by Ecoscan (1990), no surface canopy was present for this kelp bed in 1989. In 2003, 0.001 km^2 of surface canopy was recorded and

0.002 km^2 was seen in 2004 (Table 2). No surface canopy was seen in any of the quarterly surveys of 2005, 2006, 2007, or 2008, but reappeared in December 2009 as a small bed totaling 0.001 km^2. The kelp bed was small but visible in March 2010, disappeared by August, was very small in November, and was back to a coverage of 0.001 km^2 in December 2010. The La Costa kelp bed was not visible in any of the four surveys of 2011, although a dark reef patch is visible in several survey photographs. Compared to the ABAPY, the kelp bed at La Costa has been very small or non-existent since 2003 (Figure 29).

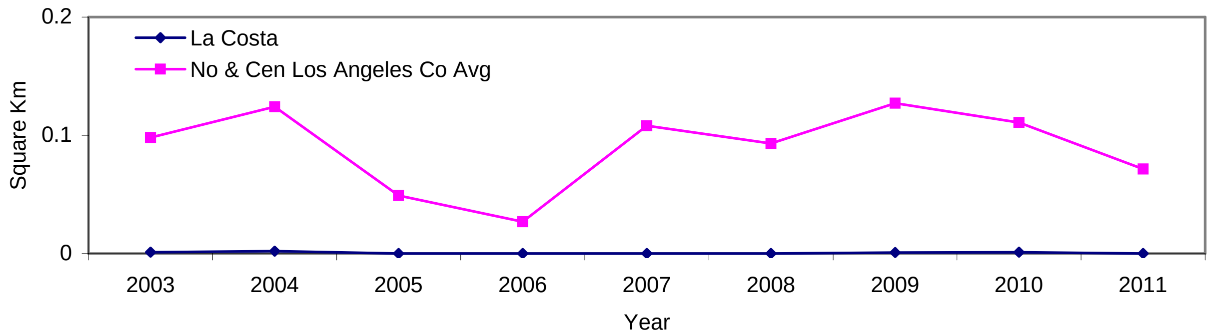


Figure 29. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off La Costa for the years shown.

Las Flores 2011. The surface canopy of Las Flores kelp bed was small in 1911 at 0.014 km^2 (Crandall 1912), and inspection of the aerial overflight survey by Ecoscan (1990) revealed that the kelp bed was much the same in 1989. Canopy measurement in 2003 was 0.0089 km^2, however in 2004 the density of the canopy increased, with 0.023 km^2 recorded, which is 61% larger than in 1911 (MBC 2004, 2005). This bed disappeared during the second and third quarterly surveys in 2004 and then reappeared during the fourth quarterly survey of 2004 (23 December) in fairly good condition. However, the largest areal extent of Las Flores kelp bed in 2005 was observed during the 15 March survey when it covered 0.004 km^2, an 83% reduction from that seen in 2004. Subsequently, the quarterly surveys of 2006 detected no canopy present except for a few possible individual giant kelp at the surface. The bed did not reappear until the October survey of 2007, when a small bed was present with a surface canopy area of 0.005 km^2; it subsequently became smaller by the end of 2008 measuring only 0.001 km^2, but increased again to 0.005 km^2 by June 2009. It became smaller during the remainder of 2009 and through August of 2010 before once again increasing to 0.005 km^2 by November and December 2010. The bed stayed small through the April, August, and October surveys, but began to increase sometime before the December survey and actually increased over the 2010 total to 0.008 km^2 Compared to the ABAPY, the kelp bed at Las Flores has been very small or non-existent since 2003 (Figure 30).

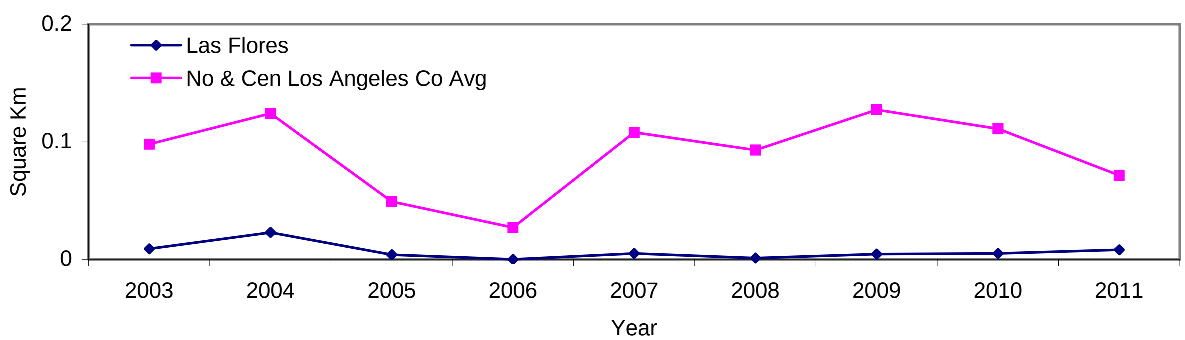


Figure 30. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Las Flores for the years shown.

Big Rock 2011. Big Rock kelp was measured by Crandall (1912) to be 0.017 km^2, which appeared to be similar to what was present in 1989 (Ecoscan 1990). Surface canopy values in 2003 were 0.005 km^2, and in 2004 the bed increased to 0.014 km^2 (Table 2). In 2005, the greatest surface area measured was 0.002 km^2; this bed continued to decrease in size throughout the year and was very small, but was the only bed with any canopy (0.001 km^2) in the region as recorded during the December 2006 survey when a small remnant of kelp canopy was present just east of the Big Rock Beach headland. This remnant increased to 0.004 km^2 by the December 2007 survey, decreased to 0.002 km^2 by the end of 2008, and again increased to 0.005 km^2 by the June 2009 survey. It waxed and waned through August 2010 but became slightly larger covering an area of 0.006 km^2 by November and December 2010. Although not visible during the first two surveys of 2011, it reappeared in October and was slightly larger (0.007 km^2) in December than recorded in 2010. Big Rock kelp has also been consistently very small and well below the ABAPY for the region (Figure 31).

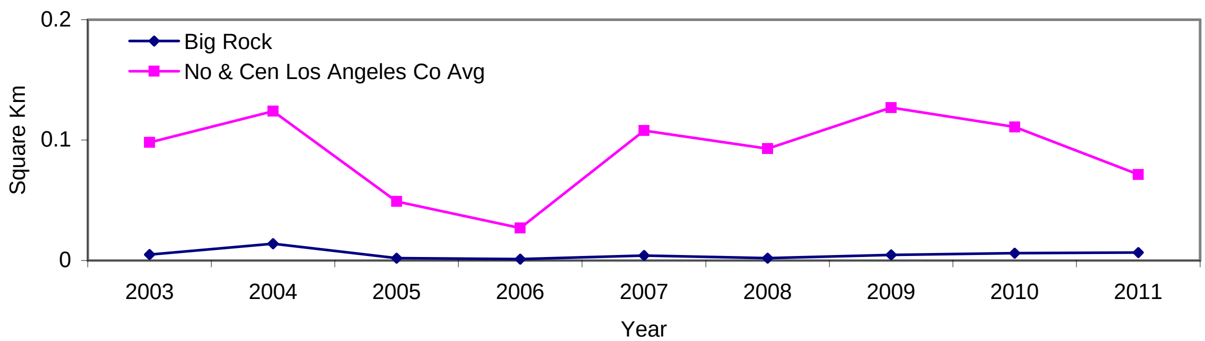


Figure 31. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Big Rock for the years shown.

Las Tunas 2011. Las Tunas kelp bed was small in 1911 at 0.017 km^2 (Crandall 1912), and Ecoscan (1990) aerial surveys showed that by 1989 the kelp bed was approximately one-quarter of the historical size. By 2003, surface canopy of this kelp bed measured only 0.003 km^2 (Table 2). However, in 2004 Las Tunas kelp bed had increased considerably to 0.018 km^2, almost identical to that observed by Crandall (1912). The greatest areal extent in 2005 was seen during the 15 March survey when the canopy of this bed measured 0.004 km^2. No kelp was seen in 2006 quarterly surveys; however it reappeared by the December 2007 survey and measured 0.008 km^2. In 2008, the bed again decreased leaving a small bed with a surface canopy area of only 0.005 km^2; by the June 2009 survey, the bed had increased to a coverage of 0.019 km^2, the largest the bed had been during the CRKSC monitoring. It became smaller during the remainder of 2009 but began increasing in size by the August and November 2010 surveys culminating in a bed of about 0.015 km^2 by December 2010. In 2011the bed remained very small through October and then began to increase again and measured 0.007 km^2 by the December survey, about one half of that recorded the previous December. Las Tunas is a very small bed well below the ABAPY for the region, but appeared to respond in the same direction of the ABAPY through most years (Figure 32).

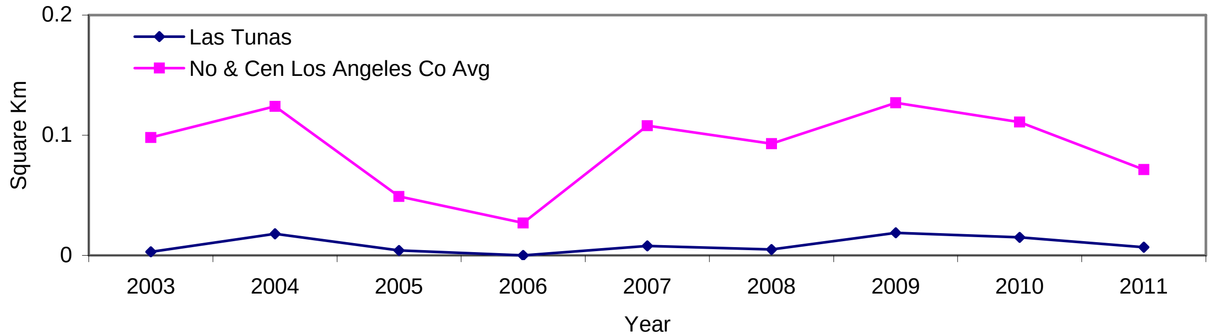


Figure 32. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Las Tunas for the years shown.

Topanga 2011. Topanga kelp bed was observed by Crandall (1912); it was small, and calculated from the maps to be about 0.017 km^2. In 1989 this bed was very small, approximately one-tenth the historical size (Ecoscan 1990). The bed was considerably smaller in 2003, measuring about 0.0002 km^2 (Table 2). This bed was absent for much of the year in 2004, but then reappeared by the fourth quarterly survey with a canopy size of 0.0024 km^2. In 2005, surface canopy was only observed as a trace amount of surface kelp (0.0001 km^2). None of the 2006 surveys recorded any canopy at this location. It was not observed in any aerial surveys of 2007, but it reappeared as a very small bed 0.0009 km^2 in 2008, and increased to the maximum canopy size seen of 0.002 km^2 by June 2009. Thus, it was surprising to see the bed begin to increase in November and December 2010 to 0.052 km^2, 26 times larger than it had been since CRKSC monitoring began and three times larger than recorded by Crandall (1912). In 2011, it was smaller (0.041 km^2) by the December survey but still much larger than Crandall recorded at the beginning of the previous century. Topanga is a very small bed well below the ABAPY for the region, but its upward trend in 2010 and its more moderate decrease in 2011 was atypical of that of the ABAPY's trend (Figure 33).

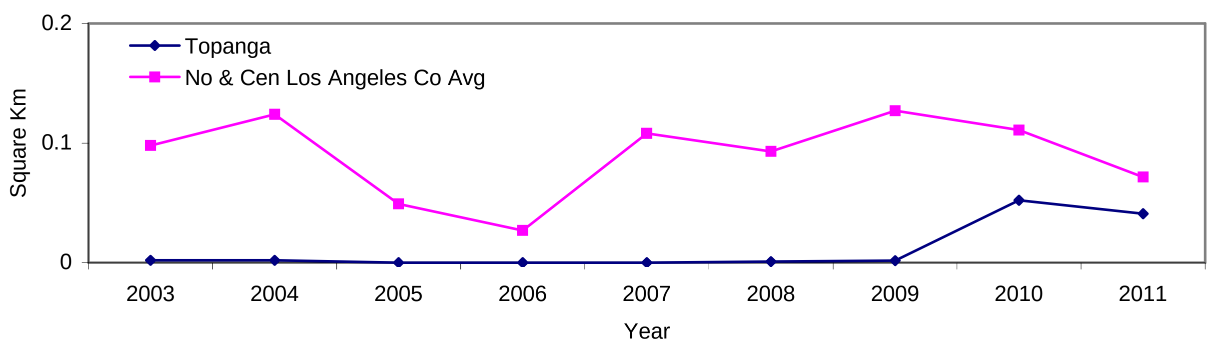


Figure 33. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverages of the kelp bed off Topanga for the years shown.

Sunset 2011. In 1890 and in 1911, Sunset kelp bed was large at 0.960 km^2 (US Coast and Geodetic Survey 1890 and Crandall 1912); however, this bed was missing or very small by 1955, indicating major environmental changes had occurred during the preceding 40 years offshore of Sunset Beach. This loss was either due to sand inundation of the reef structure or because the kelp grew on the sand which could have been extirpated by a violent storm during the preceding 40 years. In any case, no hard substrate is found in this locale suggesting one or the other discussed causative agents were responsible. By 1989, only a small fraction of the historical bed was observed (Ecoscan 1990). This bed marks the eastern boundary of Fish and Game Kelp Bed 15. Sunset kelp bed has not been observed in any of the CRKSC surveys through 2011, 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 2011 (Table 2).

CRKSC CENTRAL (Santa Monica Pier to Redondo Beach Breakwater Southern Tip)

Santa Monica Pier to Redondo Beach Breakwater Southern Tip. Although no kelp was noted in 2003 or 2004 in the region from the Santa Monica Pier to Marina del Rey Harbor, a small amount of kelp was noted along the breakwaters of the Marina del Rey Harbor and King Harbor in Redondo Beach in April 2005 and at slightly higher concentrations in December 2006, particularly near the northern end and inside the King Harbor breakwater. 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. Since at least 2005 through the 2011 surveys, kelp has been noted at both the Marina del Rey and Redondo Beach-King Harbor breakwaters during some portion of the year.

FISH AND GAME KELP BEDS 14 (Malaga Cove to Point Vicente) and 13 (Point Vicente to San Pedro Breakwaters)

The Palos Verdes 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). Appendix B also lists historical canopy areas from SWQCB (1964), Ecoscan (1990), and North (2000). It has been helpful to divide the two beds that Fish and Game recognizes into four distinct kelp regions since they have at times responded differently to local 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 8.678 km^2 of kelp was reported off Palos Verdes (Appendix B). Despite the record of 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.

During a survey conducted in 1928, the kelp beds were larger (9.912 km^2) than reported by Crandall (1912). However, the status of the Palos Verdes kelp beds was unclear between the 1928 survey and initiation of the discharge of wastewater from the Joint Water Pollution Control Project (JWPCP), which commenced operations off White Point in 1937 (IMR 1954). The first measurement of local kelp bed extent following initiation of the discharge was in 1945 when the extent of Palos Verdes kelp beds was found to be 5.591 km^2. The subsequent decline and disappearance of kelp off Palos Verdes correlated with increasing mass emission of suspended solids from the JWPCP. A study appeared to indicate that particulate inputs from the discharge and increased water column turbidity were the likely mechanism by which the wastewater contributed to the loss of kelp (SWQCB 1964). Under this continued stress, the Palos Verdes kelp beds were virtually eliminated during a large El Niño in 1958-1959.

Kelp recovery and persistence was initiated by a sharp reduction in emission of suspended solids as the result of improved primary treatment, moving the outfall progressively further offshore, and the efforts of Dr. Wheeler North and others to reestablish the kelp in that region. By 1989, Palos Verdes kelp beds covered 2.0 km^2 early in the year and increased to 4.560 km^2 later in the year, stimulated by La Niña conditions in 1989-1990 (Ecoscan 1990, Wilson 1989). This amounted to a four-fold increase in kelp canopy since 1978 and, relative to the coverage reported in 1911, was consistent with kelp coverage found throughout the SCB (Tarpley and Glantz 1992). While surveys of Palos Verdes kelp beds during the La Niña were infrequent, North flew one flight in late April 2000 showing approximately 1.230 km^2 (no surveys were conducted in 2001). Several surveys were flown in 2002 with California Department of Fish and Game reporting from 1.343 km^2 (Bedford, CDF&G 2004, pers. comm.) to 2.84 km^2 of kelp coverage (Veisze et al. 2004). Table 2 presents representative survey results of 2.676 km^2 of kelp taken on 21 February 2002 since that particular survey provides information on all four sections of the Palos Verdes Peninsula. The varying estimates probably reflect the time of year the surveys were conducted and

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

YEAR	Km^2	ACRES	HECTARES	NAUT MI^2 * ($N\ mi^2$)	COMMENT	SOURCE
2011	2.396	592.06	239.60	0.699	M	CRKSC IR Survey (4 Surveys)
2010	2.494	616.41	249.45	0.727	M	CRKSC IR Survey (4 Surveys)
2009	3.998	987.92	399.80	1.17	M	CRKSC IR Survey (4 Surveys)
2008	2.916	720.56	291.60	0.85	M	CRKSC IR Survey (3 Surveys)
2007	2.062	509.53	206.20	0.60	M	CRKSC IR Survey (4 Surveys)
2006	2.187	540.49	218.73	0.64	M	CRKSC IR Survey (4 Surveys)
2005	1.099	271.57	109.90	0.32	M	CRKSC IR Survey (4 Surveys)
2004	0.589	145.54	58.90	0.17	M	CRKSC IR Survey (4 Surveys)
2003	1.425	352.12	142.50	0.42	M	CRKSC IR Survey (4 Surveys)
2002	2.837	701.00	283.68	0.83	M	CF&G/Ocean Imaging (2 Surveys)
2000	1.230	303.94	123.00	0.36	M	W.J. North IR Survey (1 Survey)
1999	1.267	313.00	126.67	0.37	M	CF&G IR Survey (1 Survey)
1998	0.498	123.00	49.78	0.15	M	CF&G IR Survey (3 Surveys)
1997	1.048	259.00	104.81	0.31	M	CF&G IR Survey (2 Surveys)
1996	1.356	335.00	135.57	0.40	M	CF&G IR Survey (2 Surveys)
1995	1.493	369.00	149.33	0.44	M	CF&G IR Survey (2 Surveys)
1994	2.703	668.00	270.33	0.79	M	CF&G IR Survey (2 Surveys)
1993	1.214	300.00	121.41	0.35	M	CF&G IR Survey (1 Survey)
1992	1.731	427.70	173.08	0.50	M	CF&G IR Survey (3 Surveys)
1991	2.964	732.50	296.43	0.86	M	CF&G IR Survey (4 Surveys)
1990	3.641	899.60	364.06	1.06	M	CF&G IR Survey (4 Surveys)
1989	4.549	1124.20	454.95	1.33	M	CF&G IR Survey (2 Surveys)
1988	3.379	835.00	337.91	0.99	M	CF&G IR Survey (4 Surveys)
1987	4.242	1048.30	424.23	1.24	M	CF&G IR Survey (4 Surveys)
1986	3.097	765.20	309.67	0.90	M	CF&G IR Survey (4 Surveys)
1985	2.627	649.20	262.72	0.77	M	CF&G IR Survey (4 Surveys)
1984	2.861	707.00	286.11	0.83	M	CF&G IR Survey (4 Surveys)
1983	1.963	485.00	196.27	0.57	M	CF&G IR Survey (4 Surveys)
1982	2.871	709.40	287.08	0.84	M	CF&G IR Survey (4 Surveys)
1981	2.424	598.90	242.37	0.71	M	CF&G IR Survey (4 Surveys)
1980	2.397	592.40	239.74	0.70	M	CF&G IR Survey (4 Surveys)
1979	1.842	455.25	184.23	0.54	M	CF&G IR Survey (4 Surveys)
1978	1.205	297.80	120.52	0.35	M	CF&G IR Survey (4 Surveys)
1977	0.365	90.30	36.54	0.11	M	CF&G IR Survey (4 Surveys)
1976	0.262	64.80	26.22	0.08	M	CF&G IR Survey (4 Surveys)
1975	0.095	23.50	9.51	0.03	M	CF&G IR Survey (3 Surveys)
1974	0.015	3.70	1.50	0.00	M	CF&G IR Survey (2 Surveys)
1967	1.062	262.4	106.2	0.31	M	SAI (1 Survey)
1959†	0.034	8.48	3.43	0.01	M	SWQCB 1964
1958	0.171	42.38	17.15	0.05	M	SWQCB 1964
1957	0.446	110.18	44.59	0.13	M	SWQCB 1964
1955	0.823	203.41	82.32	0.24	M	SWQCB 1964
1953	1.509	372.92	150.92	0.44	M	SWQCB 1964
1947	3.601	889.93	360.14	1.05	M	SWQCB 1964
1945	5.591	1381.51	559.08	1.63	M	SWQCB 1964
1928	9.912	2449.42	991.25	2.89	M	SWQCB 1964
1911	8.678	2144.30	867.77	2.53	M	Crandall 1912

* Data in naut. mi^2 are from SWQCB (1964); 2003-2007 data includes Cabrillo; M = Measured

† 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). 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 CF&G or CRKSC aerial surveys.

suggest the February 2002 survey did not represent the annual maximum canopy at Palos Verdes that year. 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 Portuguese Bend landslide is an important local factor in limiting kelp forests on reefs along the southern face of Palos Verdes. This slide, which has been active since 1956, has put as much as 9.4 million metric tons of sediment into the nearshore waters (Kayen et al. 2002). Besides increasing water column turbidity with attendant effects on sea floor light availability, sediment from the slide has buried many low-lying reefs in the area; 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 1 m between the 3 and 15 m isobaths within the depth range suitable for kelp bed formation.

Redondo Beach Breakwater Southern Tip to Malaga Cove, Torrance 2011. This stretch of coastline appears to have been unsuitable for kelp since the survey of Crandall (1912), implying that it continues to be sandy bottom with no substantial hard bottom substrate. No kelp was seen south of King Harbor until Malaga Cove at the Palos Verdes Peninsula in 2011.

Palos Verdes IV 2011. The Palos Verdes kelp beds have the most complete record of all the beds in the Central Region because of surveys conducted by the California Department of Fish and Game and monitoring efforts by Los Angeles County Sanitation Districts. Palos Verdes IV kelp bed is one of the two beds included in Fish and Game Kelp Bed 14. Along the entire Palos Verdes Peninsula, Crandall (1912) calculated kelp canopy coverage to be 8.678 km^2; about 5.536 km^2 of which occurred in present day Fish and Game Kelp Bed 14 from Flat Rock at Malaga Cove to Point Vicente. In 1928 aerial photographs, the beds were measured to have increased to 9.912 km^2, however by 1945, all beds along the Palos Verdes Peninsula began a dramatic decline in kelp bed size, especially in Fish and Game Kelp Bed 14 (SWQCB 1964, Appendix B). By 1958, only a small remnant of the Palos Verdes kelp beds was present in the CRKSC-designated Palos Verdes IV (PV IV) kelp bed area. Efforts by Dr. Wheeler North to restore the largely reduced Palos Verdes kelp beds commenced in the 1970s. By 1989, Fish and Game Kelp Bed 14 recovered to 3.312 km^2 with the majority of that occurring in CRKSC PV IV kelp bed (Ecoscan 1990). Since 1989, areal extent of these beds have declined. In 2002, approximately 1.4 km^2 of canopy coverage was observed over the entire Fish and Game Kelp Bed 14. Specifically in the PV IV kelp bed, 0.196 km^2 of kelp coverage was seen in 2003 at the initiation of the CRKSC program (MBC 2004). By 2004, this area had increased to 0.245 km^2. The largest areal extent of PV IV kelp bed in 2005 occurred during the September survey when it exhibited 0.204 km^2 of canopy coverage (Table 2). In the first quarterly survey on 20 April 2006 , kelp coverage at PV IV kelp bed increased in size from that seen in the previous year, increasing to the largest aerial extent (0.859 km^2) observed and measured since 2002. Responding favorably to the La Niña, the beds increased still further in 2007 (1.151 km^2) and increased greatly in size in 2008 to 1.839 km^2, a size not recorded since the Ecoscan survey of 1989; however, it was probably larger than this in 1990 and 1991 (Table 6), as the total for the four kelp beds of the Palos Verdes Peninsula exceeded that of 2008. Responding to a favorable nutrient regime in early 2009, the beds in this region increased still further in March 2009 to 2.122 km^2 of kelp canopy (Table 6). The beds were reduced by the September and December 2009 surveys and the 2010 March survey, but by the August survey the beds were increasing again and reached their maximum extent in November 2010 with a coverage of 1.136 km^2, and they stayed fairly large during the first two surveys, but increased slightly during the October and December survey to 1.139 km^2, virtually the same, but a slight increase from that of 2010. The PV IV kelp bed was typically much larger than the average kelp bed in the region (Figure 34). It is apparent from the ABAPY graph that 2003 through 2005 were very poor growth years for all of the beds in the region, and was particularly devastating to this portion of the region; however, it is equally clear from the ABAPY that PV IV kelp bed responded with the ABAPY, though generally with a sharper upward or downward trend.

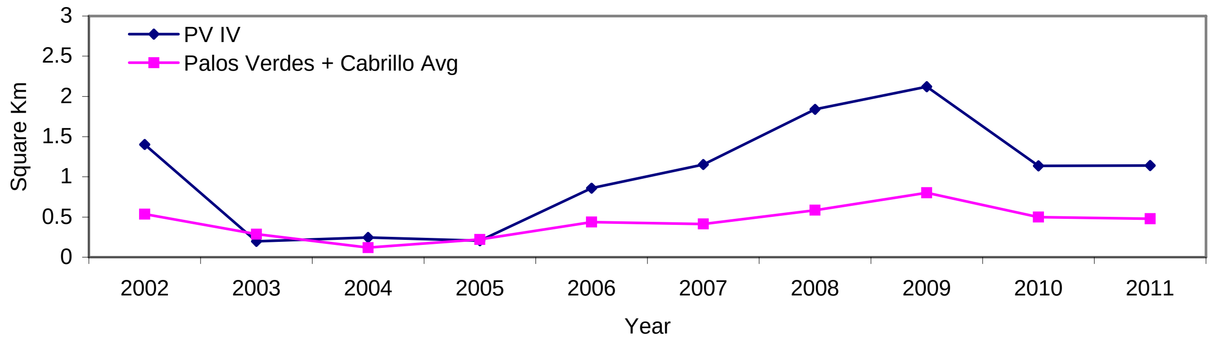


Figure 34. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off PV IV for the years shown.

Palos Verdes III 2011. 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 that during periods of area-wide kelp canopy decline, Palos Verdes III kelp bed declined to an even greater extent than PV IV. In 2002, the canopy of PV III kelp bed measured 0.028 km^2. By 2003, the canopy had increased considerably to 0.045 km^2, while in 2004 it remained similar in size at 0.040 km^2 (Table 2). The greatest areal extent in 2005 was 0.056 km^2, a 29% increase over the previous year. Canopy coverage increased even more by the December 2006 survey, especially within Lunada Bay, reaching 0.135 km^2 in surface coverage. However, the June 2007 survey total of 0.074 km^2 was the largest extent of the bed for the year indicating that localized conditions were not as favorable in 2007 for this section of the coastline. In 2008, conditions were highly favorable; the kelp bed in this section increased greatly to 0.300 km^2, and in June of 2009, the bed totaled 0.570 km^2. In August 2010, in contrast to the reductions that occurred at PV III, the canopy coverage at PV II increased to 0.624 km^2.This was a total kelp coverage area greater than any since 1989; however, as mentioned previously, it was probably larger than this from 1990 through 1991, as the total for the four kelp beds of the Palos Verdes Peninsula exceeded that of 2010 (Table 6). The kelp bed of PV III kelp had decreased in this region during the first two surveys and began to increase during the last two, but totaled just 0.452 km^2 by the equally large October and December 2011 surveys. This bed has typically been well below the ABAPY, but atypically in 2010, the kelp bed outperformed the ABAPY. It has, however, generally responded to the same stimuli as observed in the ABAPY as was noted in 2011 (Figure 35).

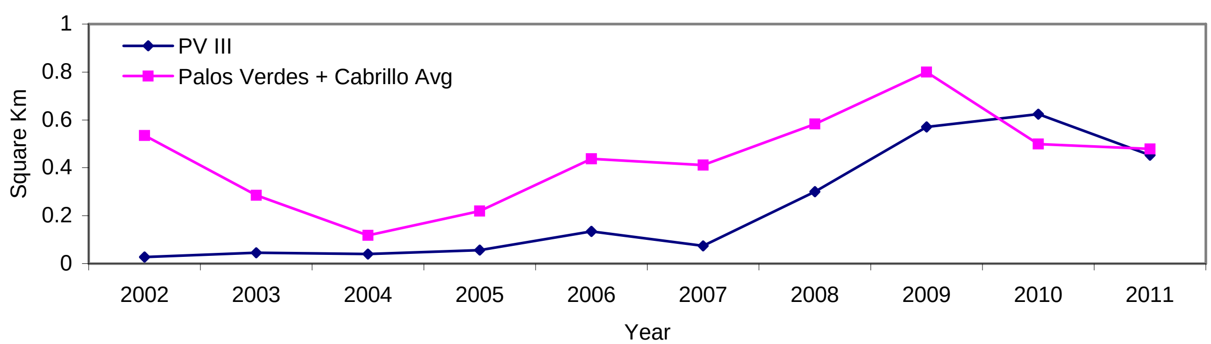


Figure 35. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off PV III for the years shown.

Palos Verdes II 2011. Palos Verdes II (PV II) kelp bed includes the offshore kelp from Point Vicente to Inspiration Point and is one of the two beds included in Fish and Game Kelp Bed 13. Historically Fish and Game Kelp Bed 13 contained considerably less kelp than in Fish and Game Kelp Bed 14. Areal coverage of these beds was 0.059 km^2 in 2003 and 0.023 km^2 in 2004 (Table 2). In 2005, the greatest canopy coverage was measured at 0.034 km^2, but canopy coverage more than doubled in the 2006 December survey, totaling 0.082 km^2. Unlike the other two beds in the Palos Verdes Peninsula, these beds decreased to 0.034 km^2 by the June 2007 survey and remained smaller during the subsequent two aerial surveys in 2007. Like PV III and PV IV kelp beds, Palos Verdes II increased in 2008 to 0.108 km^2 and to 0.163 km^2 by June 2009. Responding like PV III, PV II was also larger in August 2010, reaching a total of 0.222 km^2 and bucking the trend it was larger still through the August, October, and December 2011 surveys, totaling 0.236 km^2, the largest total of any CRKSC survey. This was again a total greater than seen since 1989, although again with the caveat that the beds were probably larger from 1989 to 1991, based on the total for the four bed areas (Table 6). PV II kelp bed was also much smaller than the ABAPY, and any response to stimuli appeared to be muted in this region, although the bed has responded opposite to the ABAPY, decreasing when it increased during 2009 and by increasing when it decreased in 2010. In 2011, however, it responded in lockstep with the ABAPY (Figure 36).

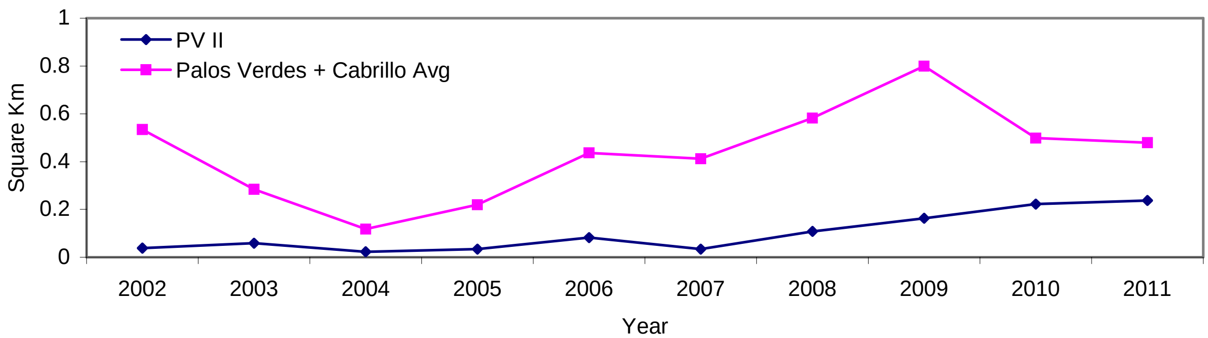


Figure 36. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off PV II for the years shown.

Palos Verdes I 2011. Palos Verdes I (PV I) kelp bed includes the area from Inspiration Point to Point Fermin. In the 2003 and 2004 surveys, PV I kelp bed included sections of the Cabrillo kelp bed, thus slightly exaggerating the size of PV I kelp bed in those years and decreasing the size of Cabrillo kelp bed. This error was corrected in the 2005 report and is correctly reported in Table 2 and Appendix B. In 2005, the recalculated total of these two beds including all canopy west of Point Fermin as PV I kelp bed and all canopy east of the point was included as Cabrillo kelp bed. New re-calculated areas for PV I kelp bed were 1.063 km^2 in 2003 and 0.211 km^2 in 2004 (Table 2). The greatest areal extent in 2005 was 0.702 km^2, a 140% increase over the previous year. However, by the December 2006 survey, canopy coverage increased dramatically to 0.951 km^2 along the entire length of the PV I kelp bed. Despite this increase and the advent of the La Niña, kelp in this region decreased in area to 0.703 km^2 by June 2007, with further decreases throughout the remainder of 2007. Although kelp coverage increased from what was observed in late 2007, it was still smaller in 2008 than observed in mid-year 2007, covering an area of 0.608 km^2, but again responding to nutrients in the early part of 2009, it increased to 0.980 km^2. The bed at PV I began to decrease after its high point in June 2009, and by August 2010 the bed was reduced to a coverage of 0.389 km^2, the lowest for this region since 2004. Although much smaller by the April 2011 survey, it had increased by the August survey and stayed larger 0.465 km^2) than observed in 2010 through the December 2011 survey. PV I kelp bed was considerably larger than the ABAPY for most years, but was nearly identical to it in 2008, and 2009, while the magnitude of the decrease was greater than the ABAPY in 2010 and slightly greater in 2011 (Figure 37).

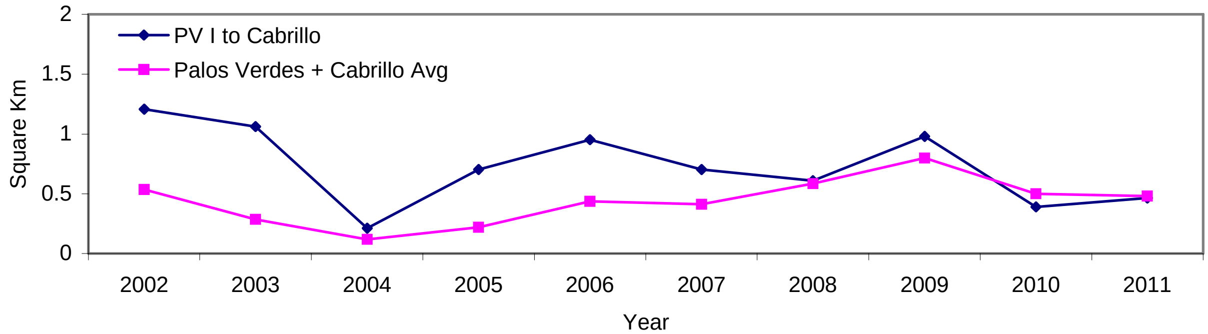


Figure 37. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off PV I for the years shown.

Cabrillo 2011. The Cabrillo kelp bed includes the area east of Point Fermin up to and including the groin extending from the beginning of the Port of Los Angeles breakwater. While Fish and Game Kelp Bed 13 is designated as including the area up to San Pedro breakwater lighthouse, it is unclear whether or not Cabrillo kelp bed has been historically included since it exists east of Point Fermin, which has been designated as the eastern-most border to Fish and Game Kelp Bed 13 in some past reports (unpublished aerial overflight surveys of the Palos Verdes Peninsula by Fish and Game, 1984-1985). Cabrillo kelp bed has consistently maintained a dense kelp bed since 1989, although Cabrillo kelp canopy declined markedly during the 1998 El Niño. As mentioned in the discussion of Palos Verdes I kelp bed, the area calculated for Cabrillo kelp bed was re-measured in 2005 to include all area east of Point Fermin. The re-calculated areas for Cabrillo kelp bed are 0.062 km^2 in 2003 and 0.070 km^2 in 2004 (Table 2, Figure 38). The greatest areal extent in 2005 was 0.102 km^2, a more than 40% increase over the previous year. The quarterly surveys culminating with the December 2006 survey, indicated canopy coverage was 0.161 km^2, much larger than previously recorded in CRKSC surveys. With the advent of the La Niña in 2007, kelp in this region responded atypically by decreasing in area to 0.100 km^2 by June 2007, with further decreases throughout the remainder of 2007. Although kelp coverage increased from what was observed in late 2007, it was still smaller (0.060 km^2) in 2008 than observed in mid-year 2007, but covered an area of 0.163 km^2 by June 2009. By March 2010, the bed was much smaller but began to increase in areal extent by November resulting in a coverage of 0.124 km^2, a reduction from the larger area in 2009. This trend continued in 2011, with the bed much smaller by April 2011, but increasing again to a bed (0.103 km^2) just slightly smaller than the previous year by August, and then decreasing somewhat thereafter in the October and December surveys. Cabrillo kelp bed was small, but with the exception of 2008 appeared to be mirroring the ABAPY through 2011 (Figure 38).

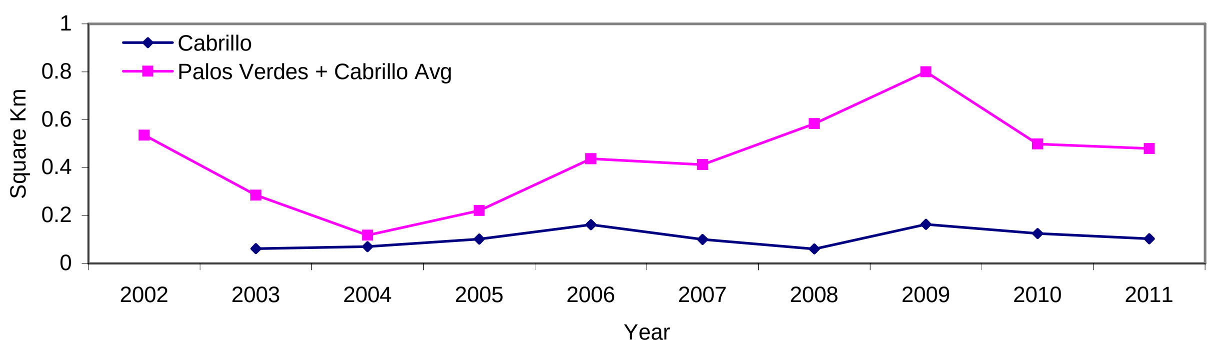


Figure 38. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off Cabrillo for the years shown.

POLA-POLB Breakwaters 2011. A notable amount of kelp exists along the Ports of Los Angeles and Long Beach breakwaters and further into the ports on the armored edges of the outer harbors. This kelp was not adequately considered in previous CRKSC reports before 2005, but is now being measured on a yearly basis. 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 harbor complex, it was requested that the overflight photographs for the third quarterly survey in 2005 (28 September 2005) include the entire outer breakwater complex. Analysis revealed a narrow band of dense kelp, 0.147 km^2 on both the inside and outside of the riprap in the outer harbor breakwater. Only a small portion of the berths in the southern part of the port complex was seen in the photographs, which suggested that the outer harbor be included in future overflights. Due to reports of kelp existing along a number of the inner breakwaters, the entire harbor was photographed and ground truthed to determine whether the images being seen in the infrared photographs may have been *Egregia menziesii* or *Sargassum* sp in addition to *M. pyrifera*. However, a shipboard visual inspection of the growth along the breakwater and within the confines of the harbors confirmed that the major portion was giant kelp (*Macrocystis pyrifera*). The more inclusive survey of the port complex in 2006 indicated that 0.494 km^2 of giant kelp was found on the inner and outer breakwaters of Los Angeles and Long Beach Harbors (Table 2). The beds decreased in 2007 to 0.118 km^2, but increased again in 2008 to 0.213 km^2. In 2009 during the minor El Niño, the beds decreased to 0.151 km^2 in 2009, but with cooler temperatures returning in 2010, the beds again increased to 0.277 km^2 a trend that continued in 2011 with 0.397 km^2, a substantial amount of kelp only exceeded in 2006. The kelp in the Ports of Long Beach and Los Angeles ABAPY appeared to be mirroring the Palos Verdes kelp beds through 2008, but were in opposition to the ABAPY with an upward trend from 2009 through 2011 (Figure 39).

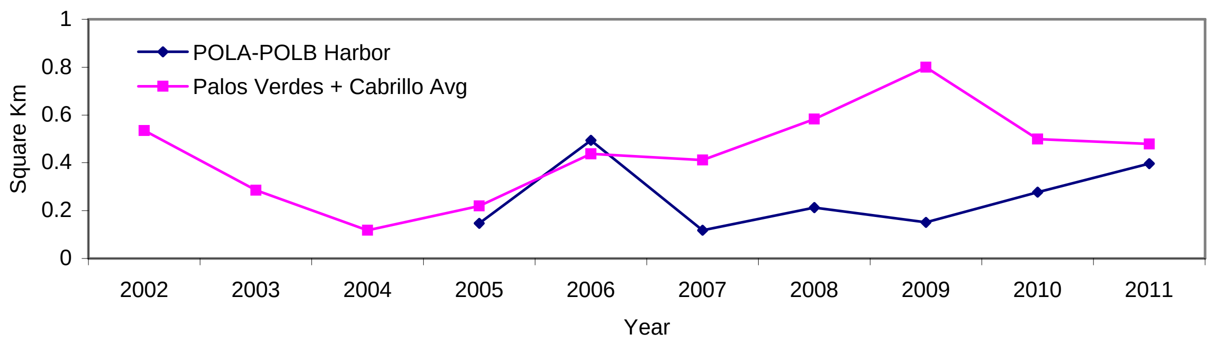


Figure 39. Comparisons between the average Palos Verdes and Cabrillo ABAPY and the canopy coverages of the kelp bed off POLA-POLB Harbor for the years shown.

CRKSC SOUTH (San Pedro Breakwater Lighthouse to Laguna Beach)

Although much of the area from the Ports of Los Angeles and Long Beach breakwaters to the Newport/Irvine coast is along a broad, flat alluvial fan from the San Bernardino Mountains, the area once supported several kelp beds. Rocky area existed off of San Pedro in the Horseshoe kelp area, and offshore of Huntington Beach in an area known as Huntington Flats, which existed prior to 1950.

Horseshoe kelp was located offshore of San Pedro Harbor at the 11 fathom curve at depths ranging from 18 to 25 m. It was not noted on the US Coast and Geodetic Survey Map 5100 of 1890, nor did Crandall (1912) depict it in his 1911 map. However, a description by Schott in 1976 and numerous other accounts gives an estimated coverage size of about 1.94 km^2 in 1928 (Schott 1976). Kelp in this area was reported to be lush and thick during the 1920s. It declined gradually through the 1930s, but remained a popular fishing spot (Simonin 1994, pers. comm.), until it vanished completely in the late 1940s. No canopy has been seen at Horseshoe kelp since the 1940s. This disappearance was probably a result of a combination of factors. Much of the dredge material including an island in Los Angeles Harbor was placed on the banks in this area. A large increase in cargo and naval ship traffic, commercial fishing, dredge disposal operations, and an increase in industrial inputs into the San Pedro Bay probably are responsible for the loss. It is possible that during periods of especially good water clarity and nutrient availability, kelp will again recruit to the area. However, continued ship traffic and inadequate water quality/clarity conditions persist. Small kelp, up to 2 m, was seen in the area in sporadic surveys through the 1970s and widely separated individual giant kelp were noted on the surface in 1989, but no canopy formed (Wilson 1986, pers. comm.). Interviews with fishermen suggest that individual giant kelp were noted just beneath the surface above 18 to 25 m depths in the late 1980s (Simonin 1994, pers. comm.; Morris 1995, pers. comm.), but failed to form canopies, with all of the individual giant kelp eventually disappearing. The large kelp *Pelagophycus* is occasionally seen in the area reaching the surface (we have observed beds of *Pelagophycus* sp offshore of Imperial Beach which raises the possibility the bed may have been that species) and *Pterogophora* beds are prevalent over most of the hard-bottom. When established, these kelp species may out compete *Macrocystis* (Dayton and Tegner 1984), thus prohibiting establishment of giant kelp. No aerial surveys in either the survey of 2009 or in surveys covering the preceding five decades have recorded the presence of giant kelp at the Horseshoe kelp fishing location (North 1968; Bedford, CDF&G 2004 pers. comm.; MBC 2004-2008). Whatever the mechanism responsible for the loss of the kelp beds in this location, it remains that no giant kelp has formed a canopy there since the 1950s, indicating an inability for giant kelp beds to reestablish at that location.

The kelp bed at Huntington Flats was located in relatively shallow water (10 m) offshore of the north end of Huntington Beach. Kelp canopy was last noted in this area in the 1920s. In 1966, Dr. Wheeler North applied for a grant from the Fish and Game Commission to transplant kelp to this region. One Fish and Game Commissioner, an avid sport fisher, told North about the location of a kelp bed that used to exist offshore of Huntington Beach near the oil islands, but pre-dating their establishment (North 2000, pers. comm.). He took Dr. North on his boat and showed him the exact location. North dove the reef at a later date and found that it was a low-lying reef in 7 to 10 m depth with approximately one foot of relief above the surrounding sand. Visibility on the reef was poor, resulting from the resuspension of fine sediments. The location was downcoast from Los Angeles-Long Beach harbors, inshore and about 200 yards northwest of Oil Island Emmy. North concluded that the construction of the extension of the breakwaters for the Port of Long Beach, Alamitos Harbor, and Anaheim Bay likely altered sediment transport in the area sufficiently to increase sedimentation, thereby precluding the continued existence of a kelp bed.

In 1975, the Los Angeles Rod and Reel Club became interested in conducting a kelp transplant after reading of North's successful restoration of kelp at Palos Verdes Peninsula during the past several years. They contacted Dr. North for guidance in starting a kelp bed restoration project in the Huntington Flats area. They collected tires, filled them with concrete, and chartered a sport fishing boat and relocated 10 adult giant kelp tied to tires and placed them on the bottom. The plan failed when most of the tires ended up on the beach the following winter. Later observations in the 1970s and 1980s indicated that suitable low-lying habitat was available, but visibility continued to be poor and probably limiting kelp growth (Curtis 2003, pers. comm.). The site is sufficiently removed in distance from any potential kelp spore source to be unlikely to recover even during good years when water clarity and nutrients might otherwise be favorable.

A small bed formed offshore of Huntington Harbor in 1989 on the rocky riprap of the remains of Oil Island Esther that was destroyed during storms in the 1980s. The kelp was present for approximately one year, but has not been seen since. No kelp is found from the Huntington Flats area to Newport Harbor, which includes the area offshore of the Huntington Beach Generating Station and Orange County Sanitation District outfalls. A sandy bottom dominates the subtidal zone along this entire stretch of coastline. The movement of currents and the exposure of this portion of coast to breaking waves discourage the establishment of kelp beds in this area, even on the abundant worm tubes found in high densities subtidally. Although kelp is found growing along the inside of the northwest breakwater in Newport Harbor, it disappeared from the coastline from Newport Harbor along the Newport/Irvine Coast during the 1982-1984 El Niño. Kelp persisted through that El Niño in Laguna Beach, but was extirpated from the area in a series of small El Niño events in the early 1990s. A series of kelp restoration projects in the Newport/Irvine Coast and Laguna Beach have resulted in the successful reestablishment of kelp to the reefs in this area.

Horseshoe Kelp 2011. No canopy has been seen at Horseshoe kelp since the 1940s. In 1928, canopy coverage of the Horseshoe kelp bed was approximately 1.94 km^2 (Schott 1976). No kelp surface canopy was observed in aerial surveys by the California Department of Fish and Game or by Dr. Wheeler North (North 2000, pers. comm.), nor has kelp been seen at this location in any CRKSC surveys, including the quarterly surveys of 2011.

Huntington Flats 2011. A kelp bed was located off the northern end of Huntington Beach in the 1920s in an area known as Huntington Flats. The bed was on a low lying reef in about 30 ft of water and situated between Bolsa Chica State Beach and 23rd Street in Huntington Beach (North and Jones 1991). No information is available on its size and it was not observed during aerial surveys by Fish and Game in the 1950s. The construction of the Port of Long Beach, Alamitos Harbor, and Anaheim Bay likely changed or interrupted sediment transport in the area sufficiently to increase sedimentation in the area, thereby reducing the likelihood of a kelp bed being sustained in this area. Kelp at Huntington Flats has not been noted in any of the CRKSC surveys through 2011.

Huntington Flats to Newport Harbor 2011. No kelp has been observed historically or in any CRKSC survey along the shoreline past the Huntington Beach Generating Station, the Orange County Sanitation District outfalls, or along the remainder of the coastline to Newport Harbor. Kelp continues to grow on the inside west jetty of the Newport Harbor entrance and on the outside of the east jetty. These narrow bands of kelp were observed in the 2011 quarterly surveys.

Newport Coast - Corona del Mar to Crystal Cove, 2011. Giant kelp in this region consisted of a number of small beds (collectively called the Newport Coast kelp bed) covering 0.580 km^2 of the nearshore coastline during Crandall's survey of 1911, but canopies covered only about 0.180 km^2 by 1970. Kelp beds persisted in the region until the El Niño of 1982-1984, when they disappeared from this section of the coastline. Due to kelp reforestation efforts in the late-1980s they reappeared as very small beds until disappearing again in the early 1990s as a result of a series of small El Niño events. Approximately one decade later, reforestation operations began in 2000 at sites located at Corona del Mar near Arch Rock (known to be a purple urchin barrens), and expanded to the southeast to Scotchman's Cove (now Crystal Cove). Two other sites, Wheeler's Reef and the bed southeast of Rocky Point at Scotchman's Cove, displayed small canopies during the early portion of 2003. A dive survey was conducted at the restored Corona del Mar bed in 2003 and it indicated that purple urchins were still prevalent in the area, but kelp recruitment was so successful that drift algae was apparently sufficient to keep the urchins from moving and overwhelming the kelp recruits. Neither of these two beds had canopy during any of the aerial surveys of 2005, but the Newport Coast kelp bed was the largest bed in Orange County in 2006 (0.023 km^2). By 2007, it had grown substantially (0.054 km^2) and coverage was at 1983 levels. Kelp was growing at Cameo Shores and Whistler's Reef, and small beds were visible at either end of Crystal Cove offshore of the cottages with the beds near Reef Point at Scotchman's Cove also expanding; by the end of 2008, the total of all of the Newport Coast kelp bed was (0.089 km^2), which increased in June 2009 to 0.095 km^2, about 65% of the bed size recorded in 1980 (Tables 1 and 2). In the March, November, and December aerial surveys of 2010, the beds of this region were very robust. The measurement of the Newport Coast kelp bed in December 2010 calculated a coverage of 0.161 km^2, which was large but only about half of what was recorded in 1989 of 0.319 km^2. The 2011 aerial surveys indicated that the beds continued to expand as a result of a sustained La Niña and by the December 2011 survey, the north and south Laguna Beach kelp beds totaled 0.386 km^2 which was larger than any time in the past 45 years. This indicates that as a result of kelp restoration efforts from 1986 through 2009, the beds of this region have finally recovered from their total extirpation in the early 1980s. The average bed area per year (ABAPY) was graphed showing that this bed followed the other beds of the region until giant kelp was extirpated from the coastline during the El Niño of 1982-1984 and did not return (result of restoration efforts) until about 1989, was lost again, and returned (again as the result of further restoration efforts) in 2003 (Figure 40).

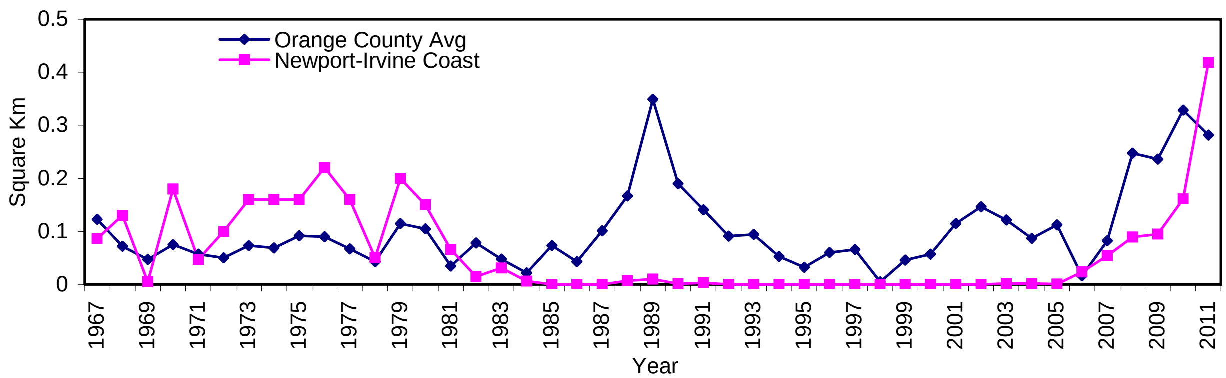


Figure 40. Comparisons between the average Orange County ABAPY and the canopy coverages of the kelp bed off the Newport-Irvine Coast for the years shown.

Laguna Beach 2011. There apparently was only a trace of kelp in the area of North and South Laguna Beach in 1911, as Crandall did not record any kelp beds at this location; however, kelp appears prominently in a map from 1890 produced by T.C. Mendenhall for the U.S. Coast and Geodetic Survey. By 1967, they were listed as very small beds totaling only 0.005 km^2 for both. However, in 1955 they were recorded at 0.680 km^2, but stayed relatively small until reaching 0.187 km^2 by 1989 (Table 1). The beds persisted for a few years, becoming smaller, and North Laguna Beach kelp disappeared in 1991 while the larger bed at South Laguna Beach lasted until 1993. Giant kelp disappeared from North Laguna Beach in 1991 and 1993 due to several small El Niños, coupled with a large influx of purple urchins. In South Laguna Beach, giant kelp persisted through 1993, but had declined every year since 1989 and was last noted in the aerial survey of 1994. Kelp was not seen during extensive diving surveys conducted as a prelude to restoration activities in 2002. Following restoration efforts funded by several groups at sites clustered along a one-mile strip of coastline extending from Heisler Park to the offshore breaking reefs at Cress Street, and ranging in depth from 25 to 45 ft, a small amount of kelp reappeared at South Laguna Beach in 2002, and a trace was observed at North Laguna Beach in 2003. These stayed small or disappeared (but observed below the thermocline) over the next several years. No surface kelp was seen during the first two aerial surveys of 2007; however, diver surveys in March and May 2007 indicated that some areas were beginning to recover and several hundred giant kelp were found on the bottom (out of several thousand about 1.5 years earlier). As 2007 progressed, kelp densities began to increase at the restoration sites and many more hundreds of giant kelp (increasing to about one-third of the density seen in early 2005) of various sizes were found throughout the restoration area. These giant kelp persisted throughout 2007 and formed a small canopy of about 0.002 km^2 at North Laguna Beach and 0.025 km^2 at South Laguna Beach by late-December 2008. Both areas continued to increase in 2009 and totaled 0.063 km^2 by mid-2009. Conditions returned to near normal by the beginning of 2010, resulting in recovery of the canopies from losses in the latter half of 2009. As these beds had disappeared after the 1989 maximum of 0.319 km^2 was reached, the calculation of coverage of 0.191 km^2 in December 2010 indicated that these beds were recovering again as the result of 1000s of hours of restoration efforts over an eight-year period (MBC 2010b). The results of the 2011 survey indicate that the Laguna Beach kelp beds were larger in 2011 (0.419 km^2) than at any time in the continuous 45 year record, but not as large as the canopy coverage in 1955 of 0.680 km^2 (Table 1). The ABAPY for the two Laguna Beach bed areas also followed the fortunes of the other beds in the region, surviving the El Niño of 1982-1984, until about 1994 when they too were extirpated from the region, remaining at zero in our measurements until about 2006 when the beds again reappeared as a result of restoration efforts (Figure 41).

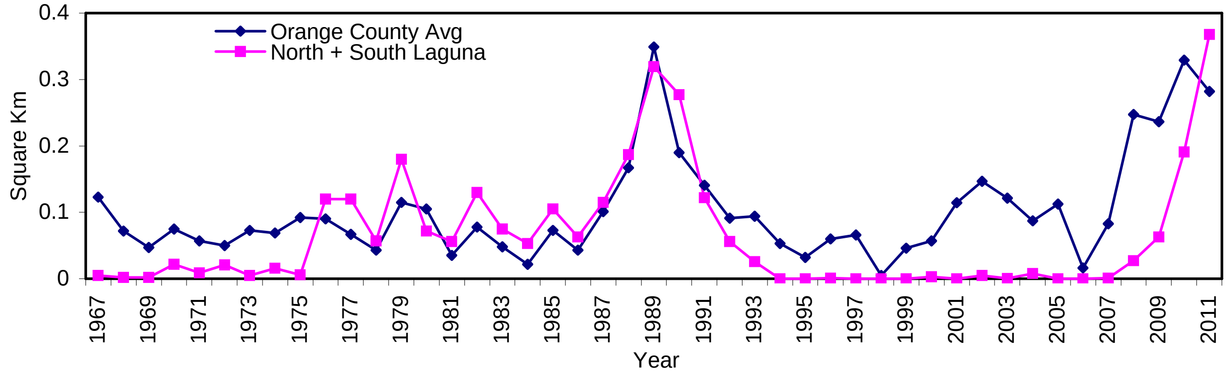


Figure 41. Comparisons between the average Orange County ABAPY with the history of Laguna Beach kelp (i.e., the sums of canopy coverages for North Laguna Beach plus South Laguna Beach kelp) for the years shown.

2012 UPDATE TO THE PRESENT

One aerial survey for 2012 has been conducted and been critically evaluated. This survey was conducted on 6 April 2012. The daily pattern in temperature change tracked closely between the northern and southern automated sampling stations through May 2012 (the latest data available) with SSTs cooler-than-average at Point Dume, Santa Monica Pier, Palos Verdes, and Newport Pier in March and April (Figure 7). Swells from 3 to 3.5 m were recorded at both the Santa Monica and San Pedro wave buoys (Figures 14 and 15) which may have adversely affected some of the kelp beds. At this early stage, it is unclear how the Central Region kelp beds will fare in 2012; however, based on boat surveys in the southern portion of the range, kelp beds are continuing to expand from what was observed in December 2011. Most recently, the models being used to forecast El Niño suggest neutral conditions developing and possibly reentering a El Niño phase.

DISCUSSION

Based on the analysis of the oceanographic data and the aerial overflight surveys in 2011, kelp growth within the 27 kelp beds monitored as part of the CRKSC program was poor in the first several months of 2011 based on the observation that most of the Central Region beds decreased, but conditions became more favorable during the spring as the region was in the grip of a La Niña cold water event that resulted in cooler-than-average spring water temperatures. Sea surface temperatures stayed cooler-than-average through October 2011 resulting in kelp beds becoming robust and maintaining canopies through the summer months which is atypical. Kelp beds then reached most of their maximums during the December survey, although SSTs returned to more average temperatures during the last two months of the year. During the 2011-2012 season, the nutrient quotient for the waters off the Santa Monica Pier was 34, indicating above average nutrients were theoretically available. The quotient values were 41 in the 2010-2011 season and 23 in the 2009-2010 season and, implying nutrient availability was high in the previous year (during the La Niña) and low in the prior year but has increased over the last two years. Based on the nutrient quotient for the two Palos Verdes temperature stations, nutrient availability was very good in the southern station and average in the northern station in 2010-2011 season, but it has been relatively poor in the 2011-2012 season, at least through February 2012. Offshore of the Newport Pier in the 2011-2012 season, the nutrient quotient was 34, again suggesting greater-than-average availability of nutrients. This value was 35 in 2010-2011, but only 19 in the 2009-2010 season, indicating much poorer availability of nutrients than present during the past two years. The prime factor that appeared to be influencing kelp health and growth in 2011 was nutrient availability. SSTs indicated that nutrients were adequate in the beginning of the year, becoming exceptional in the later part of the year imparting a good recovery of the kelp bed resources by the December 2011 survey. The reduction in canopies in the northern portion of the range likely was due to changing nutrient conditions since the extremely strong impetus given by the La Niña 2007 and 2008 which resulted in canopy maximums for most of the kelp beds of the region by early-2009. These reductions were set in motion by the El Niño of late-2009 which even the La Niña of 2010 and 2011 have not been able to arrest. Still canopies remain robust, just not to the very large sizes obtained in 2009.

Swells were relatively mild with very few approaching the 3.0-m and none close to the 4.0-m range where we can expect to see damage. None of the periods of intense swell appeared as if they lasted long enough to impart any lasting damage to the kelp bed resources.

There was a mixture of increases and decreases in canopy sizes up and down the coast with the beds responding to micro-variations in climatic regimes in the various habitats of the Central Region. The overall results were that most of the northern beds of the region decreased (while visually still remaining large) and the more southern beds increased, with a small overall reduction in canopy total for the region from 5.0 to 4.8 km^2, larger-than-average since the CRKSC monitoring commenced in 2003 (Table 2). Other than for the ultra-exceptional growth observed in early 2009, the results of 2011 would also be deemed a good year with very good canopies throughout the region. Overall, most of the kelp beds persisted into 2012 fairly healthy. Canopy coverage appears to have responded favorably in the region by maintaining the robust canopies observed in December 2011. A La Niña persisted through much of 2011 and contributed to a recovery of many of the kelp beds to significant fractions of what was observed during the early part of 2009. The ongoing discussion at the El Niño watch forum suggests the region has transitioned to neutral conditions by May 2012. In light of recent studies suggesting that all of southern California, since 1977, has been subjected to a marine environment relatively depleted in nutrients, the recent La Niña has been welcome.

CONCLUSION

Kelp canopy coverage was decreasing as observed in the April aerial survey of 2011. The response in canopy size to nutrients was marked and by the August survey kelp beds had increased greatly from that observed in the early half of 2011 as the La Niña continued to bathe the region in cool water temperatures. As has been typical (with a few atypical years such as 2009), the kelp beds in the region varied in their response to stimuli such as nutrient availability. During 2010 and 2011, much broader temperature data was available across the Central Region with the addition of two stations along the Palos Verdes Peninsula by the Los Angeles County Sanitation District and an offshore SCCOOS station at Point Dume. With these three additional stations to the two we have been using in place, temperatures could be correlated with broad reductions or increases in kelp canopies over the region. The data collected showed that most areas of the region were subjected to similarly large temperature fluctuations synoptically, but that in isolated areas, responses were different enough to affect the local kelp beds. However, even with a better picture of temperature regimes across the region, individual beds still reacted differently to what on the surface appeared to be identical stimuli. This illustrates that conditions throughout the Central Region are determined by differing localized factors, which reflect the variability in flow regimes and oceanographic conditions, locally and regionally determined sources of turbidity, the angle of the coastline, and exposure to swells. If the influence is region wide, as seen in early 2009, it may indicate an overarching influence to varying degrees by larger scale meteorological cycles such as Pacific Decadal Oscillation (PDO), and Inter-decadal Pacific Oscillation (IPO), as well as the better understood ENSOs.

The 2011 kelp study demonstrated that oceanographic environmental factors controlled the fate of the Central Region kelp beds. 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

Bedford, D. 2004. Dennis Bedford is a marine biologist, working for the Department of Fish and Game, coordinating photographic overflights of the kelp beds of northern California and the offshore islands. Los Alamitos, California.

Curtis, M. 2003, 2010. Mike Curtis is a marine biologist working on kelp ecosystems for MBC Applied Environmental Sciences in Costa Mesa, California.

Elwany, H. 2007. Oceanographer and Coastal Engineer, CE Coastal Environments.

Morris, K. 1995. 16 March 1995. Kevin Morris fishes both freshwater and salt. He is a respected fisherman among his peers and has written numerous articles for fishing magazines. He reported that in several trips in April and May (remembers month because kelp bass were just beginning to spawn) of 1987 and 1988 that he would see two or three giant kelp per trip just below the surface while fishing in 60 to 80 ft depths in different areas of the banks. This is consistent with records of kelp growing on the submerged oil island riprap at the mouth of Huntington Harbor during this same period.

North, W. 2000. Dr. Wheeler North was a well-published and respected kelp ecologist with California Institute of Technology. Dr. North passed away in 2002.

Pondella, D.J. 2012. Presentation to OCMPAC Symposium.

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.

Simonin, E. 1994. 25 May 1994. Edward Simonin is a retired high school principal from the Long Beach area. Mr. Simonin fished the Horseshoe Kelp area with his father on their boat the Moonstone in the late 1920s and 1930s. Mr. Simonin is still fishing off of the boat the Moonstone IV and has continued to fish the Horseshoe Kelp area frequently since the late 1920s.

Wilson, K. 1986. Ken Wilson is a California Department of Fish and Game Biologist who previously worked on the kelp beds of Southern California for the Department on the Nearshore Sport Fish Habitat Enhancement Project.

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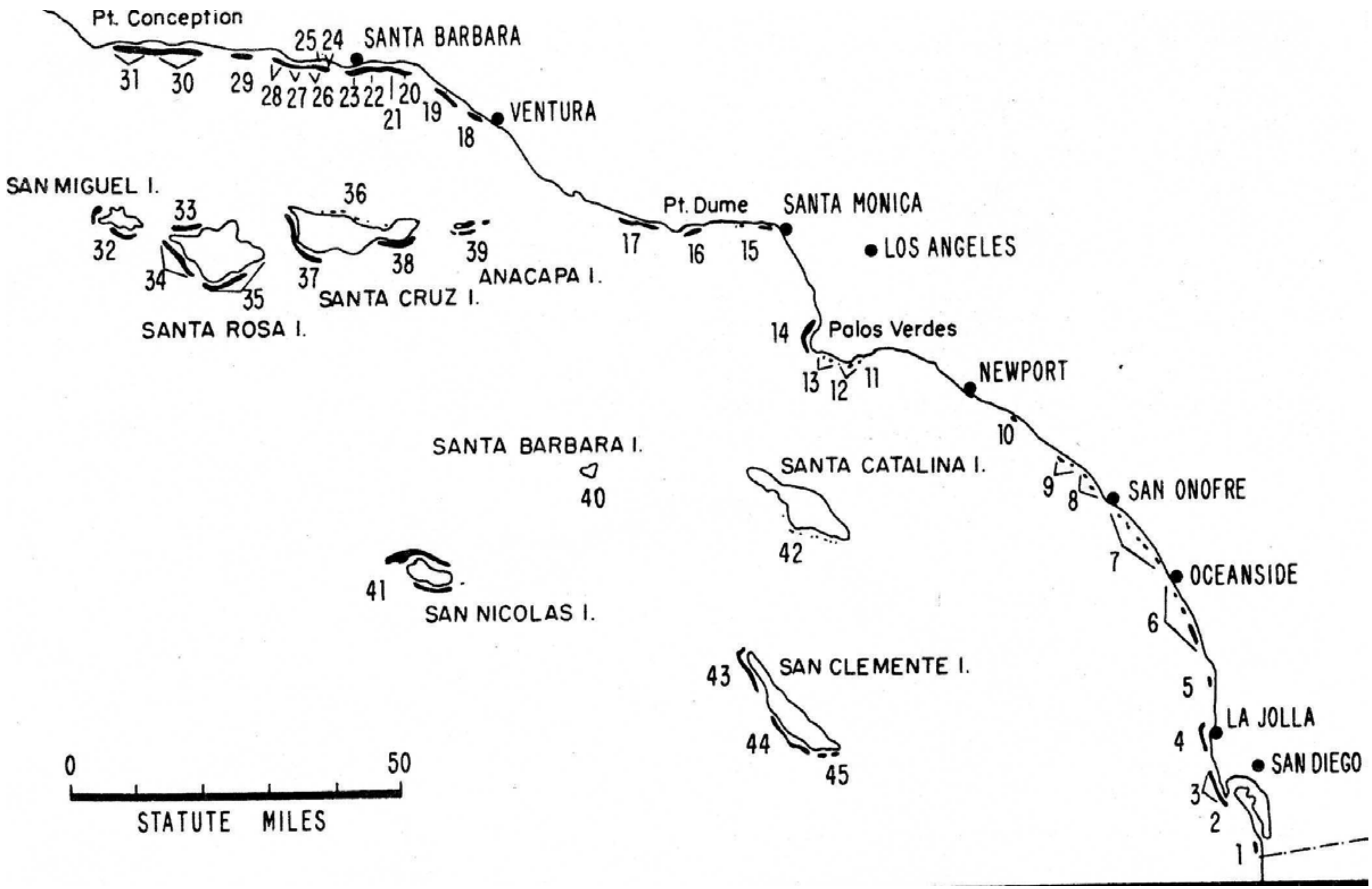
APPENDIX A

Kelp Canopy Maps

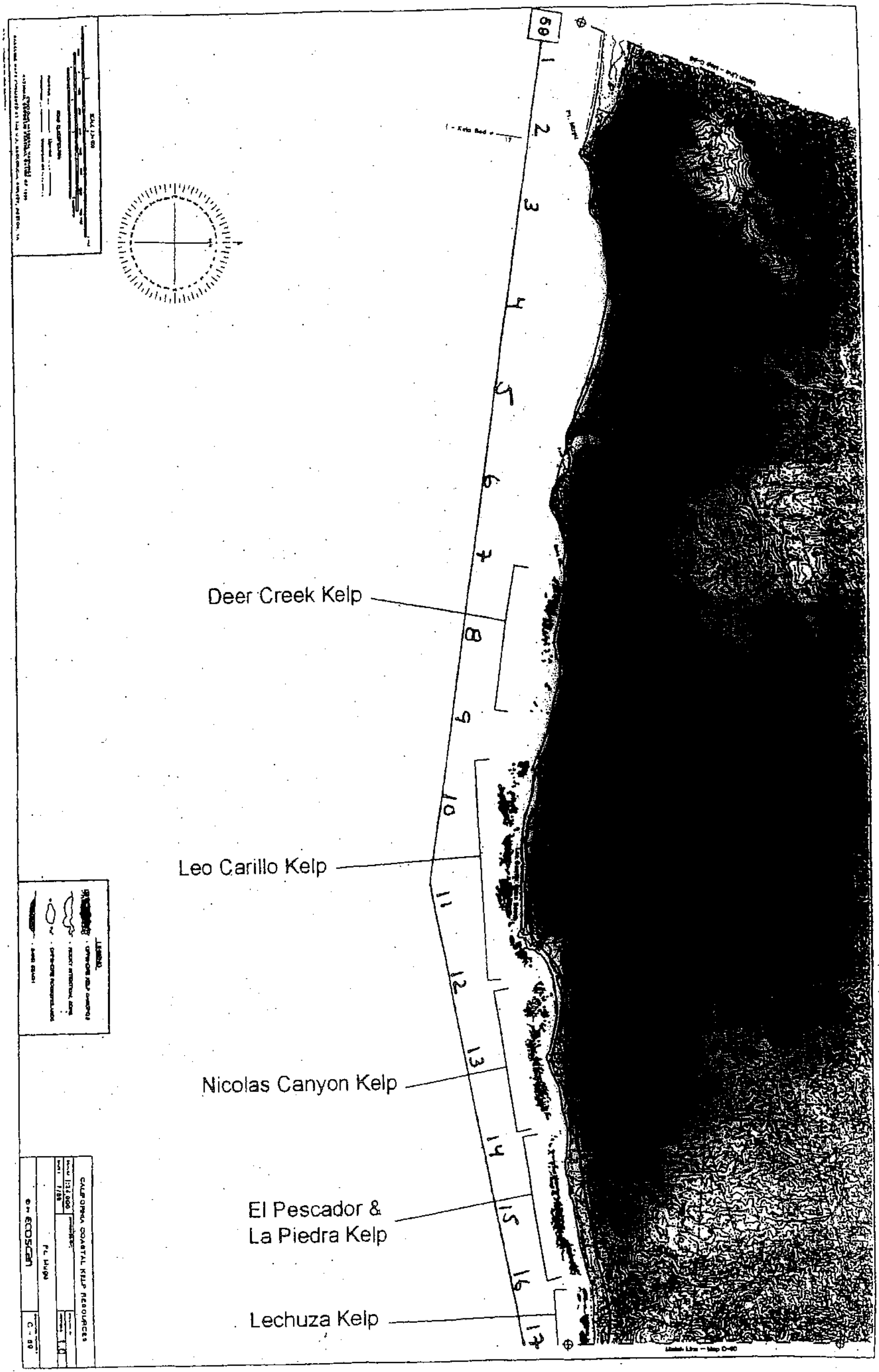


Appendix A. Fish and Game designated kelp bed numbers in the Southern California Bight.

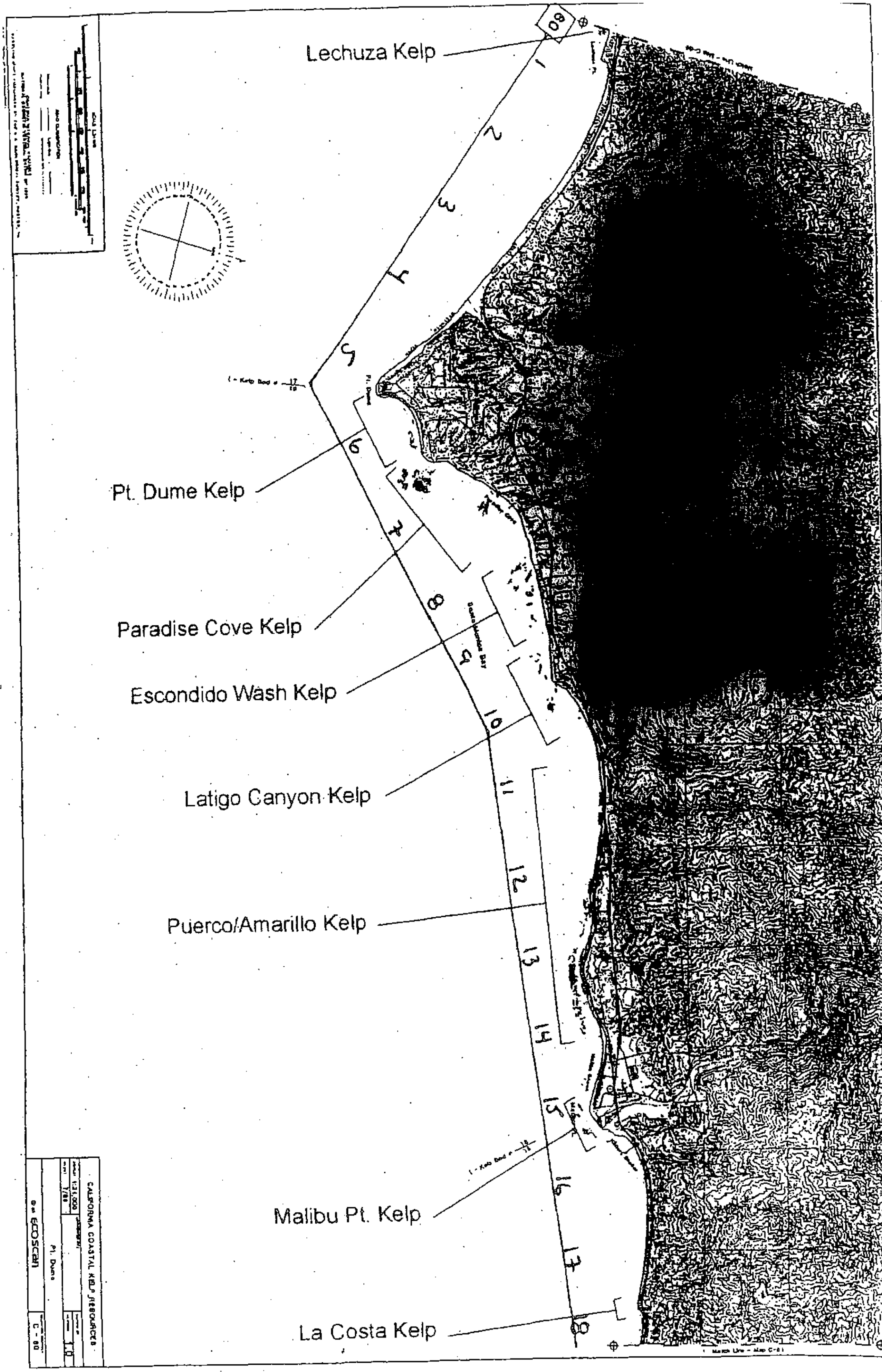
Kelp Slide Atlas

Central Region

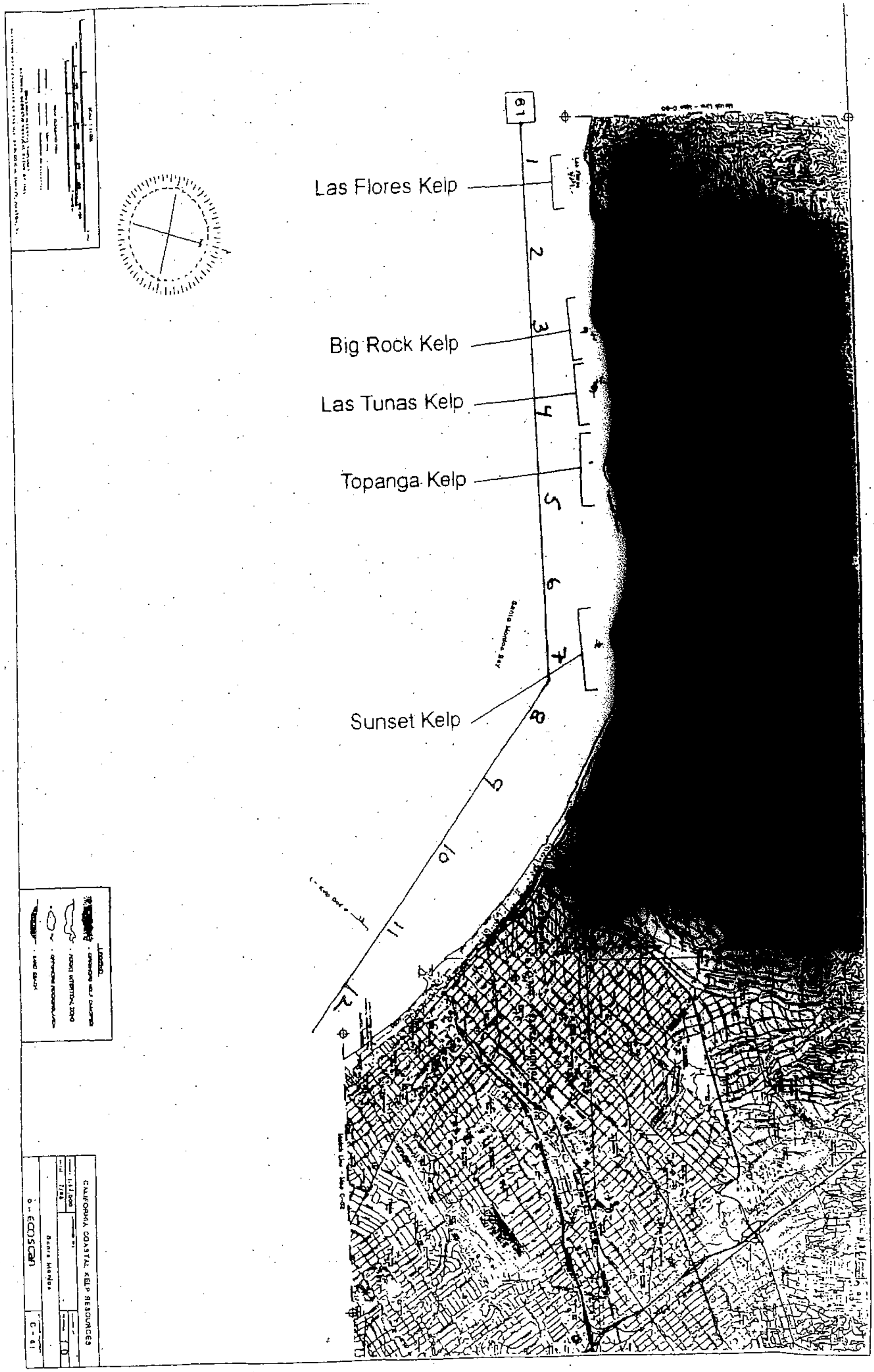
Kelp Bed	Map No.	Shot Nos
Ventura Harbor	57	1,2,3,4
Channel Islands Harbor	58	1--6
Port Hueneme	58	7,8,9,10
Deer Creek	59	5--9
Leo Carillo	59	9--12
Nicolas Canyon	59	12--14
El Pescador/La Piedra	59	14-16
Lechuza Kelp	59, 60	16, 1, 2
Point Dume	60	4--7
Paradise Cove	60	6--8
Escondido Wash	60	7--10
Latigo canyon	60	9--11
Puerco/Amarillo	60	11--14
Malibu Pt.	60	14--16
La Costa	60	17--18
Las Flores	61	1--2
Big Rock	61	2--4
Las Tunas	61	3--5
Topanga	61	4--6
Sunset	61	6--11
Marina Del Rey	62	4,5
Redondo Breakwater	62	16--18
Malaga Cove - PV Point (IV)	63	1--7
PV Point - Point Vicente (III)	63	7--11
Point Vicente - Inspiration Point (II)	63	11--18
Inspiration Point - Point Fermin (I)	63	18--25
Cabrillo	63	25--28
LB/LA Harbor and Breakwaters	63, 64	28--51, 1--32
Horseshoe Kelp	63	
Huntington Flats	64	39--43
Newport Harbor	65	15-18
Corona Del Mar	65, 66	17--20, 1--3
North Laguna Beach	66	4--6



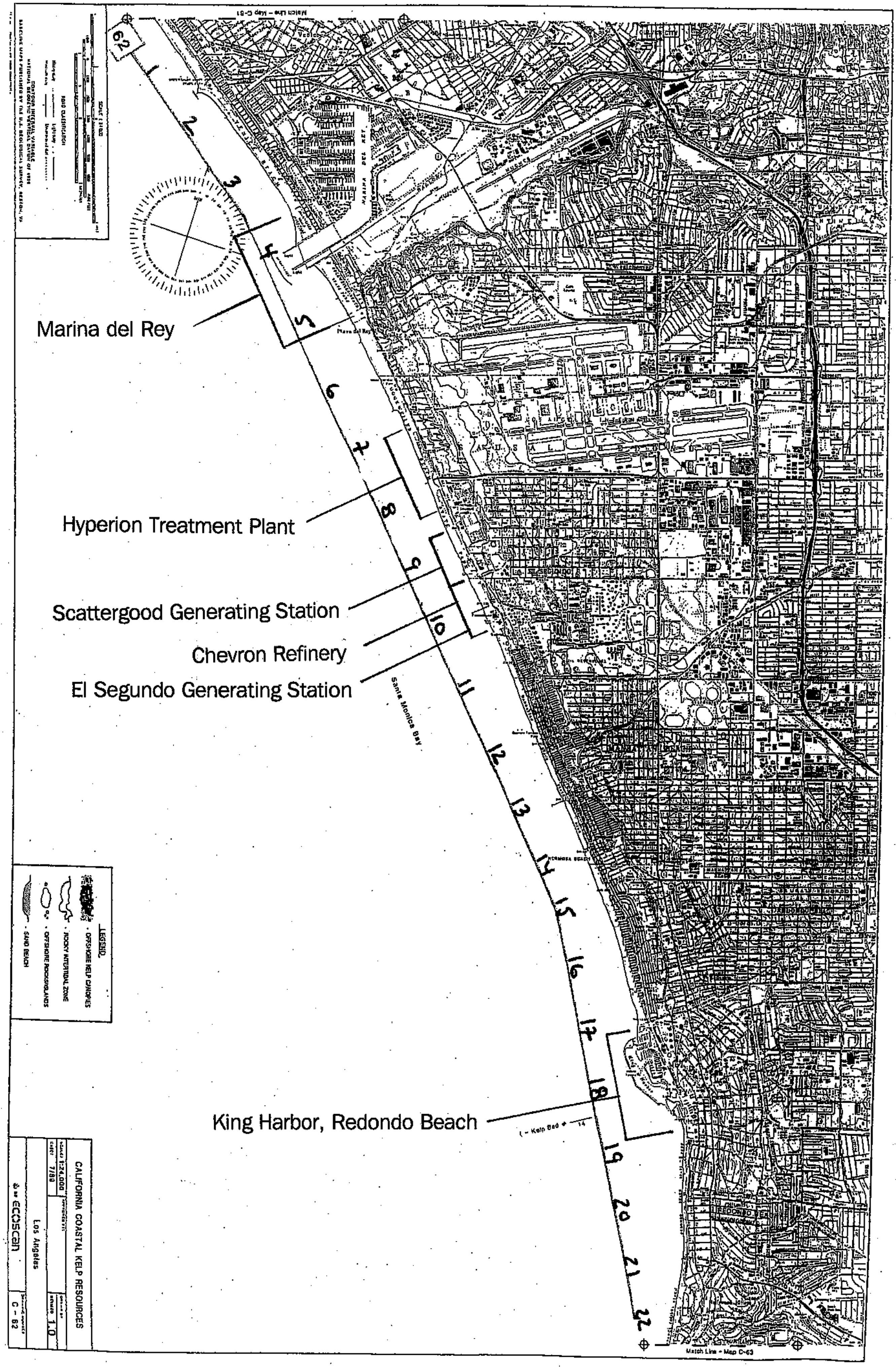
Deer Creek Kelp
Leo Carillo Kelp
Nicolas Canyon Kelp
El Pescador &
La Piedra Kelp
Lechuza Kelp
CALIFORNIA COASTAL KELP RESOURCES

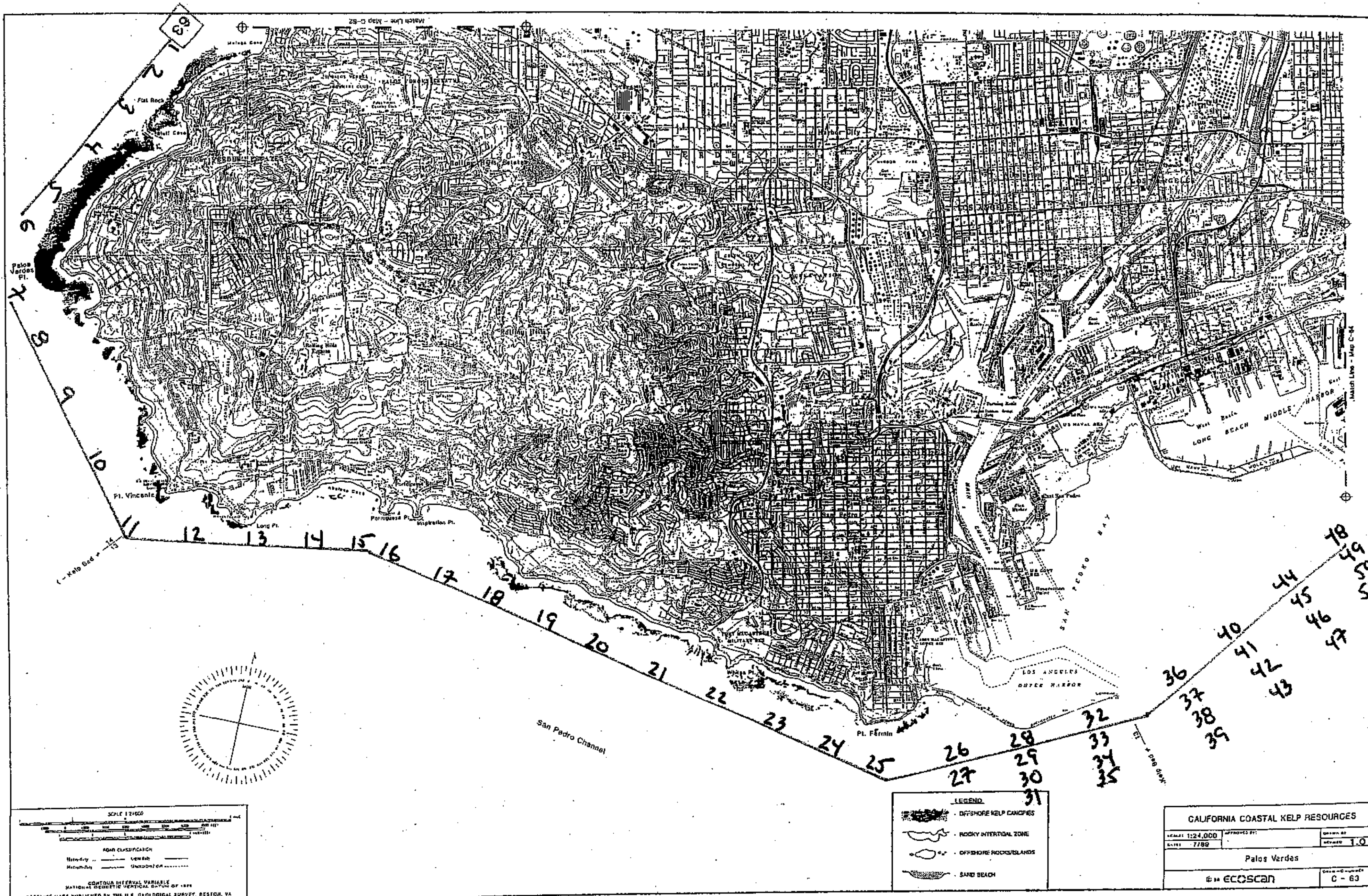


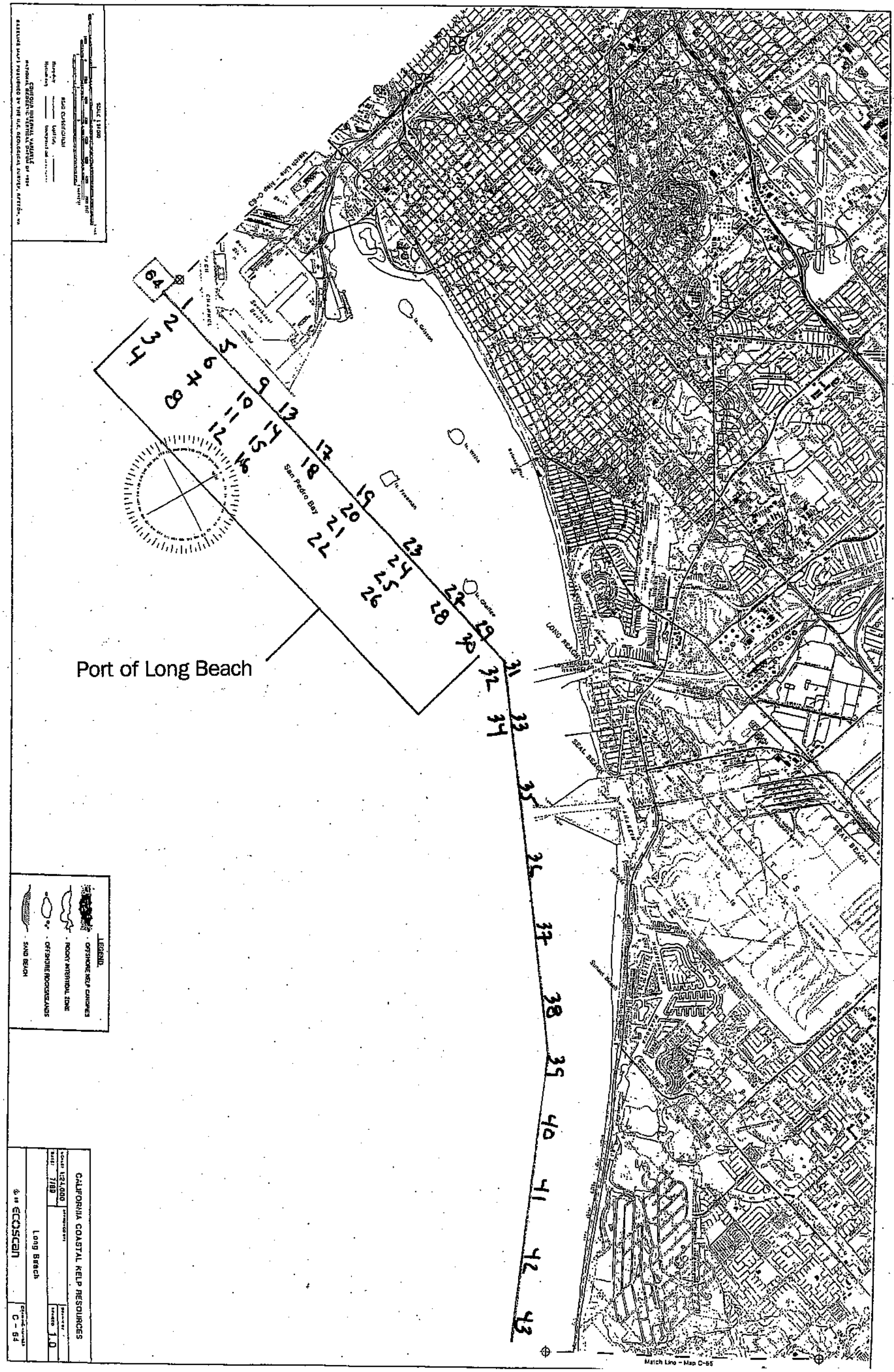
Lechuza Kelp
Pt. Dume Kelp
Paradise Cove Kelp
Escondido Wash Kelp
Latigo Canyon Kelp
Puerco/Amarillo Kelp
Malibu Pt. Kelp
La Costa Kelp
CALIFORNIA COASTAL KELP RESOURCES
Pt. Dume
ECOSCAN
C - 80

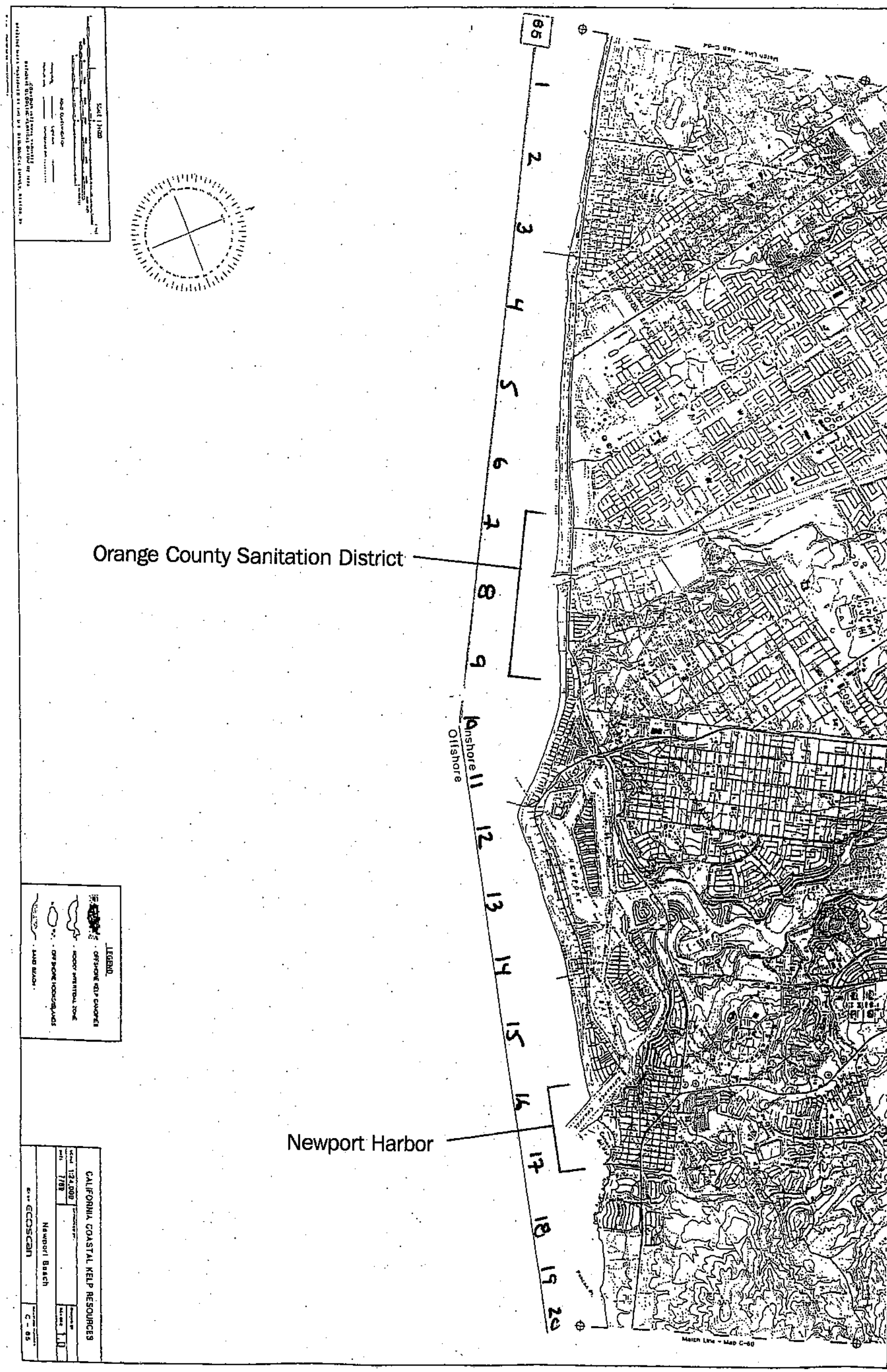


61
Las Flores Kelp
Big Rock Kelp
Las Tunas Kelp
Topanga Kelp
Sunset Kelp
1
2
3
4
5
6
7
8
9
10
11
12
CALIFORNIA COASTAL KELP RESOURCES

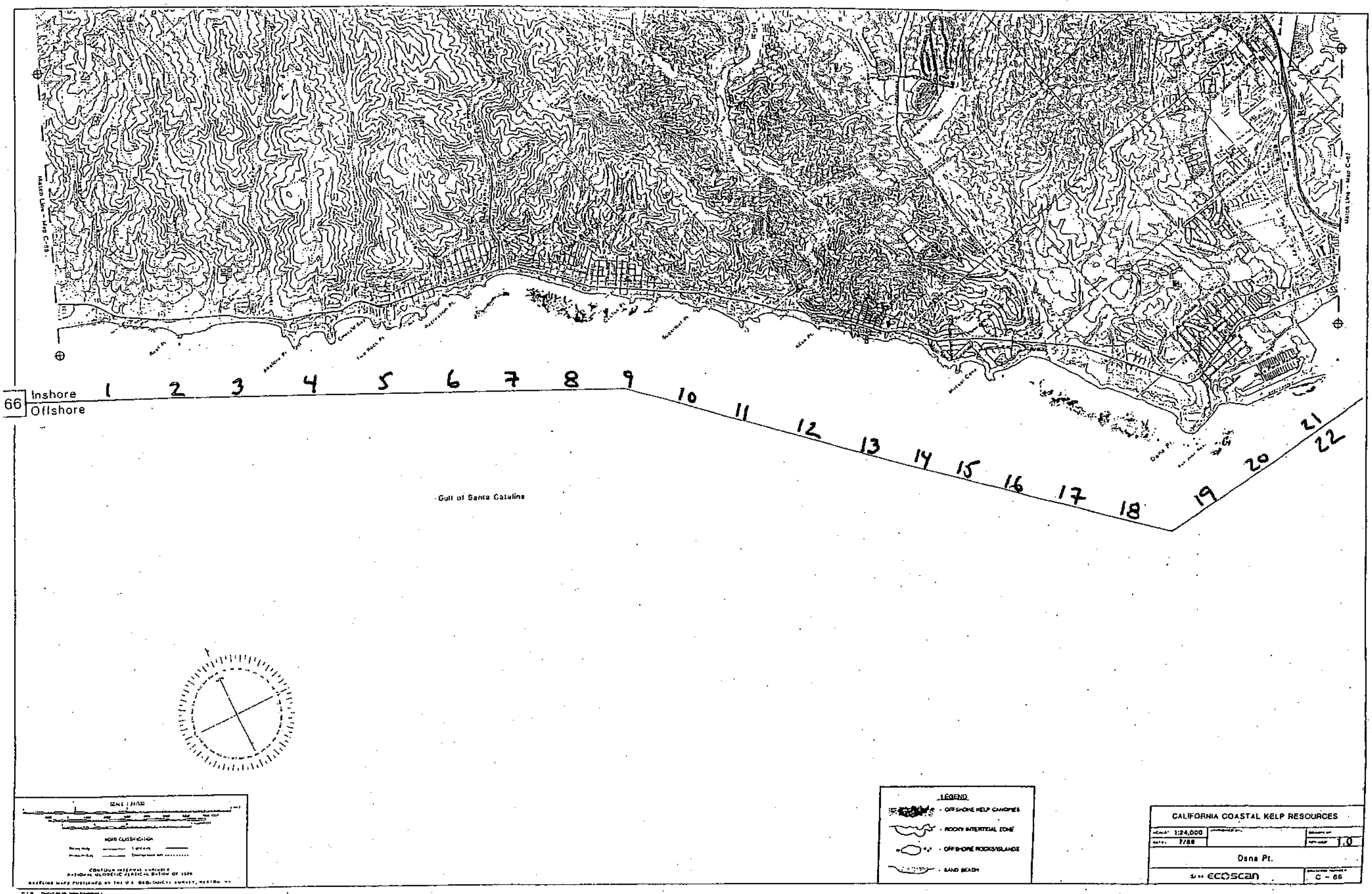

Marina del Rey
Hyperion Treatment Plant
Scattergood Generating Station
Chevron Refinery
El Segundo Generating Station
King Harbor, Redondo Beach
Santa Monica Bay
Match Line - Map C-63
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
Los Angeles
ecoscan
C - 62

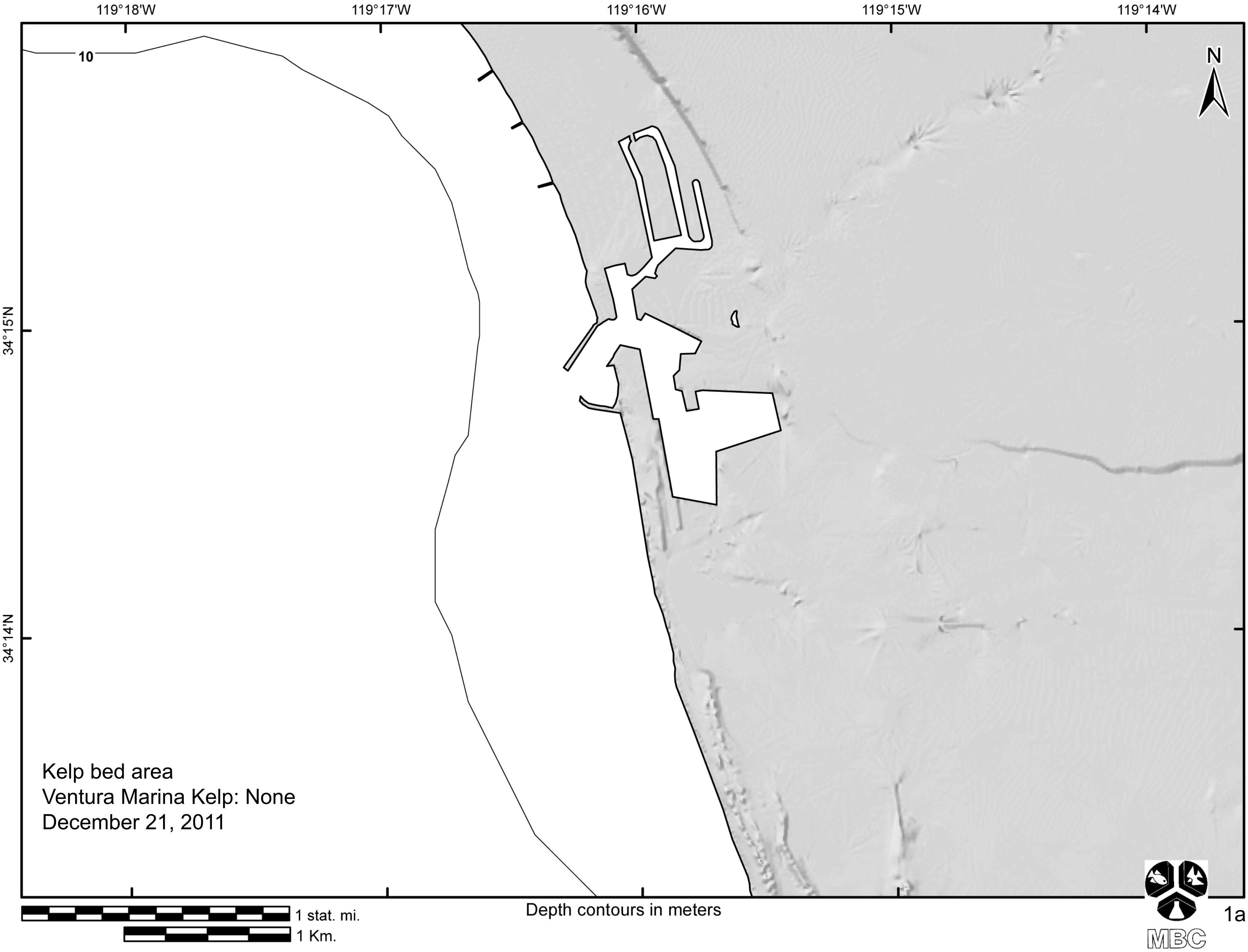

CALIFORNIA COASTAL KELP RESOURCES
SCALE 1:24,000
DATE 7/89
REVISED 1.0
Palos Verdes
ECOSCAN
C - 63
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
Match Line - Map C-62
Match Line - Map C-64
Kelp Bed # 14
Kelp Bed # 13
63
Palos Verdes Pt.
Flat Rock
Malaga Cove
Pt. Vicente
Long Pt.
Portuguese Pt.
Inspiration Pt.
Pt. Fermin
San Pedro Channel
SAN PEDRO BAY
LOS ANGELES OUTER HARBOR
MAIN CHANNEL
LONG BEACH MIDDLE HARBOR
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51


Port of Long Beach
San Pedro Bay
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
Long Beach
C - 64
ECOSCAN
Match Line - Map C-65



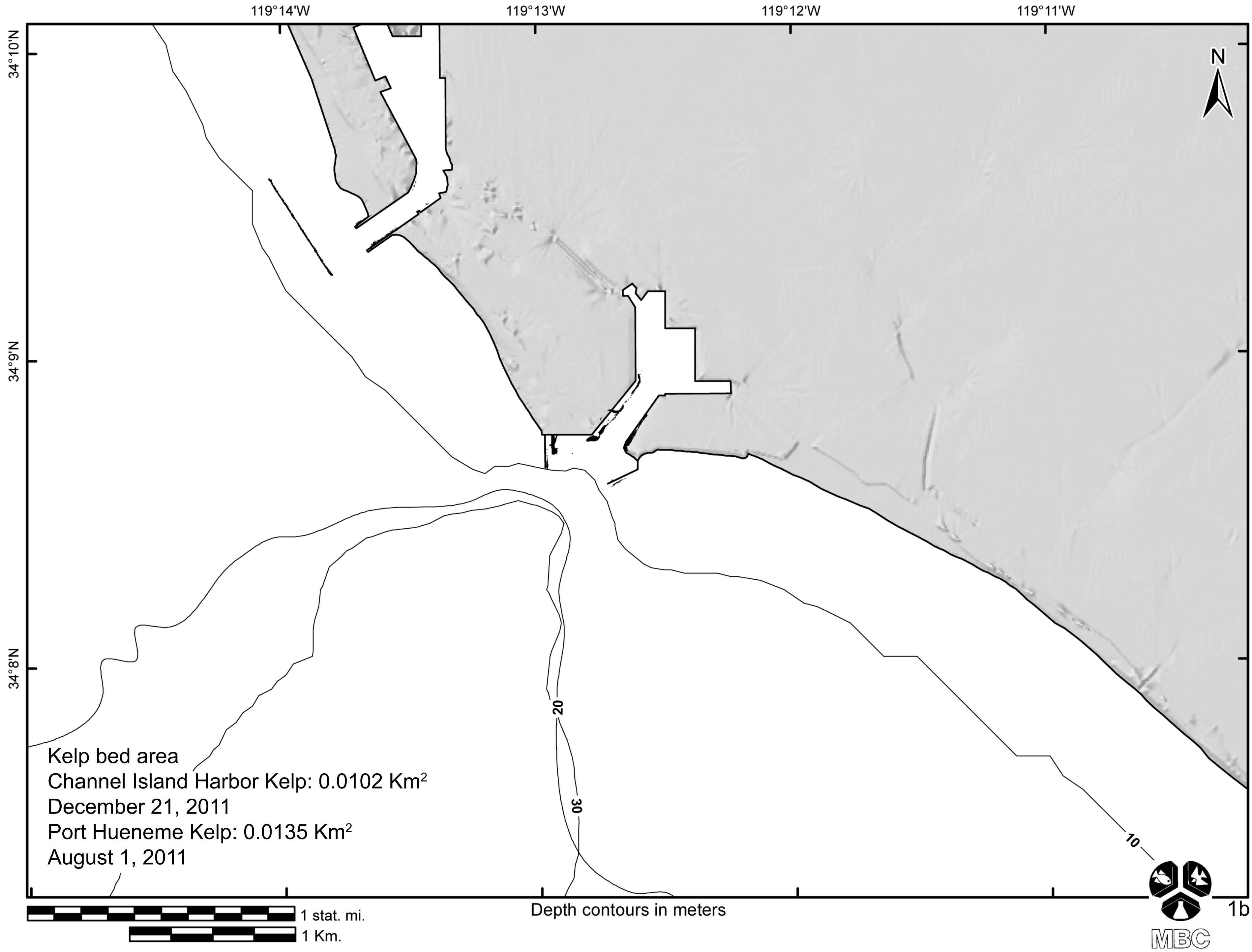
Orange County Sanitation District
Newport Harbor
85
1
2
3
4
5
6
7
8
9
10
Inshore
Offshore
11
12
13
14
15
16
17
18
19
20
CALIFORNIA COASTAL KELP RESOURCES
Newport Beach
C - 85
ecoscan
LEGEND


66
Inshore
Offshore
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Gulf of Santa Catalina
Dana Pt.
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/88
1.0
Dana Pt.
ecoscan
C - 66

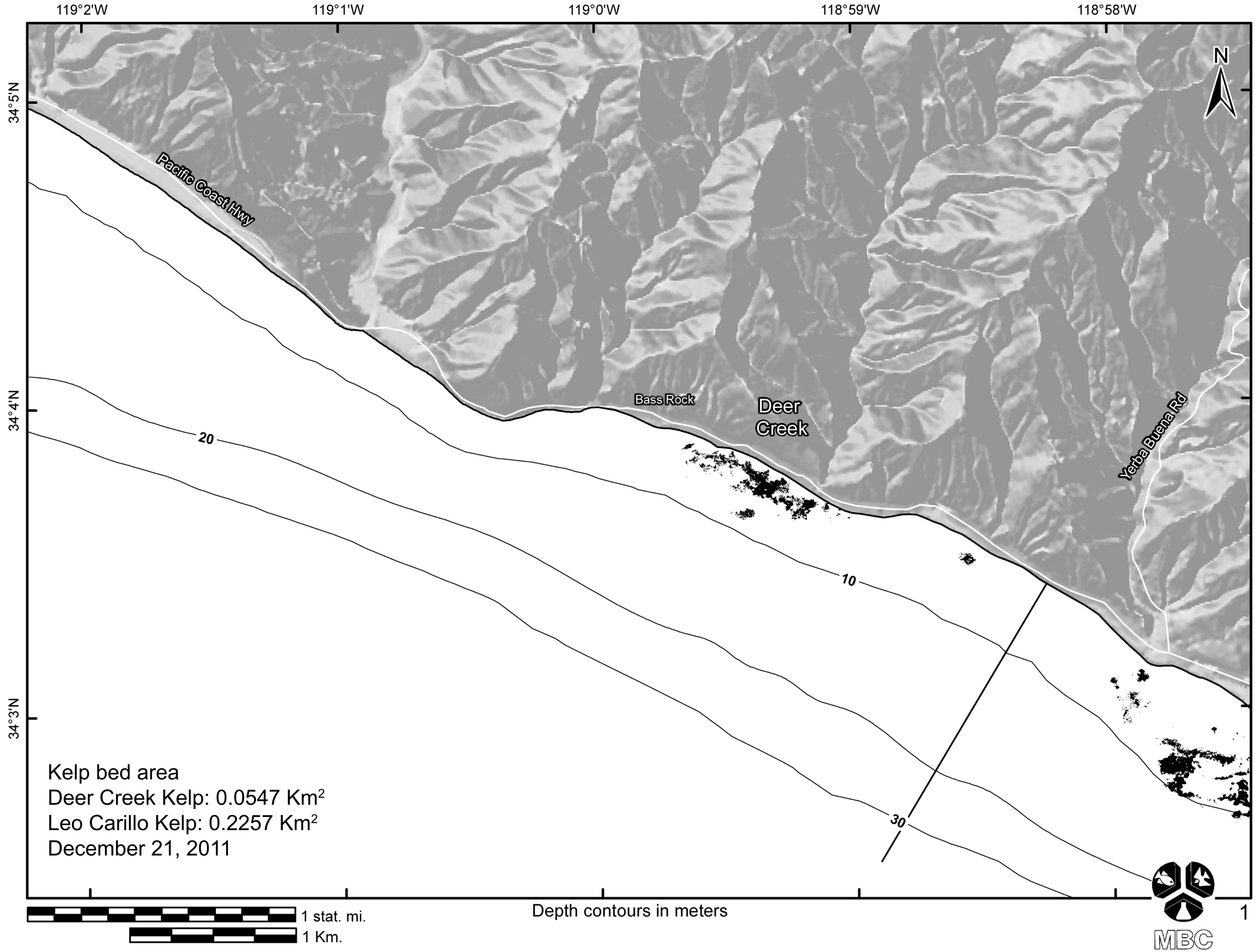


119°18'W
119°17'W
119°16'W
119°15'W
119°14'W
34°15'N
34°14'N
10
N
Kelp bed area
Ventura Marina Kelp: None
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

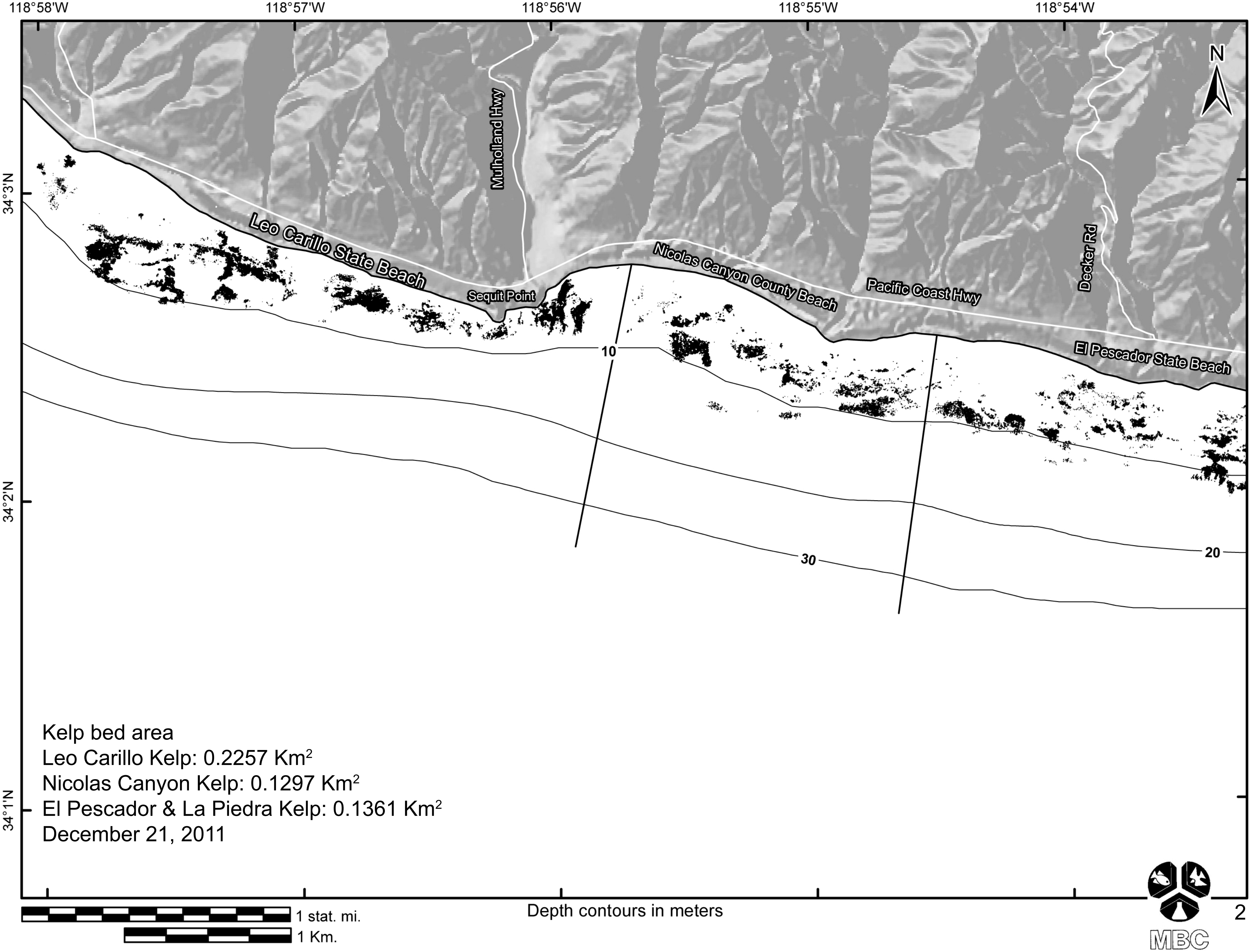
1a

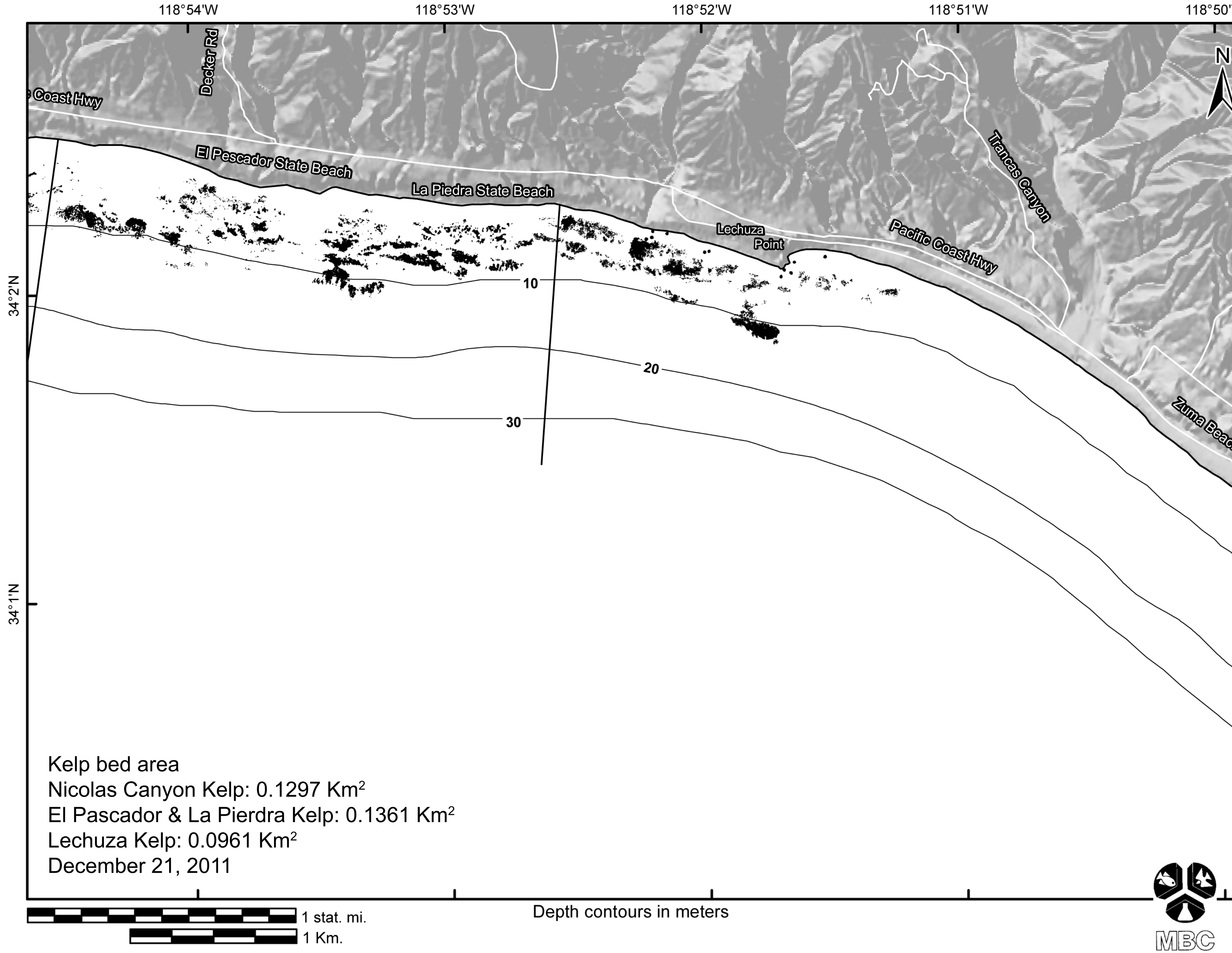

119°14'W
119°13'W
119°12'W
119°11'W
34°10'N
34°9'N
34°8'N
N
20
30
10
Kelp bed area
Channel Island Harbor Kelp: 0.0102 Km2
December 21, 2011
Port Hueneme Kelp: 0.0135 Km2
August 1, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

1b

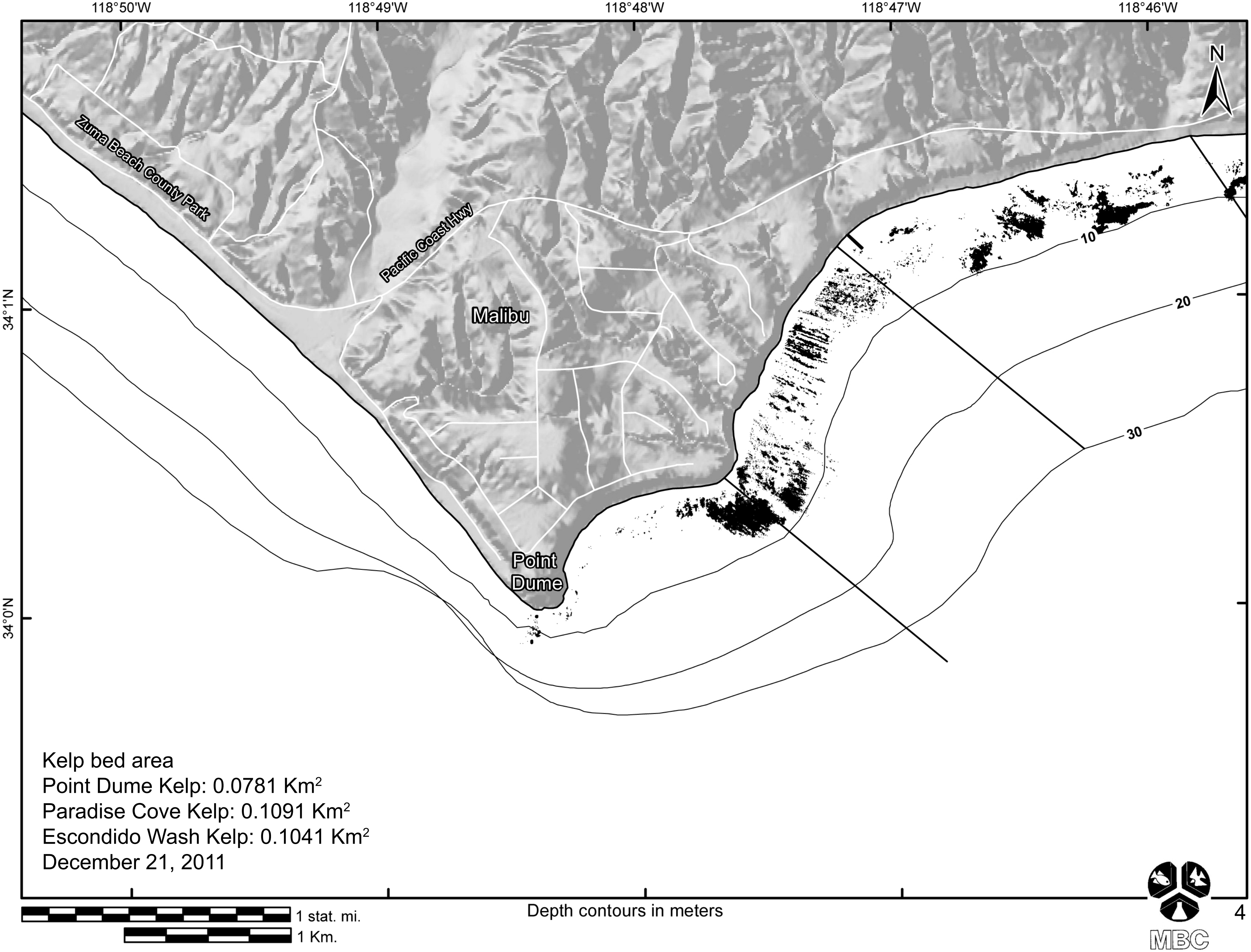


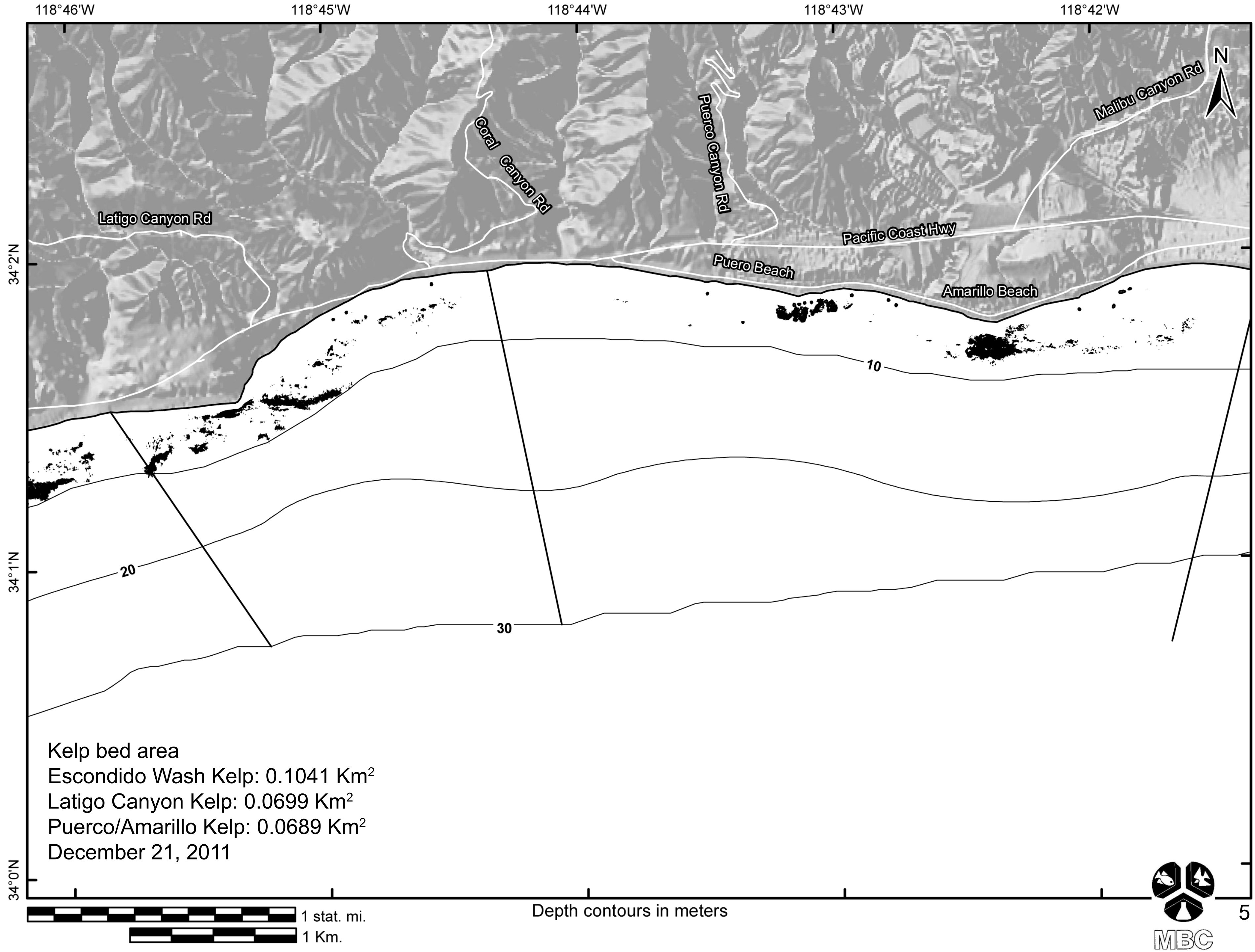
119°2'W
119°1'W
119°0'W
118°59'W
118°58'W
34°5'N
34°4'N
34°3'N
N
Pacific Coast Hwy
Bass Rock
Deer Creek
Yerba Buena Rd
20
10
30
Kelp bed area
Deer Creek Kelp: 0.0547 Km²
Leo Carillo Kelp: 0.2257 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

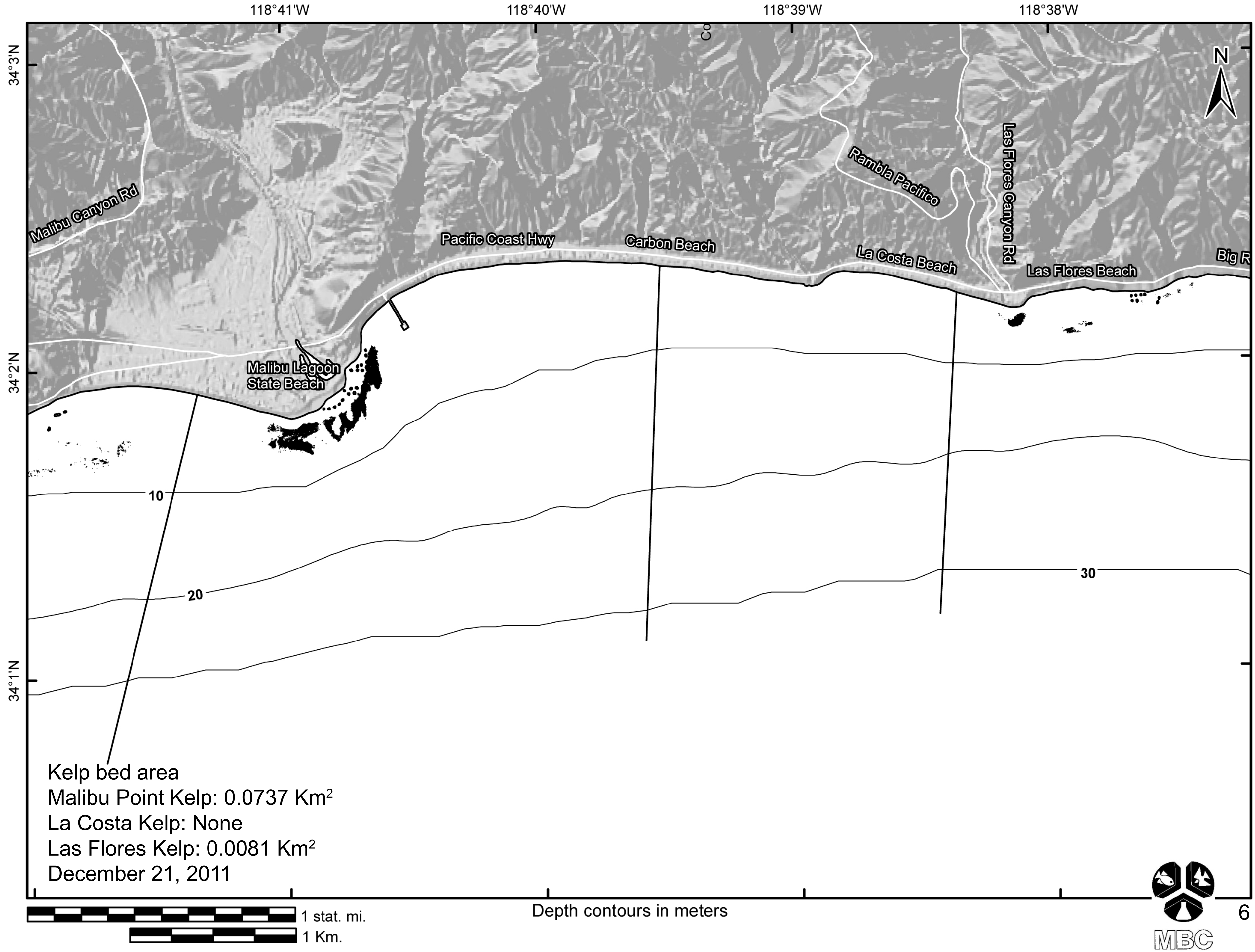

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°3'N
34°2'N
34°1'N
N
Mulholland Hwy
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Decker Rd
El Pescador State Beach
10
20
30
Kelp bed area
Leo Carillo Kelp: 0.2257 Km2
Nicolas Canyon Kelp: 0.1297 Km2
El Pescador & La Piedra Kelp: 0.1361 Km2
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC



118°54'W
118°53'W
118°52'W
118°51'W
118°50'W
34°2'N
34°1'N
N
Decker Rd
Coast Hwy
El Pescador State Beach
La Piedra State Beach
Lechuza
Point
Pacific Coast Hwy
Trancas Canyon
Zuma Beach Co
10
20
30
Kelp bed area
Nicolas Canyon Kelp: 0.1297 Km2
El Pascador & La Pierdra Kelp: 0.1361 Km2
Lechuza Kelp: 0.0961 Km2
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

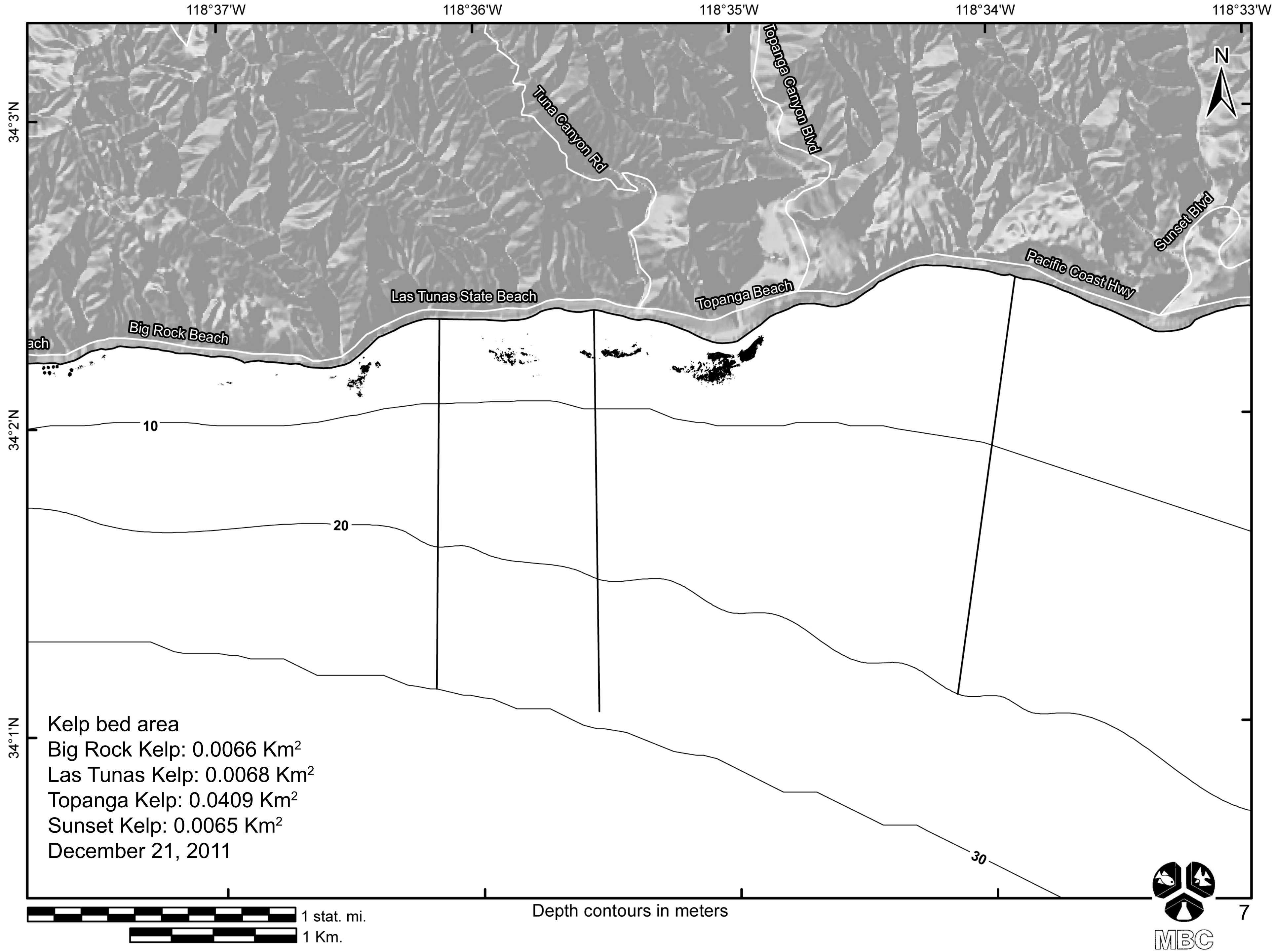

118°50'W
118°49'W
118°48'W
118°47'W
118°46'W
34°1'N
34°0'N
N
Zuma Beach County Park
Pacific Coast Hwy
Malibu
Point Dume
10
20
30
Kelp bed area
Point Dume Kelp: 0.0781 Km²
Paradise Cove Kelp: 0.1091 Km²
Escondido Wash Kelp: 0.1041 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC


118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°2'N
34°1'N
34°0'N
N
Malibu Canyon Rd
Coral Canyon Rd
Puerco Canyon Rd
Latigo Canyon Rd
Pacific Coast Hwy
Puero Beach
Amarillo Beach
10
20
30
Kelp bed area
Escondido Wash Kelp: 0.1041 Km²
Latigo Canyon Kelp: 0.0699 Km²
Puerco/Amarillo Kelp: 0.0689 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

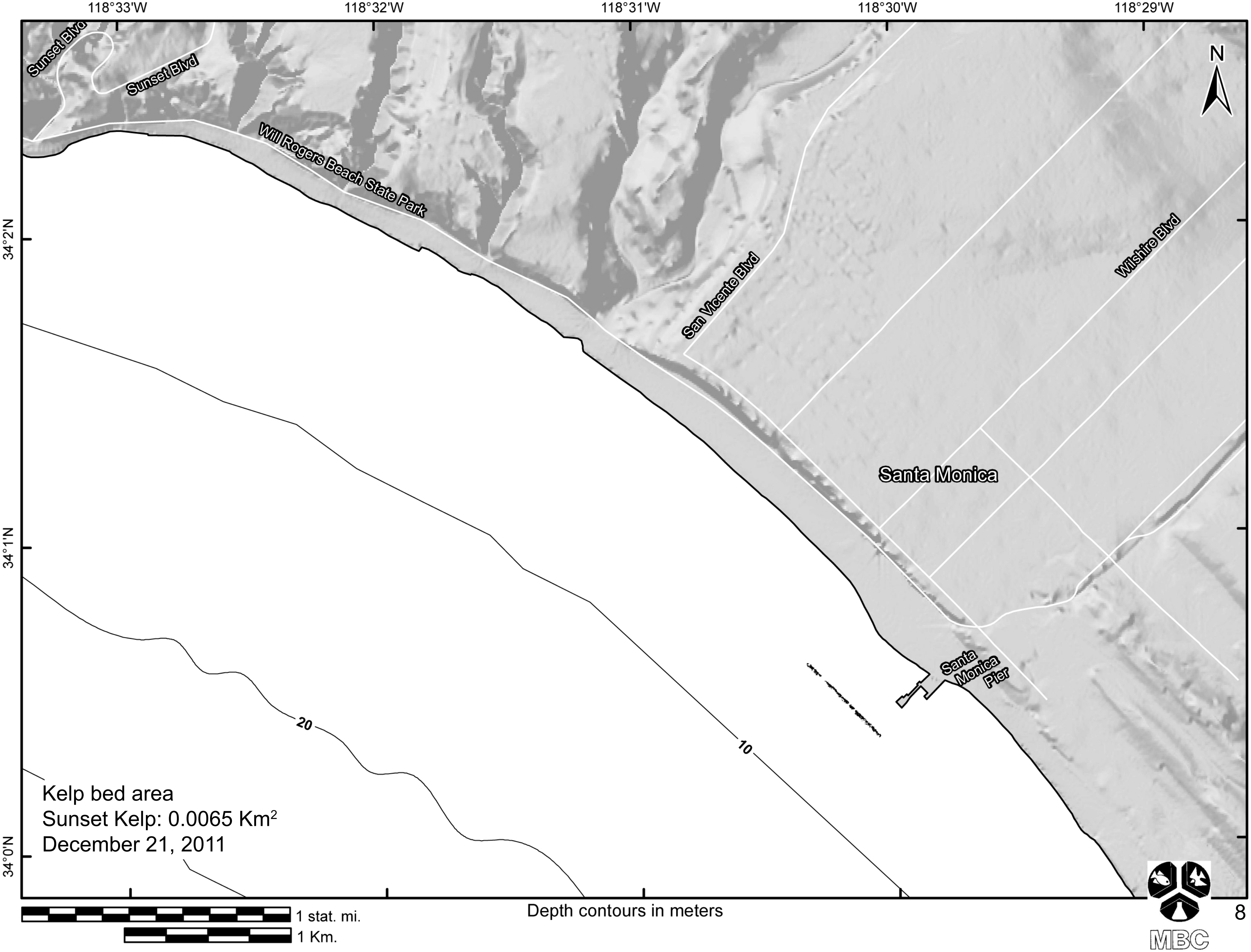


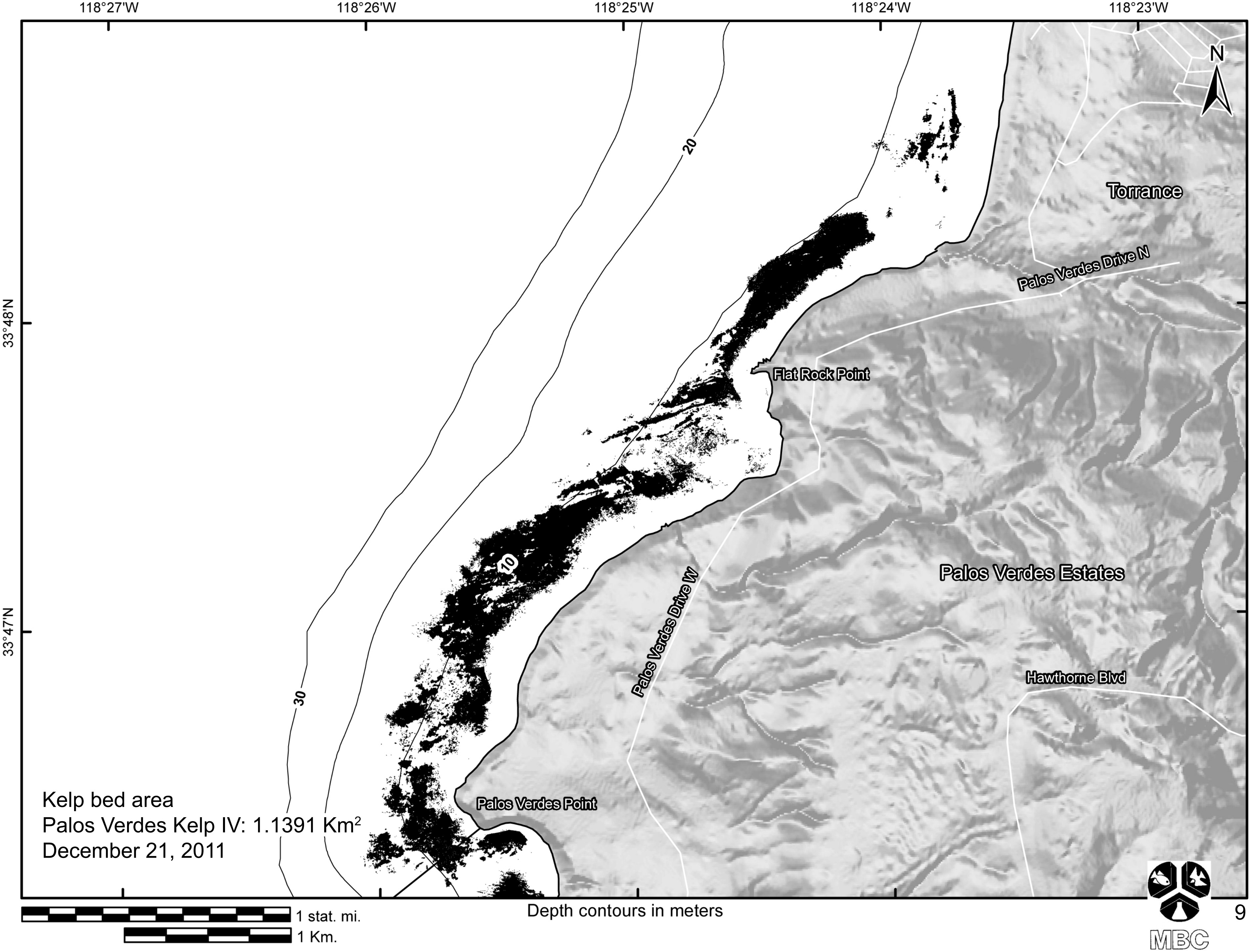
Kelp bed area
Malibu Point Kelp: 0.0737 Km^2
La Costa Kelp: None
Las Flores Kelp: 0.0081 Km^2
December 21, 2011

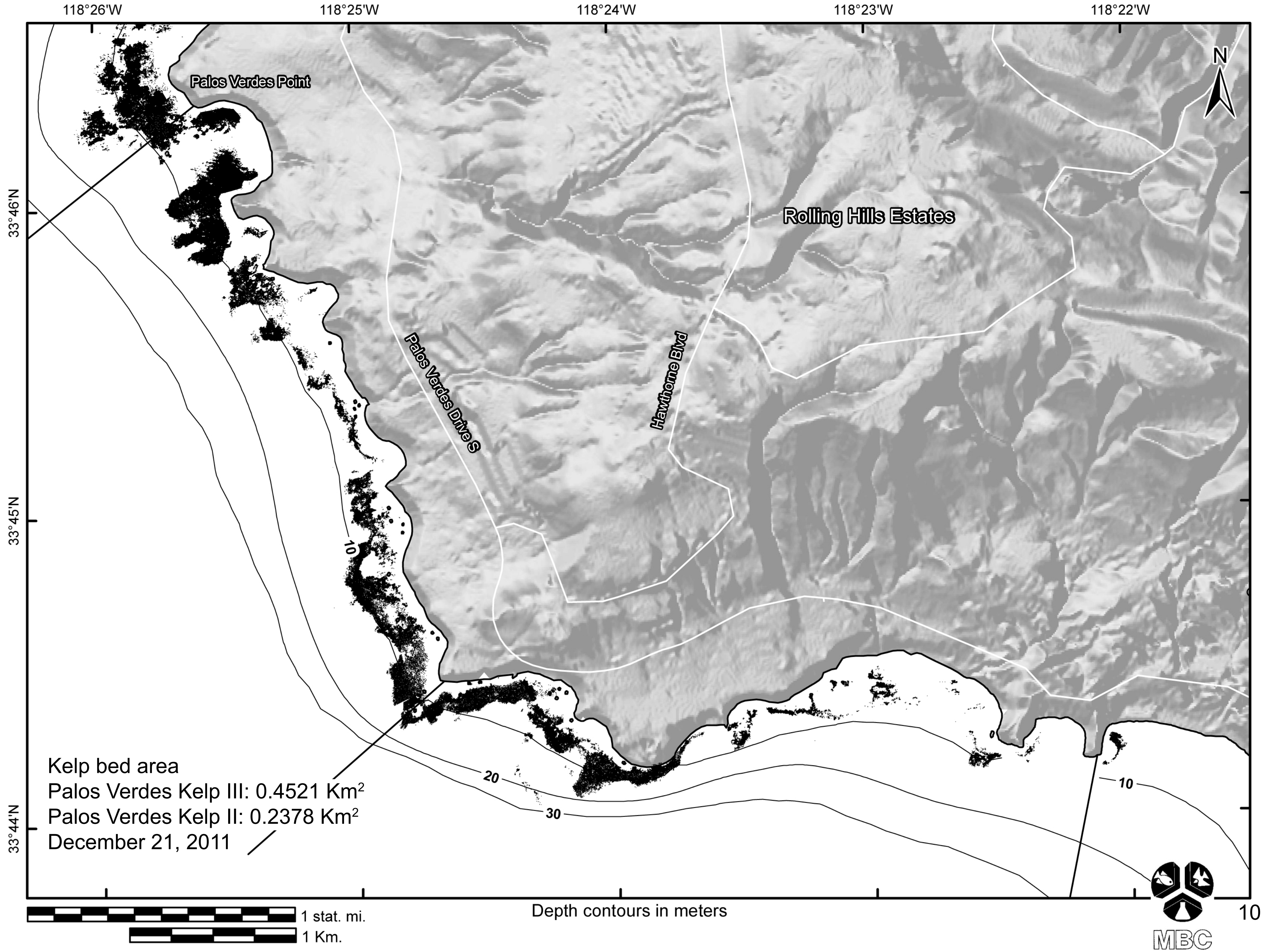
Depth contours in meters

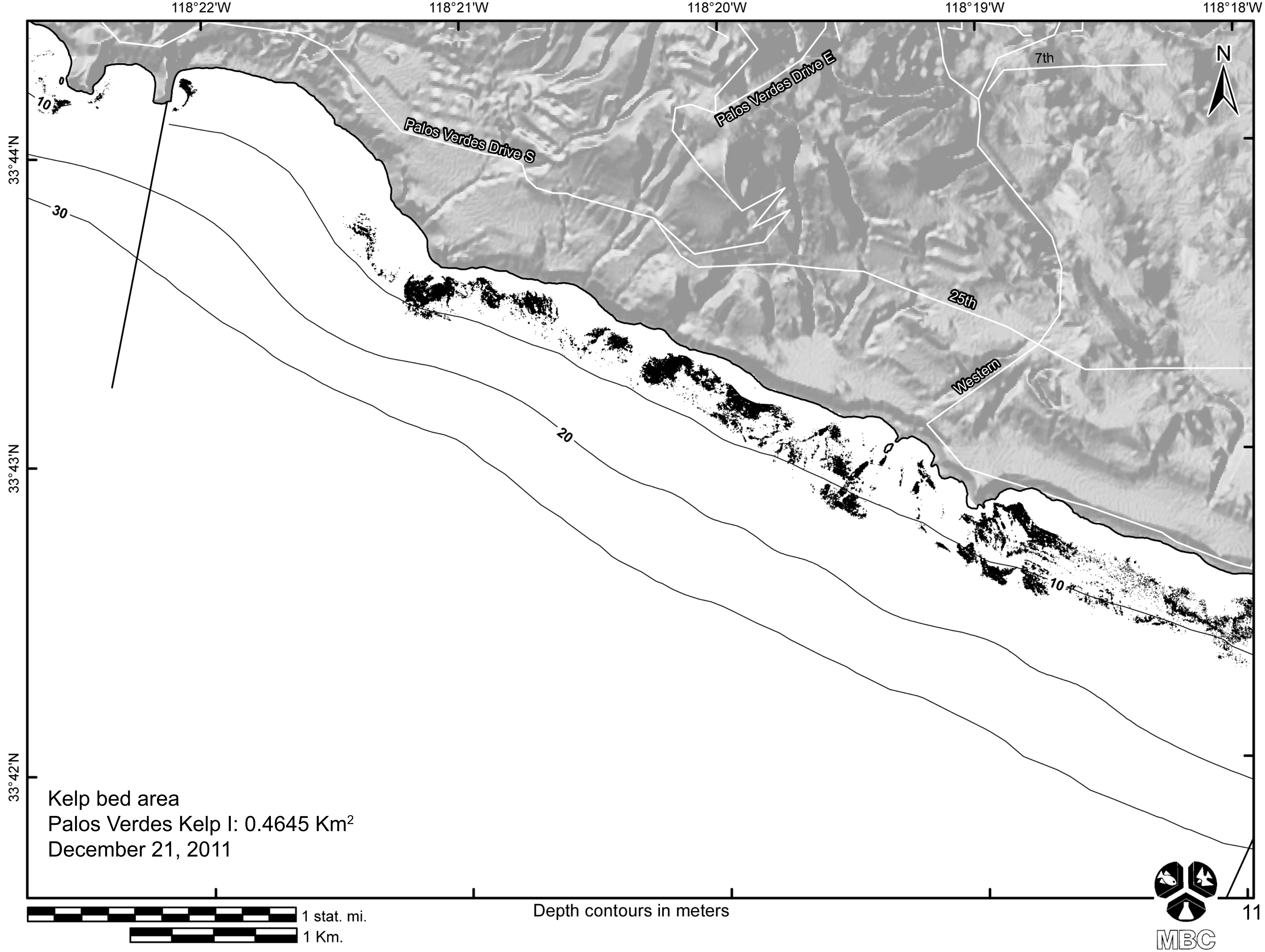


118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°3'N
34°2'N
34°1'N
N
Tuna Canyon Rd
Topanga Canyon Blvd
Sunset Blvd
Pacific Coast Hwy
Las Tunas State Beach
Topanga Beach
Big Rock Beach
10
20
30
Kelp bed area
Big Rock Kelp: 0.0066 Km^2
Las Tunas Kelp: 0.0068 Km^2
Topanga Kelp: 0.0409 Km^2
Sunset Kelp: 0.0065 Km^2
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

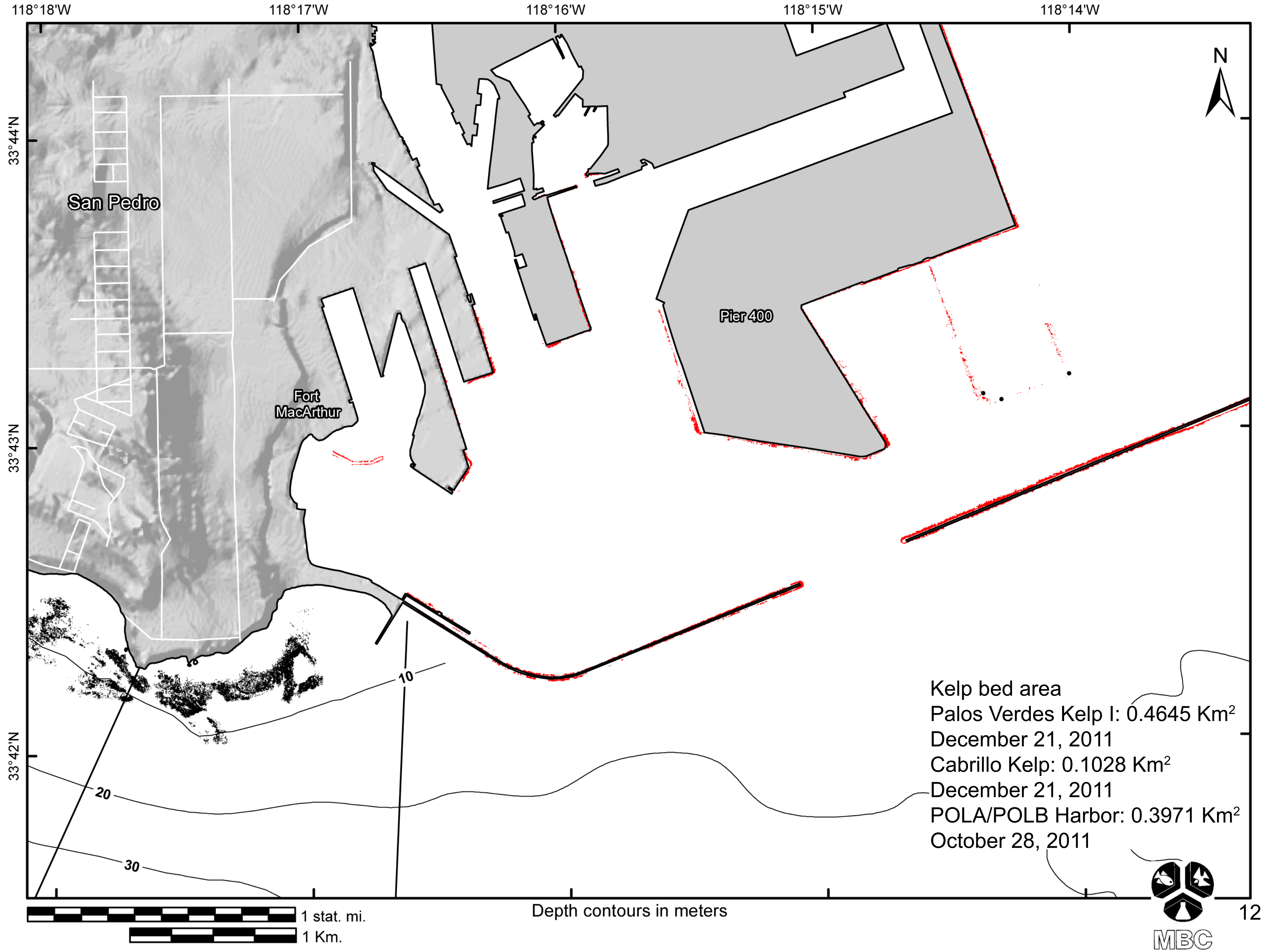

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°2'N
34°1'N
34°0'N
N
Sunset Blvd
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Wilshire Blvd
Santa Monica
Santa Monica Pier
20
10
Kelp bed area
Sunset Kelp: 0.0065 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters


118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
33°48'N
33°47'N
N
Torrance
Palos Verdes Drive N
Flat Rock Point
Palos Verdes Estates
Palos Verdes Drive W
Hawthorne Blvd
Palos Verdes Point
20
10
30
Kelp bed area
Palos Verdes Kelp IV: 1.1391 Km2
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

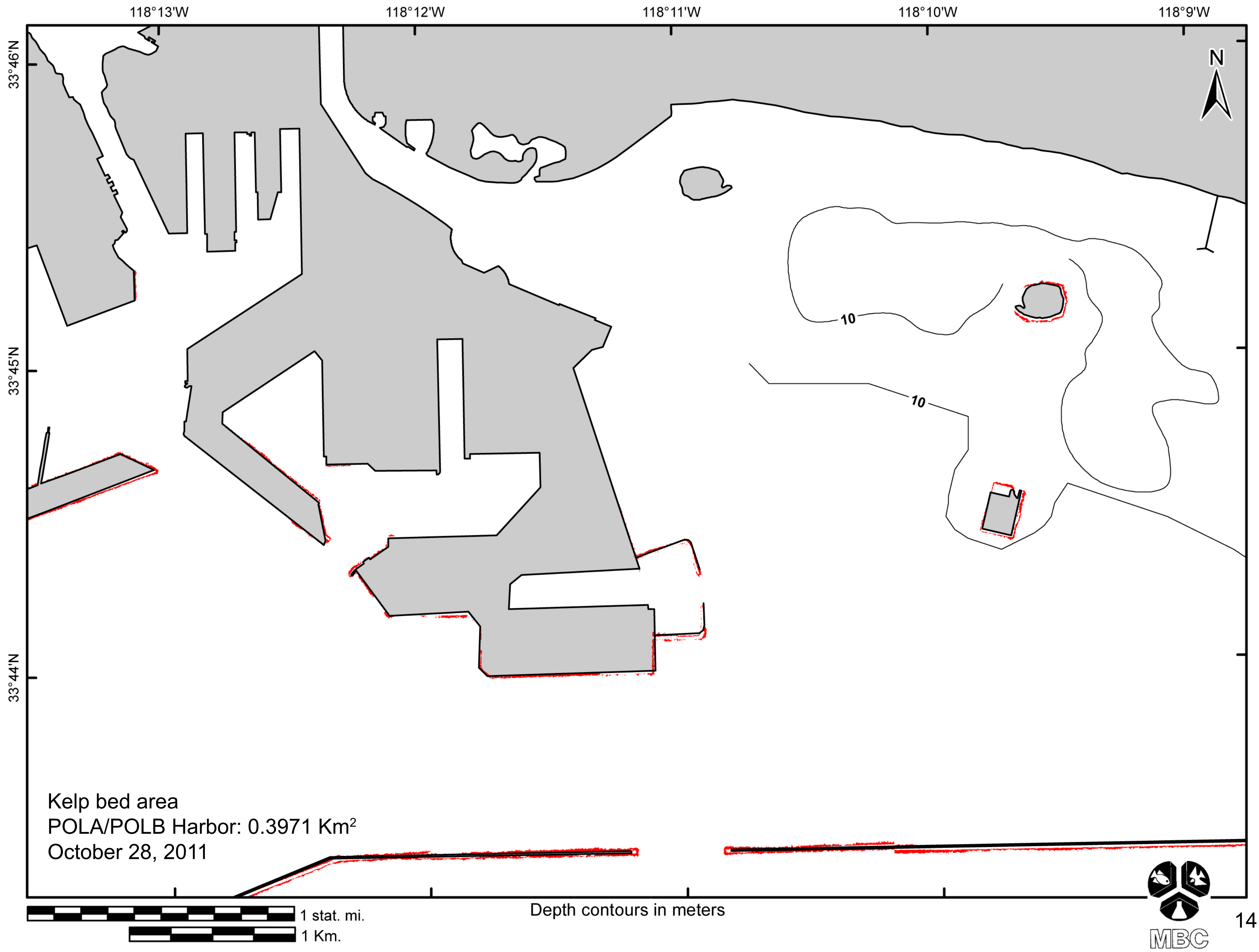

118°26'W
118°25'W
118°24'W
118°23'W
118°22'W
33°46'N
33°45'N
33°44'N
N
Palos Verdes Point
Rolling Hills Estates
Palos Verdes Drive S
Hawthorne Blvd
10
20
30
Kelp bed area
Palos Verdes Kelp III: 0.4521 Km²
Palos Verdes Kelp II: 0.2378 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC



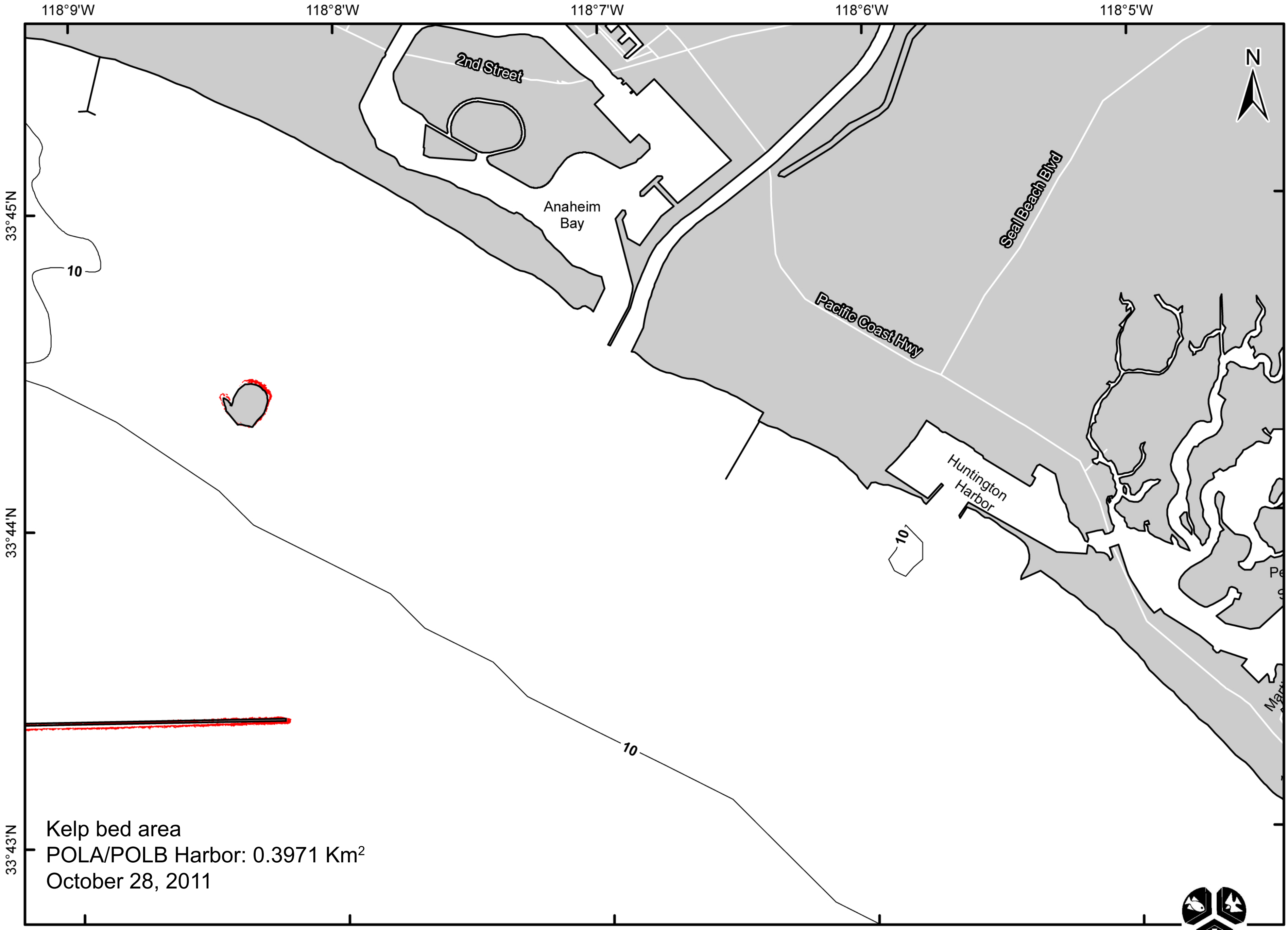
118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
33°44'N
33°43'N
33°42'N
N
Palos Verdes Drive S
Palos Verdes Drive E
7th
25th
Western
10
20
30
Kelp bed area
Palos Verdes Kelp I: 0.4645 Km²
December 21, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC


118°18'W
118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
N
San Pedro
Fort MacArthur
Pier 400
10
20
30
Kelp bed area
Palos Verdes Kelp I: 0.4645 Km2
December 21, 2011
Cabrillo Kelp: 0.1028 Km2
December 21, 2011
POLA/POLB Harbor: 0.3971 Km2
October 28, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC

118°15'W
118°14'W
118°13'W
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
N
10
10
00
Kelp bed area
POLA/POLB Harbor: 0.3971 Km2
October 28, 2011
1 stat. mi.
1 Km.
Depth contours in meters
MBC



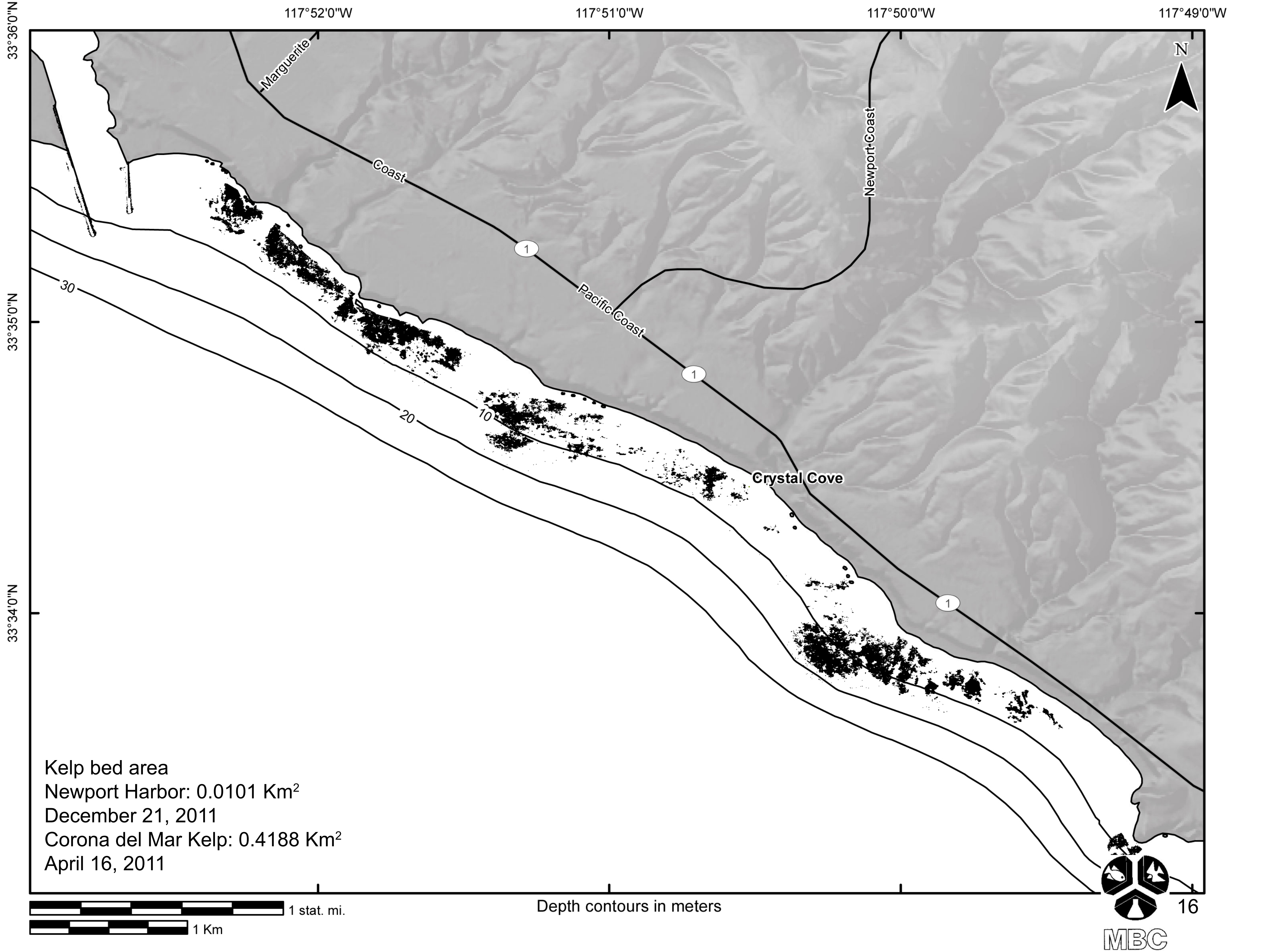
118°13'W
118°12'W
118°11'W
118°10'W
118°9'W
33°46'N
33°45'N
33°44'N
N
10
10
Kelp bed area
POLA/POLB Harbor: 0.3971 Km²
October 28, 2011
1 stat. mi.
1 Km.
Depth contours in meters

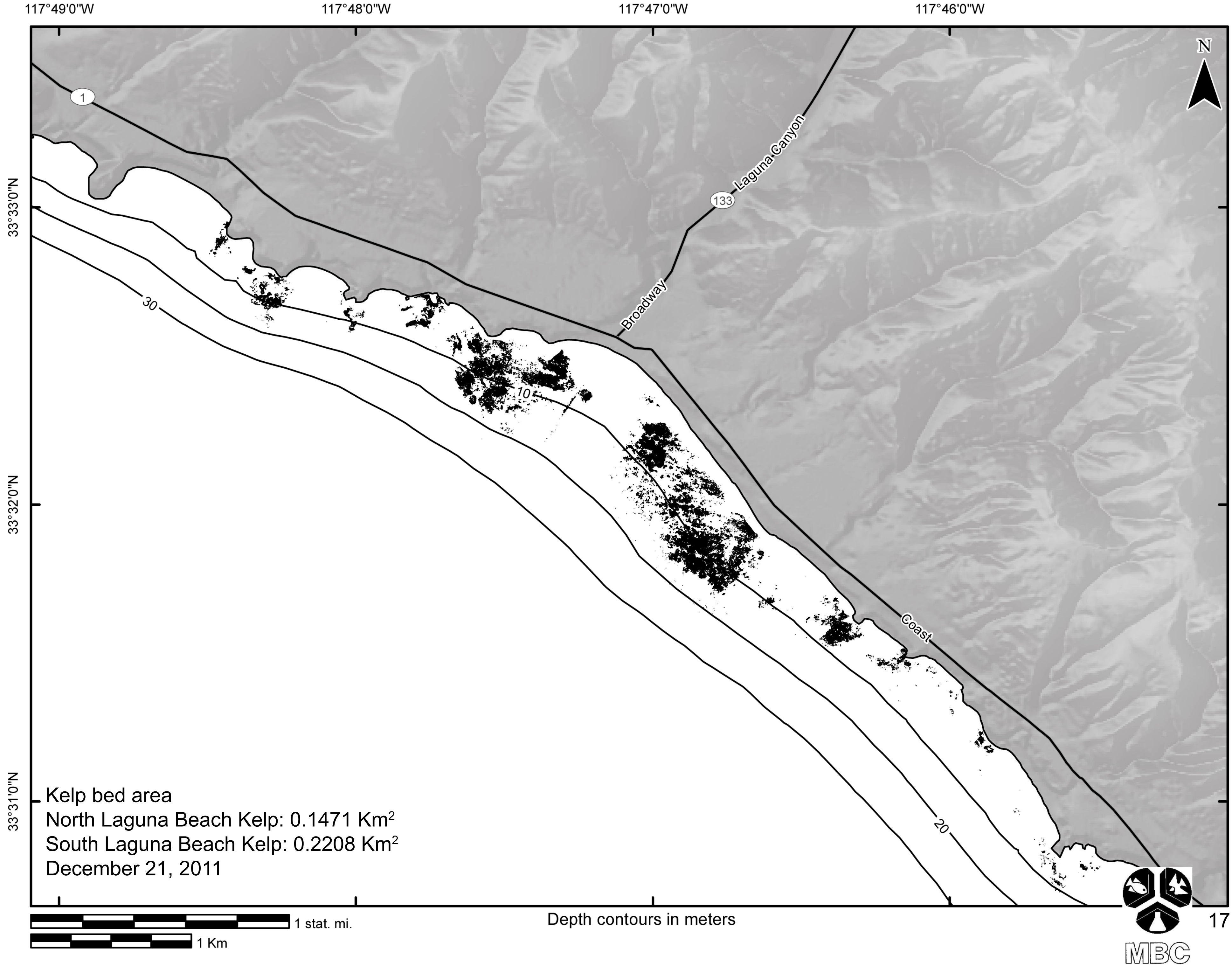


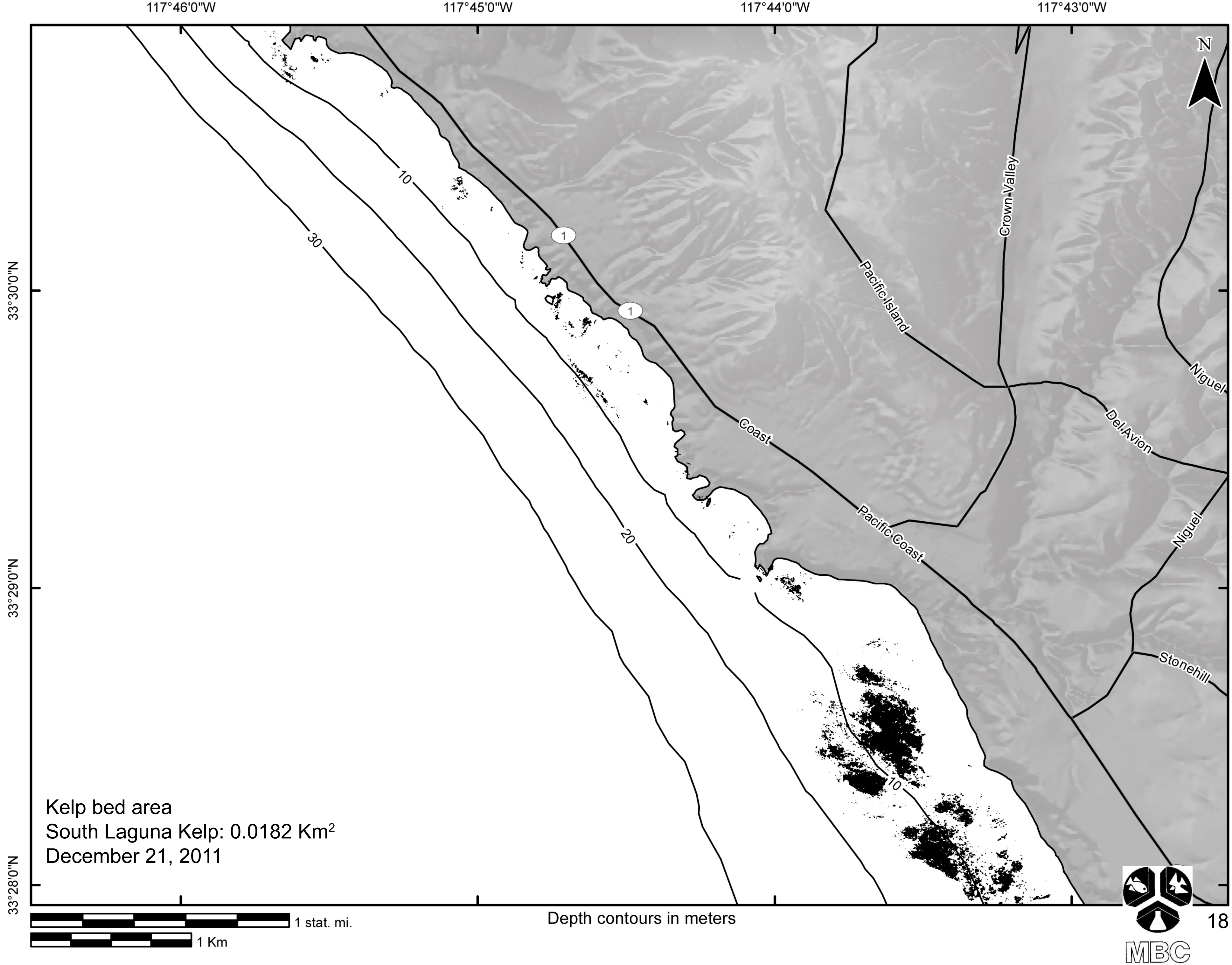
1 stat. mi.
1 Km.

Depth contours in meters

MBC


117°52'0"W
117°51'0"W
117°50'0"W
117°49'0"W
33°36'0"N
33°35'0"N
33°34'0"N
N
Marguerite
Coast
Newport Coast
1
Pacific Coast
Crystal Cove
30
20
10
Kelp bed area
Newport Harbor: 0.0101 Km2
December 21, 2011
Corona del Mar Kelp: 0.4188 Km2
April 16, 2011
1 stat. mi.
1 Km
Depth contours in meters
MBC


117°49'0"W
117°48'0"W
117°47'0"W
117°46'0"W
33°33'0"N
33°32'0"N
33°31'0"N
N
1
133
Laguna Canyon
Broadway
Coast
30
20
10
Kelp bed area
North Laguna Beach Kelp: 0.1471 Km2
South Laguna Beach Kelp: 0.2208 Km2
December 21, 2011
1 stat. mi.
1 Km
Depth contours in meters
MBC


117°46'0"W
117°45'0"W
117°44'0"W
117°43'0"W
33°30'0"N
33°29'0"N
33°28'0"N
N
10
20
30
1
Crown Valley
Pacific Island
Niguel
Del Avion
Coast
Pacific Coast
Stonehill
Kelp bed area
South Laguna Kelp: 0.0182 Km2
December 21, 2011
1 stat. mi.
1 Km
Depth contours in meters
MBC

APPENDIX B

Historic Coverage Area of Kelp Canopies

Appendix B. Explanation of historical canopy area estimations for each of the 27 CRKSC kelp beds. The earliest records are from Crandall (1912) where values for square nautical miles were converted to square kilometers. In some cases, Crandall's beds overlapped with multiple CRKSC beds. In such cases, the proportion of a historical bed occurring within a CRKSC bed was made using a digital area estimation technique to determine the appropriate percentage of the historical bed to assign to the CRKSC bed.

1 Deer Creek	Does not appear in Crandall (1912). 1989-1999 totals includes beds 1-5 Ecosystems 1989 (CDF&G 1999)
2 Leo Carillo	Crandall (1912) Chart 13 - used 67% area of Bed No. 8
3 Nicolas Canyon	Crandall (1912) Chart 13 - used 33% area of Bed No. 8
4 El Pescador/LaPiedra	Crandall (1912) Chart 13 - used 67% area of Bed No. 7
5 Lechuza	Crandall (1912) Chart 13 - used 33% area of Bed No. 7
Total 1-5 F&G 17	**Crandall (1912) Chart 13 - Bed No. 7 and 8 combined = 1.21 n mi^2 = 4.151 km^2**
6 Pt. Dume	Crandall (1912) Chart 13 - used 20% area of Bed No. 6
7 Paradise Cove	Crandall (1912) Chart 13 - used 40% area of Bed No. 6
8 Escondido Wash	Crandall (1912) Chart 13 - used 17% area of Bed No. 6
9 Latigo Canyon	Crandall (1912) Chart 13 - used 13% area of Bed No. 6
10 Puerco/Amarillo	Crandall (1912) Chart 13 - used 10% area of Bed No. 6
11 Malibu Pt.	Bed does not appear in Crandall (1912)
Total 6-11 F&G 16	**Crandall (1912) Chart 13 - Bed No. 6 = 1.00 n mi^2 = 3.430 km^2**
12 La Costa	Crandall (1912) Chart 13 Bed No. 5 = 0.006 n mi^2 = 0.021 km^2
13 Las Flores	Crandall (1912) Chart 13 Bed No. 4 = 0.004 n mi^2 = 0.014 km^2
14 Big Rock	Crandall (1912) Chart 13 Bed No. 3 = 0.005 n mi^2 = 0.017 km^2
15 Las Tunas	Crandall (1912) Chart 13 - used 50% area of Bed No. 2 = 0.005 n mi^2 = 0.017 km^2
16 Topanga	Crandall (1912) Chart 13 - used 50% area of Bed No. 2 = 0.005 n mi^2 = 0.017 km^2
17 Sunset	Crandall (1912) Chart 13 Bed No. 1 = 0.28 n mi^2 = 0.960 km^2
Total 12-17 F&G 15	**Crandall (1912) Chart 13 - Bed No. 1-5 combined = 0.305 n mi^2 = 1.046 km^2**
18 Flat Rk-PV Pt. (IV)	
19 PV Pt-PT. Vin (III)	
Total 18-19 F&G 14	**Crandall (1912) Chart 16 - combined Bed No. 24 and 20% area of Bed No. 23 = 1.614 n mi^2 = 5.536 km^2**
20 Pt Vin to Pt Insp(II)	
21 Pt Insp to Cabr (I)	
22 Cabrillo	
Total 20-22 F&G 13	**Crandall (1912) Chart 16 - combined Beds No. 21-22 and 80% area of Bed No. 23 = 0.916 n mi^2 = 3.142 km^2**
Total 18-22 PV	**Crandall (1912) Chart 16 - combined Beds No. 21-24 = 2.53 n mi^2 = 8.678 km^2**
23 POLA/POLB Kelp	First measured in 2005, outer harbor breakwaters only; entire harbor included in aerial surveys 2006.
24 Horseshoe	About mid-1920s (approximately 0.375 stat. mi {0.25 by 0.50} width by 2.0 stat. mi length) CDF&G (Schott 1976). Disappeared by 1940.
25 Huntington Flats	Kelp bed was located offshore Huntington Beach until the 1920s in an area called the Huntington Flats.
26 Newport-Irvine Coast	Crandall (1912) Bed No 20 & Fish and Game Kelp Bed No.10 Corona Del Mar - referred to as Newport or Irvine Coast includes area from Santa Ana River to Abalone Point.
27 N & S Laguna Beach	Part of Fish and Game Kelp Bed No. 9 Area calculated for North Laguna Beach for 1972 and 1977 were determined by taking total area of Laguna and detemining % in north and south (WJN 1991)

Appendix B (Cont.). Historical canopy coverage in km² of Ventura and Los Angeles County kelp beds from 1911 to 2002. Values represent an estimate of coverage utilizing varying methods over the years.

	Canopy Area (km²)																	
Kelp Bed	1911	1928	1945	1955	1959	1963	1967	1971	1972	1975	1976	1977	1980	1984	1989	1999	2000	2002
1 Deer Creek	ND	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
2 Leo Carillo	2.515	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
3 Nicolas Canyon	1.258	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
4 El Pesc/La Pied	0.252	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
5 Lechuza	0.126	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
Total 1-5 (F&G 17)	**4.151[a]**	**ND**	**ND**	**3.010**	**3.650**	**ND**	**4.144**	**1.970**	**2.589**	**1.606**	**1.688**	**1.579**	**ND**	**ND**	**0.914**	**0.530**	**ND**	**ND**
6 Pt. Dume	0.686	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
7 Paradise Cove	1.372	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
8 Escondido Wash	0.583	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
9 Latigo Canyon	0.446	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
10 Puerco/Amarillo	0.343	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
11 Malibu Pt.	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
Total 6-11 (F&G 16)	**3.430[a]**	**ND**	**ND**	**2.140**	**2.220**	**1.780**	**2.538**	**1.510**	**1.813**	**1.502**	**1.672**	**1.528**	**ND**	**ND**	**0.220**	**0.033**	**ND**	**ND**
12 La Costa	0.021	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
13 Las Flores	0.014	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
14 Big Rock	0.017	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
15 Las Tunas	0.017	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
16 Topanga	0.017	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
17 Sunset	0.960	p	ND	p	p	p	p	p	p	p	p	p	p	p	p	p	ND	ND
Total 12-17 (F&G 15)	**1.355[a]**	**ND**	**ND**	**0.020**	**ND**	**ND**	**0.026**	**0.007**	**ND**	**0.026**	**0.155**	**0.000**	**ND**	**ND**	**0.045**	**0.000**	**ND**	**ND**
18 Flat Rk-PV Pt. (IV)	p	p	ND	p	p	p	p	p	ND	p	p	p	0.940	0.655	p	p	p	1.400
19 PV Pt-PT. Vin (III)	p	p	ND	p	p	p	p	p	ND	p	p	p	0.215	0.692	p	p	p	0.028
Total 18-19 F&G 14	**5.536**	**ND**	**ND**	**0.820**	**ND**	**0.003**	**1.062**	**ND**	**ND**	**0.009**	**0.024**	**0.026**	**1.155**	**1.347**	**3.312**	**0.737**	**0.648**	**1.429**
20 Pt Vin to Pt Insp (II)	p	p	ND	p	p	p	p	p	ND	p	p	p	0.190	0.171	p	p	p	0.039
21 Pt Insp to Cabr (I)	p	p	ND	p	p	p	p	p	ND	p	p	p	1.052	1.342	p	p	p	1.208
22 Cabrillo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0001	0.0001	ND	ND
Total 20-22 F&G 13	**3.142**	**ND**	**ND**	**0.080**	**0.003**	**0.015**	**0.000**	**0.008**	**ND**	**0.259**	**0.126**	**0.104**	**1.342**	**1.513**	**1.248**	**0.530**	**0.582**	**1.247**
Total 18-22 PV	**8.678[a]**	**9.912[a]**	**5.591[a]**	**0.900**	**0.003**	**0.018**	**1.062**	**0.008**	**ND**	**0.268**	**0.150**	**0.130**	**2.497**	**2.860**	**4.560[b]**	**1.267**	**1.230**	**2.676[c]**
23 POLA-POLB Harbor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24 Horseshoe	ND	1.94[d]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	tr	0.0001	tr	0.0001
25 Huntington Flats	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	tr	-	-	-
26 Newport-Irvine Coas	0.580	ND	ND	ND	ND	ND	0.086	0.047	0.100	0.160	0.220	0.160	0.150	0.006	0.010	-	-	-
27 N & S Laguna Beacl	tr	ND	ND	0.680	ND	ND	0.005	0.009	0.021	0.006	0.120	0.120	0.072	0.053	0.187	-	0.003	0.005
TOTAL	**18.194[e]**	**11.852[e]**	**5.591**	**6.750**	**5.873**	**1.798**	**7.861**	**3.551**	**4.512[e]**	**3.568**	**4.005**	**3.517**	**2.681[e]**	**2.893[e]**	**5.935**	**1.829**	**1.233**	**2.676[e]**

ND = No Data p = this bed included in the total below tr = trace of kelp "-" = 0

a = measurement in naut m^2 converted to km^2

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

c = In another survey by LACSD in 2002 total area was estimated at 2.84 k^2

d = Estimate in mid-1920s

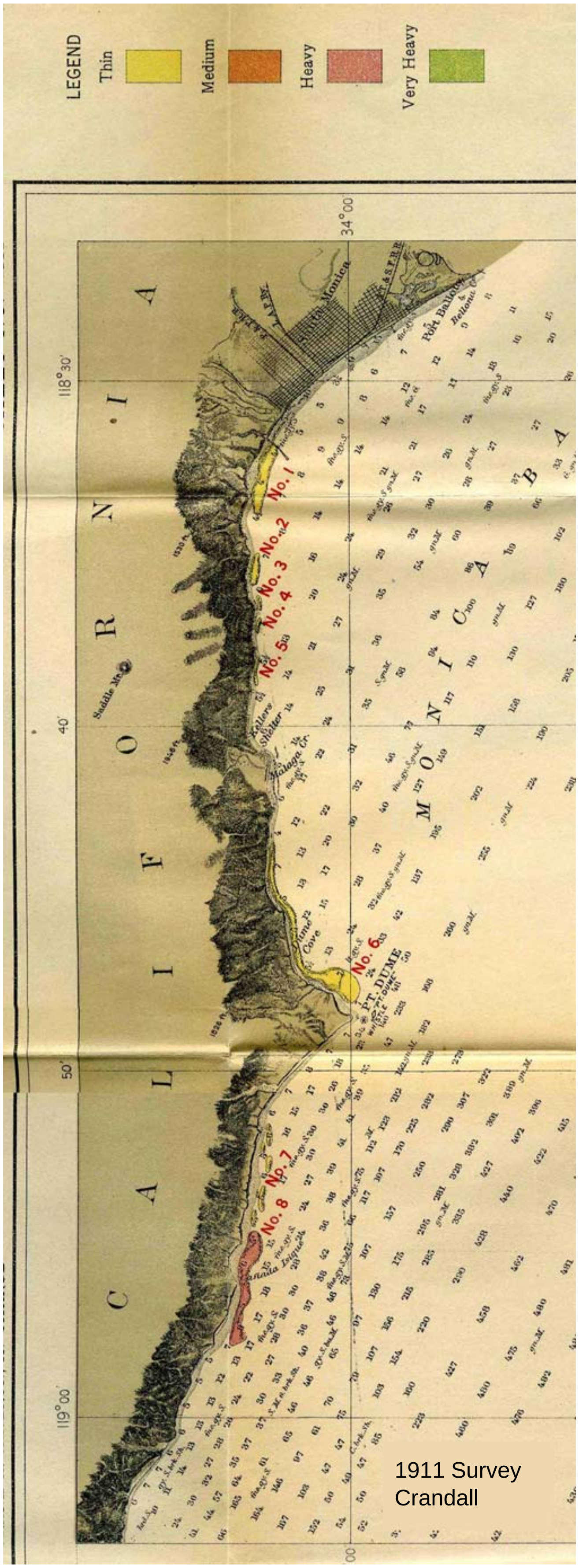
e = total is not inclusive of all beds in region

Sources: Crandall (1912); 1928, 1945, 1955 from SWQCB (1964); 1955 from Neushul (1981); 1967, 1972, 1975, 1977 from Hodder and Mel (1978); Ecoscan (1990) and Wilson (1989), Veisze et al. (2004); North (2000); TMLandsat 7 (2002); MBC 2004-2002.

Appendix B-1. Seasonal kelp nutritional index based on weighting values given to monthly temperature data derived from Santa Monica Pier (SMP), indicated in parenthesis, and Newport Pier† (NP). The weighting values are derived from nitrate versus temperature data from North and Jones (1991), and nitrate uptake rates from Haines and Wheeler (1978), and Gerard (1982). The season begins 1 July and ends 31 June. Years in Red denote warm-water years, Blue cold-water years, both colors are transition years, based on NOAA Multivariate ENSO Index (MEI), May 2011.

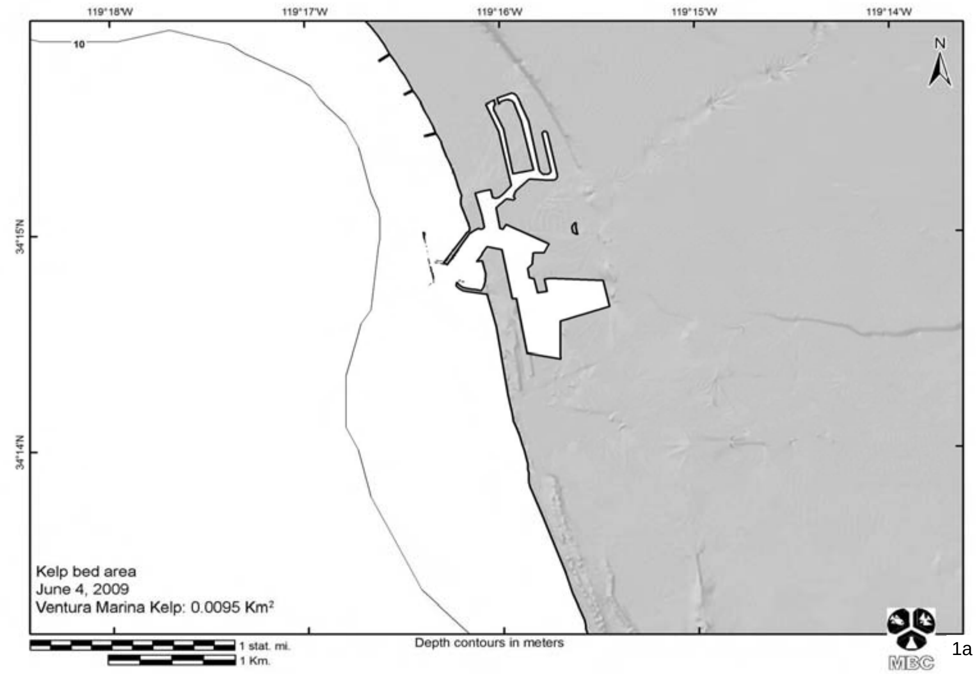
	Number of months falling into indicated temperature range						
Weighting Factor	14	8	4	2	1	Season	Season
Season	12.01-13.00°C	13.01-14.00°C	14.01-15.00°C	15.01-16.00°C	16.01-17.00°C	NQ	NQ
	NP (SMP)	NP (SMP)	NP (SMP)	NP (SMP)	NP (SMP)	NP	SMP
2010-2011*	- (-)	2 (3)	3(3)	3 (1)	1 (2)	35	40
2009-2010	- (-)	- (-)	3 (5)	3 (1)	1 (1)	19	23
2008-2009	- (-)	- (1)	4 (3)	2 (2)	3 (1)	23	25
2007-2008	- (-)	2 (2)	3 (3)	- (1)	1 (1)	29	33
2006-2007	- (-)	- (-)	4 (3)	1 (2)	- (-)	18	16
2005-2006	- (1)	1 (1)	3 (3)	1 (-)	- (3)	22	37
2004-2005	- (-)	- (1)	1 (2)	3 (2)	1 (2)	11	22
2003-2004	- (-)	- (2)	2 (1)	2 (1)	2 (2)	14	24
2002-2003	- (-)	1 (-)	2 (3)	3 (4)	2 (1)	24	21
2001-2002	- (-)	1 (3)	4 (2)	1 (1)	1 (1)	27	35
2000-2001	4 (-)	1 (2)	1 (3)	1 (1)	- (1)	70	31
1999-2000	2 (-)	2 (1)	- (3)	2 (2)	3 (1)	51	25
1998-1999	3 (-)	2 (4)	- (1)	3 (-)	- (2)	64	38
1997-1998	- (-)	- (-)	1 (-)	1 (1)	5 (5)	11	7
1996-1997	- (-)	3 (-)	1 (3)	2 (2)	2 (1)	34	17
1995-1996	- (-)	3 (-)	1 (3)	1 (2)	2 (-)	32	16
1994-1995	- (-)	3 (-)	3 (3)	1 (4)	- (-)	38	20
1993-1994	- (-)	- (-)	- (1)	4 (3)	2 (1)	10	11
1992-1993	- (-)	- (-)	- (1)	3 (2)	3 (2)	9	10
1991-1992	- (-)	- (-)	3 (1)	1 (2)	2 (2)	16	10
1990-1991	- (-)	- (-)	5 (3)	1 (3)	1 (-)	23	18
1989-1990	- (-)	2 (1)	- (1)	2 (1)	1 (3)	21	17
1988-1989	2 (2)	- (1)	2 (1)	1 (1)	1 (-)	39	42
1987-1988	- (-)	1 (2)	1 (1)	4 (1)	1 (2)	21	24
1986-1987	- (-)	- (-)	2 (3)	1 (-)	1 (2)	11	14
1985-1986	- (-)	- (-)	4 (3)	1 (1)	2 (2)	20	16
1984-1985	- (-)	3 (1)	2 (3)	1 (1)	1 (2)	35	24
1983-1984	- (-)	- (-)	1 (1)	2 (3)	2 (1)	10	11
1982-1983	- (-)	- (-)	- (-)	5 (1)	2 (-)	12	2
1981-1982	1 (-)	1 (1)	3 (1)	3 (3)	- (2)	40	20
1980-1981	- (-)	- (-)	5 (1)	1 (3)	1 (1)	23	11
1979-1980	- (-)	- (-)	4 (3)	4 (4)	- (-)	24	20
1978-1979	- (-)	4 (3)	2 (-)	- (2)	- (-)	40	28
1977-1978	- (-)	- (-)	- (-)	2 (3)	3 (3)	7	9
1976-1977	- (-)	1 (1)	1 (-)	2 (3)	1 (2)	17	16
1975-1976	1 (-)	4 (2)	- (4)	1 (-)	2 (-)	50	32
1974-1975	- (-)	4 (4)	1 (2)	2 (1)	1 (1)	41	43
1973-1974	1 (1)	4 (3)	- (2)	2 (1)	2 (1)	52	49
1972-1973	- (-)	- (3)	3 (3)	3 (1)	1 (1)	19	39
1971-1972	2 (2)	1 (1)	3 (3)	- (-)	1 (2)	49	50
1970-1971	2 (2)	2 (2)	1 (2)	2 (1)	- (-)	52	54
1969-1970	- (-)	1 (1)	2 (2)	3 (3)	1 (1)	23	23
1968-1969	- (-)	2 (3)	2 (2)	2 (1)	1 (1)	29	35
1967-1968	- (-)	1 (1)	3 (4)	2 (1)	- (-)	24	26
1966-1967	- (-)	2 (1)	1 (3)	3 (2)	2 (1)	28	25
1965-1966	- (-)	2 (1)	1 (2)	2 (1)	2 (1)	26	19
1964-1965	- (-)	2 (3)	2 (1)	2 (1)	1 (2)	29	46
1963-1964	- (-)	2 (1)	2 (5)	2 (-)	2 (2)	30	30
1962-1963	- (-)	2 (3)	2 (2)	2 (2)	1 (-)	29	36
1961-1962	- (-)	3 (4)	2 (1)	3 (2)	1 (1)	39	55
1960-1961	- (-)	- (1)	5 (4)	1 (1)	2 (2)	24	28
1959-1960	- (-)	1 (2)	2 (2)	1 (1)	1 (1)	19	27
1958-1959	- (-)	- (-)	- (1)	3 (2)	2 (3)	8	11
1957-1958	- (-)	- (-)	- (-)	3 (3)	3 (3)	9	9
1956-1957	- (-)	4 (2)	4 (4)	2 (1)	1 (-)	29	34
1955-1956	2 (2)	2 (2)	2 (2)	2 (2)	- (-)	56	56
Totals						1565	1460
Average						28.0	26.05

* Data through 26 May 2011; † 2003 and 2004 ocean temperature were measured at Kerckhoff Marine Laboratory, in Newport Harbor. Prior to 2002, all temperature data were taken from the end of the Balboa Pier, 1.1 km downcoast of the Newport Pier. Since 2002, data taken from Newport Pier and since 2010 from SCCOOS automated data from Newport Pier.



1911 Survey
Crandall


U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
FRANK K. CAMERON, IN CHARGE
MAP OF KELP GROVES.
SHEET NO. XVI
UNITED STATES - WEST COAST
CALIFORNIA
LOS ANGELES HARBOR
AND VICINITY
No. 24
No. 23
No. 22
No. 21
Rocky Pt.
Pt Vicente
Pt Fermin
San Pedro Hill
SAN PEDRO
WILMINGTON
Smiths I.
East San Pedro
Timm's Pt.
Bixby Slough
1911 Survey
Crandall
Mapped by
W. C. Crandall
BASE MAP FROM
COAST AND GEODETIC
SURVEY CHART NO. 5143
Scale
Statute Miles
Nautical Miles
SOUNDINGS
The soundings are in fathoms and show the depth at mean lower low water.
Senate Doc. 190; 62d Cong., 2d Sess.
118° 24'
118° 20'
118° 16'
33° 46'
33° 42'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119°17'W
119°16'W
119°15'W
119°14'W
34°15'N
34°14'N
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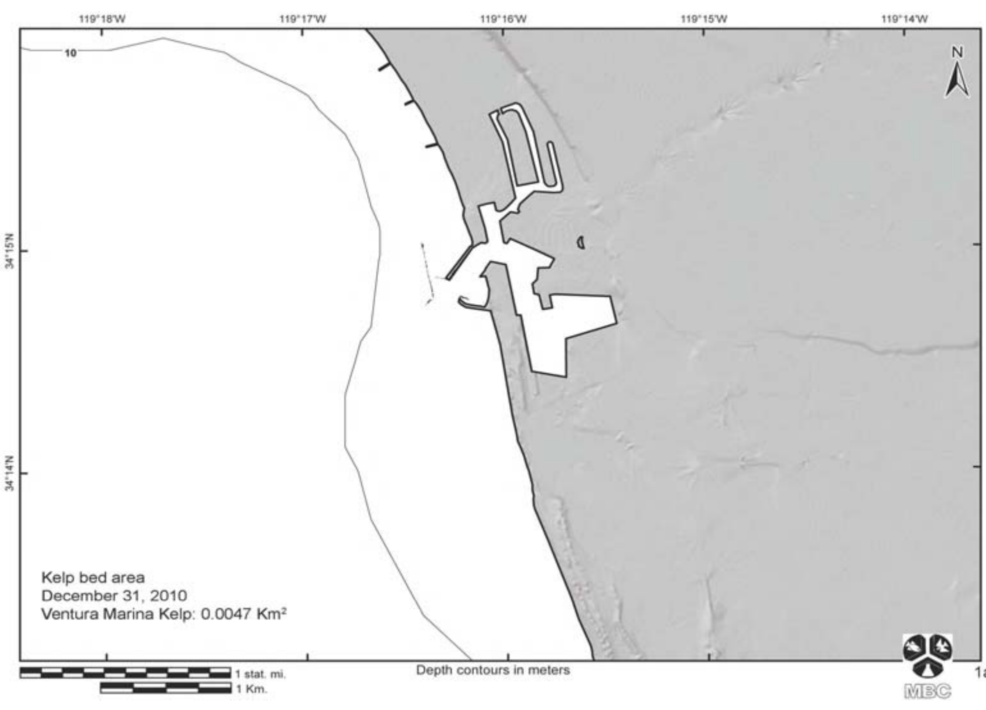
N
Kelp bed area
June 4, 2009
Ventura Marina Kelp: 0.0095 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
1a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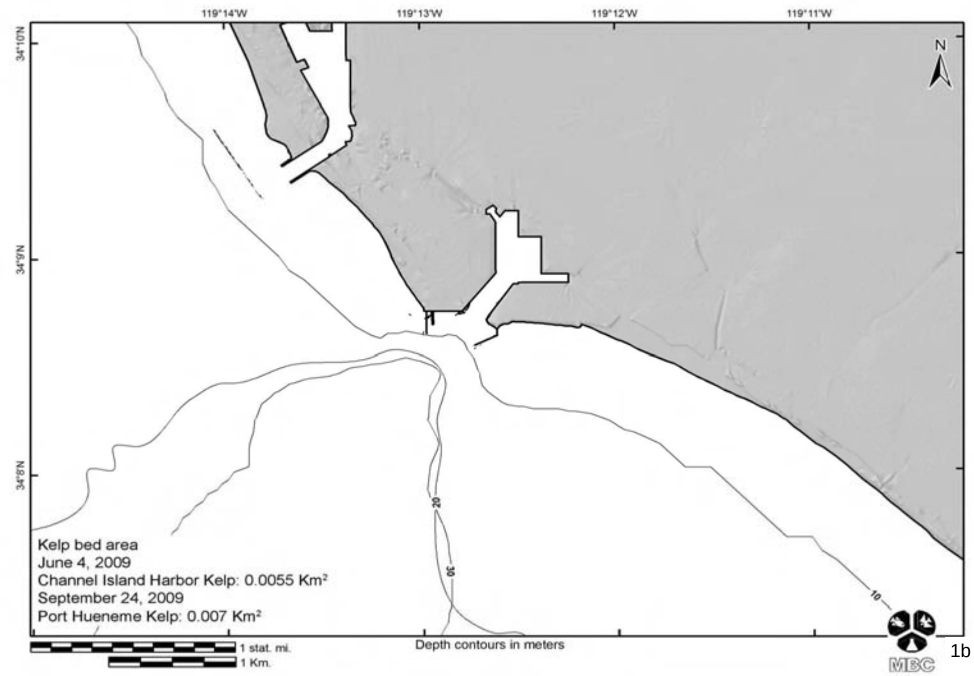
December 31, 2010
Ventura Marina Kelp: 0.0047 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
1a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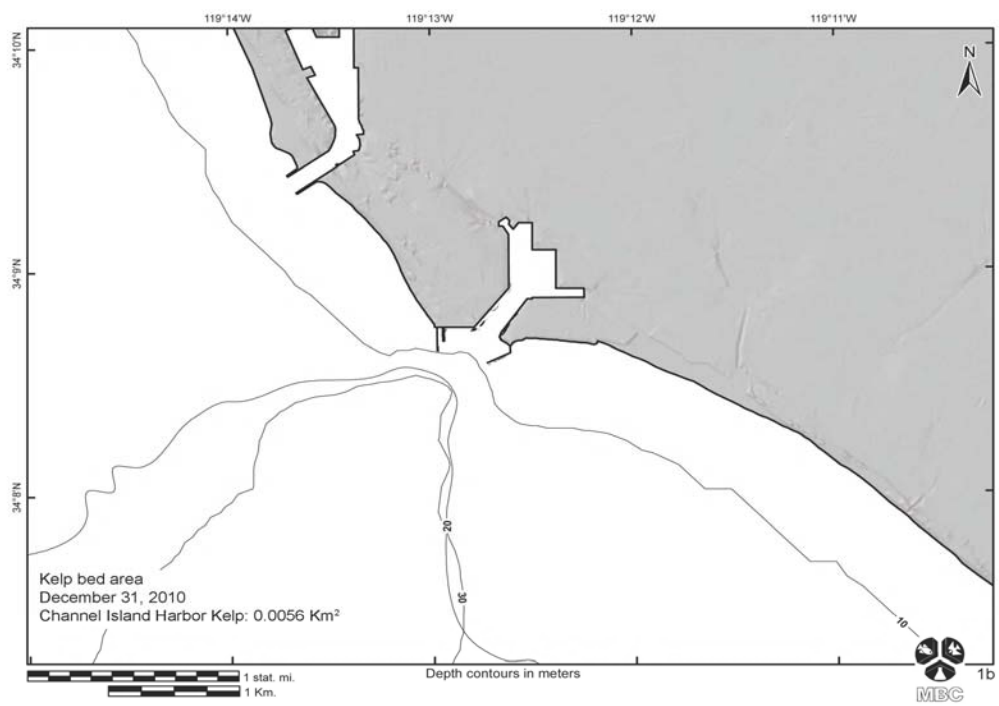
34°9'N
34°8'N
N
20
30
10
Kelp bed area
June 4, 2009
Channel Island Harbor Kelp: 0.0055 Km²
September 24, 2009
Port Hueneme Kelp: 0.007 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

1b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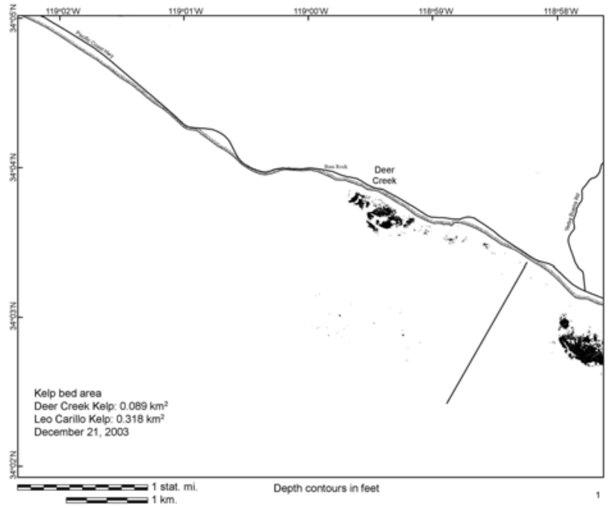
34°9'N
34°8'N
N
20
30
10
Kelp bed area
December 31, 2010
Channel Island Harbor Kelp: 0.0056 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

1b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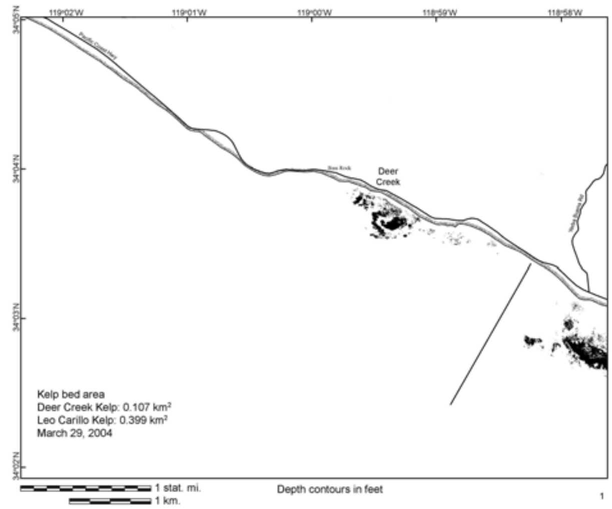
118°59'W
118°58'W
34°05'N
34°04'N
34°03'N
34°02'N
Pacific Coast Hwy
Bass Rock
Deer
Creek
Kelp bed area
Deer Creek Kelp: 0.089 km²
Leo Carillo Kelp: 0.318 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet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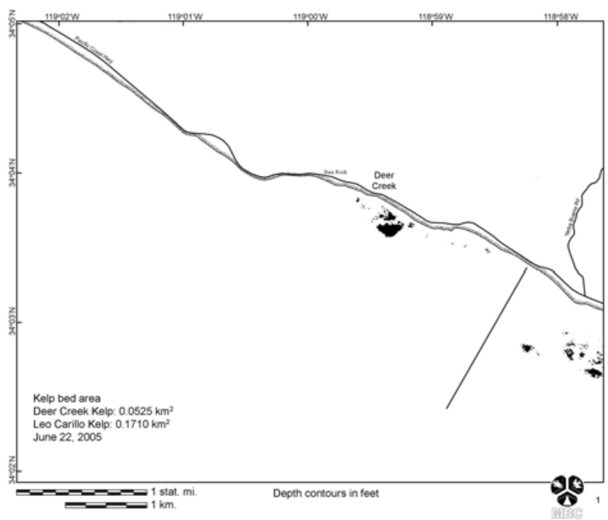
34°05'N
34°04'N
34°03'N
34°02'N
Pacific Coast Hwy
Bass Rock
Deer
Creek
Kelp bed area
Deer Creek Kelp: 0.107 km²
Leo Carillo Kelp: 0.399 km²
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet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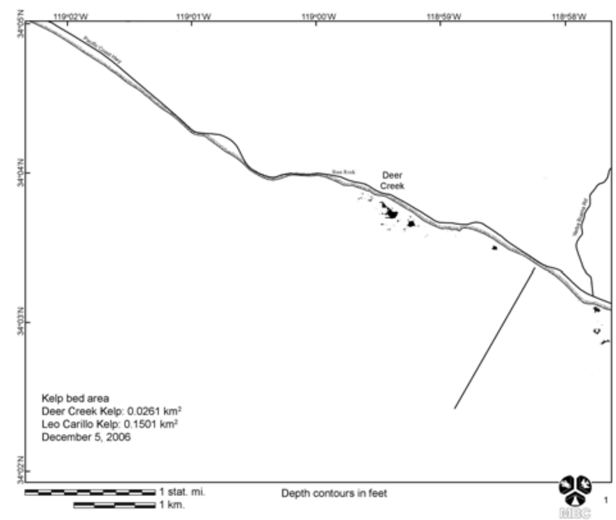
34°05'N
34°04'N
34°03'N
34°02'N
Pacific Coast Hwy
Bass Rock
Deer
Creek
Kelp bed area
Deer Creek Kelp: 0.0525 km²
Leo Carillo Kelp: 0.1710 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
MBC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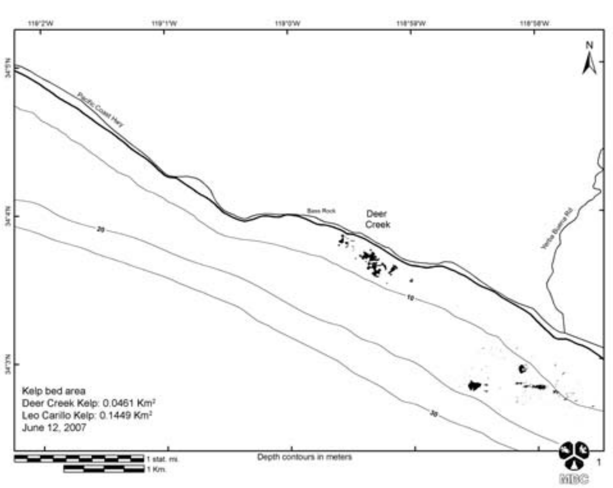
118°59'W
118°58'W
34°05'N
34°04'N
34°03'N
34°02'N
Pacific Coast Hwy
Bass Rock
Deer
Creek
Kelp bed area
Deer Creek Kelp: 0.0261 km²
Leo Carillo Kelp: 0.1501 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC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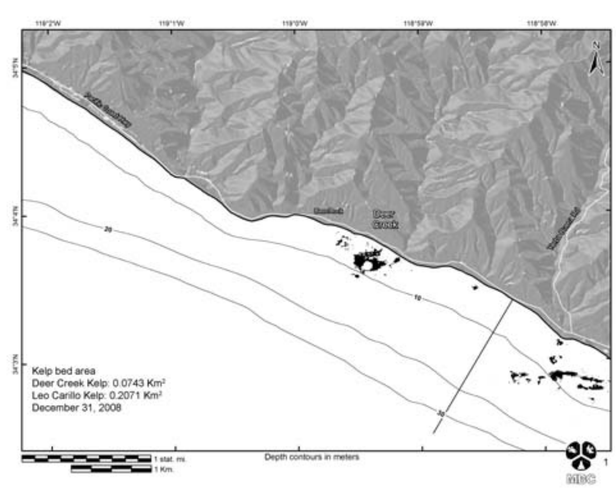
N
34°5'N
34°4'N
34°3'N
Pacific Coast Hwy
Bass Rock
Deer
Creek
20
10
30
Kelp bed area
Deer Creek Kelp: 0.0461 Km²
Leo Carillo Kelp: 0.1449 Km²
June 12, 2007
1 stat. mi.
1 Km.
Depth contours in meters
MBC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118°59'W
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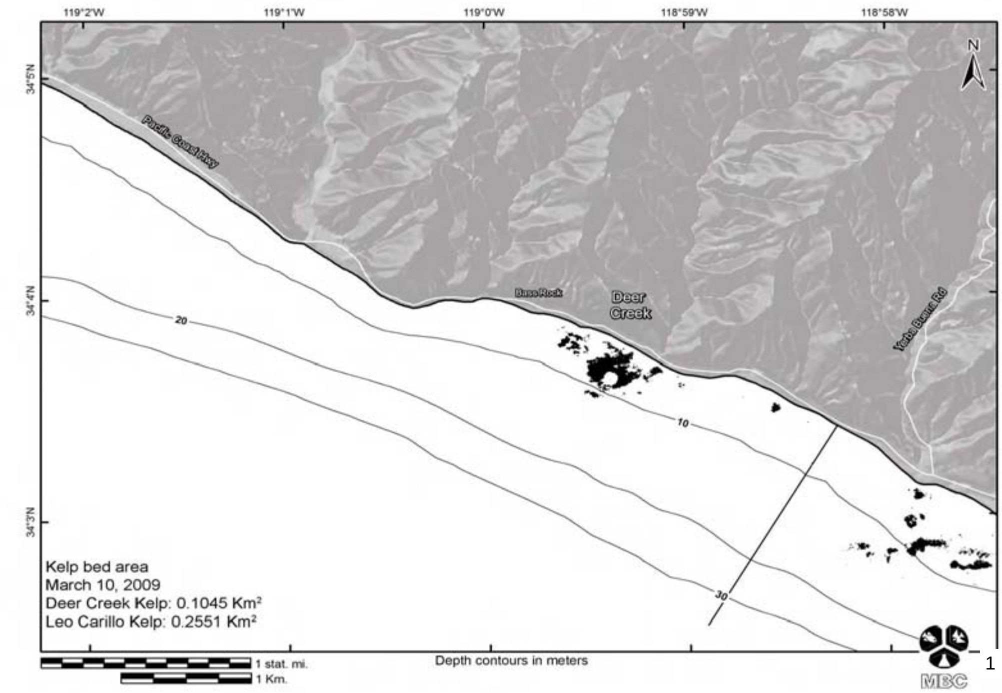
N
34°5'N
34°4'N
34°3'N
Deer
Creek
20
10
30
Kelp bed area
Deer Creek Kelp: 0.0743 Km²
Leo Carillo Kelp: 0.2071 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
MBC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119°1'W
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118°59'W
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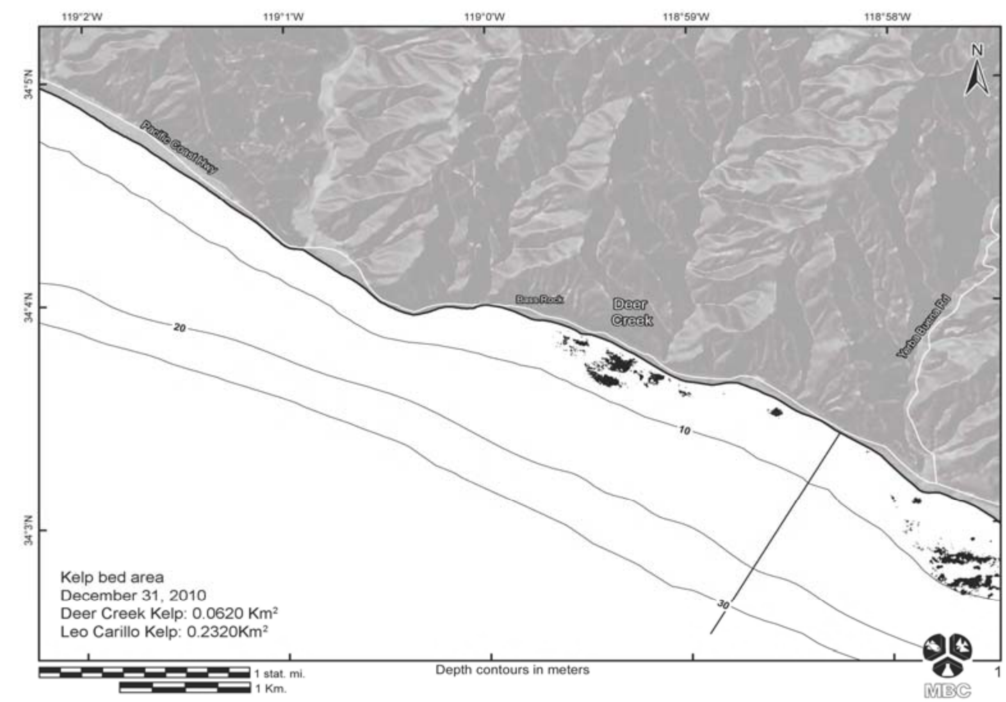
34°5'N
34°4'N
34°3'N
N
Pacific Coast Hwy
Bass Rock
Deer Creek
Yerba Buena Rd
20
10
30
Kelp bed area
March 10, 2009
Deer Creek Kelp: 0.1045 Km²
Leo Carillo Kelp: 0.2551 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

1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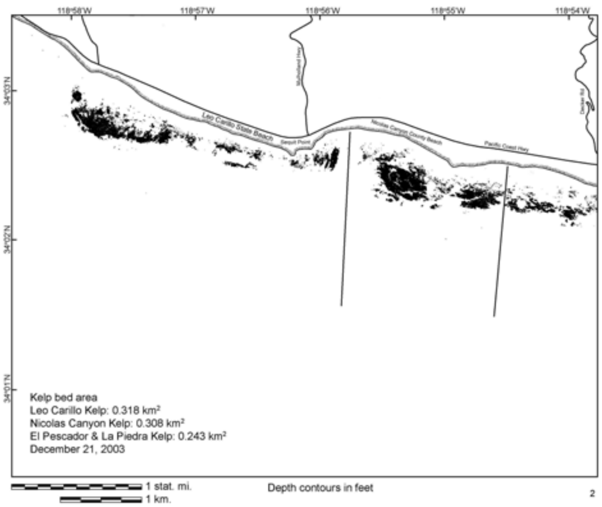
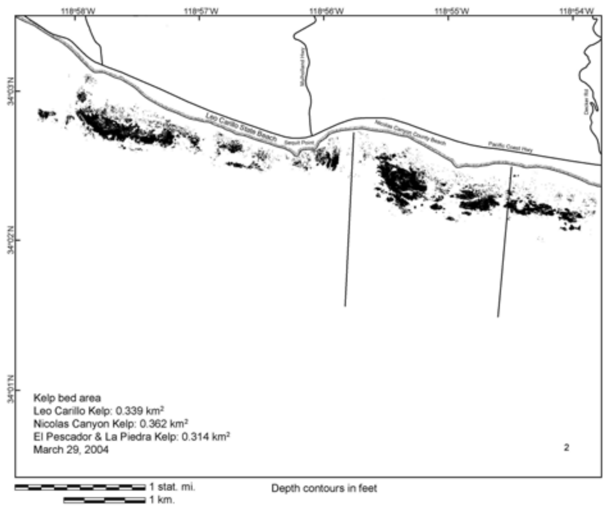
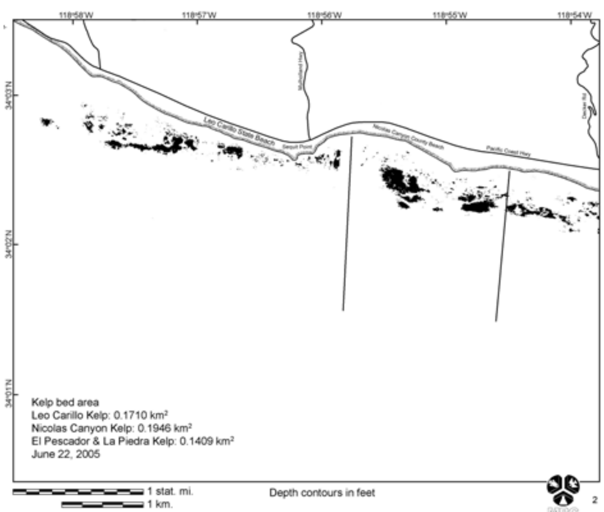
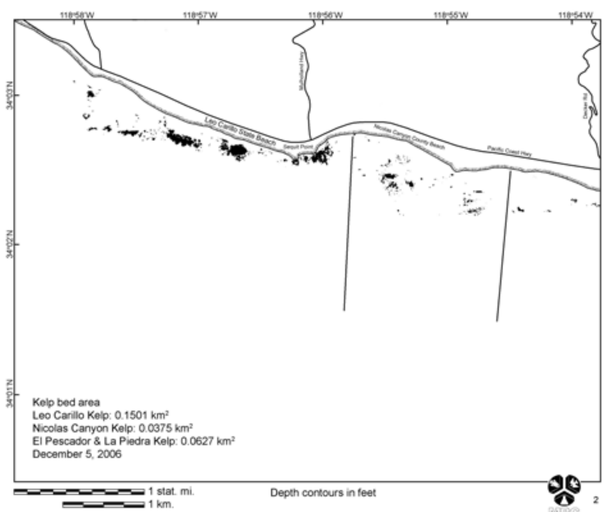
119°1'W
119°0'W
118°59'W
118°58'W
34°5'N
34°4'N
34°3'N
N
Pacific Coast Hwy
Bass Rock
Deer Creek
Yerba Buena Rd
20
10
30
Kelp bed area
December 31, 2010
Deer Creek Kelp: 0.0620 Km²
Leo Carillo Kelp: 0.2320Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

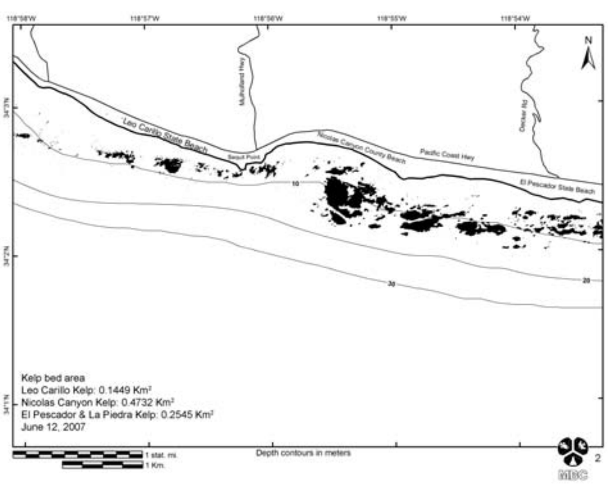
1

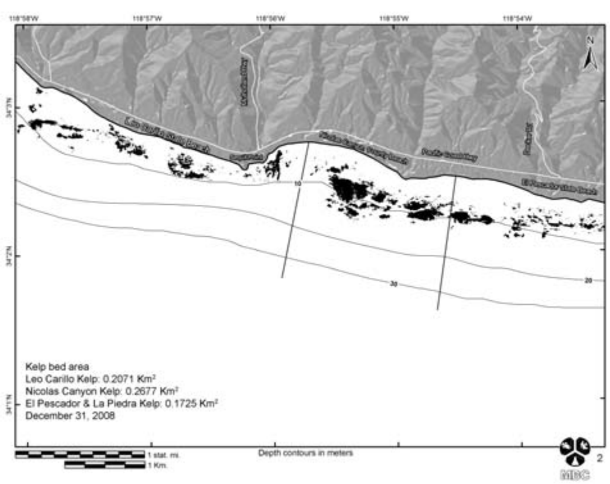

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°03'N
34°02'N
34°01'N
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Mulholland Hwy
Decker Rd
Kelp bed area
Leo Carillo Kelp: 0.318 km²
Nicolas Canyon Kelp: 0.308 km²
El Pescador & La Piedra Kelp: 0.243 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
2

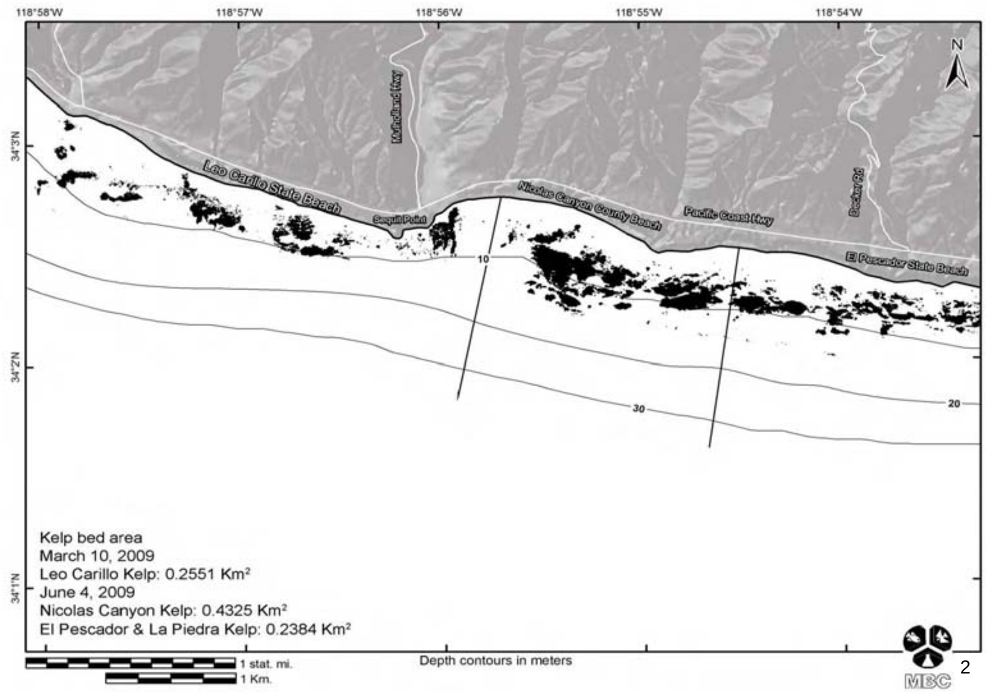

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°03'N
34°02'N
34°01'N
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Mulholland Hwy
Decker Rd
Kelp bed area
Leo Carillo Kelp: 0.339 km²
Nicolas Canyon Kelp: 0.362 km²
El Pescador & La Piedra Kelp: 0.314 km²
March 29, 2004
2
1 stat. mi.
1 km.
Depth contours in feet


118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°03'N
34°02'N
34°01'N
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Mulholland Hwy
Decker Rd
Kelp bed area
Leo Carillo Kelp: 0.1710 km²
Nicolas Canyon Kelp: 0.1946 km²
El Pescador & La Piedra Kelp: 0.1409 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
2

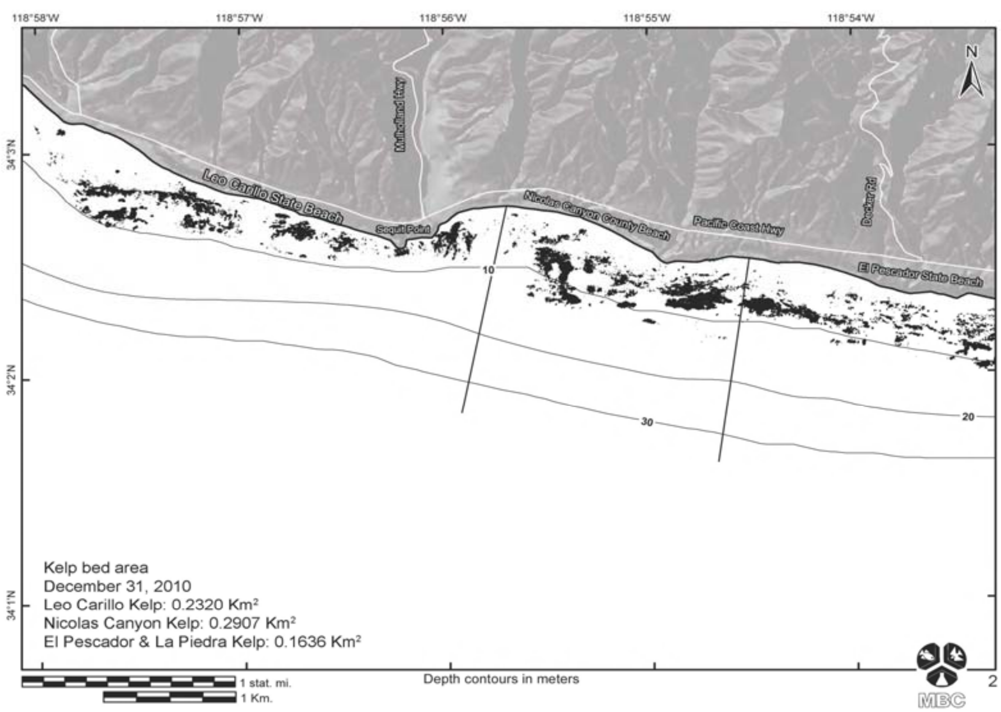

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°03'N
34°02'N
34°01'N
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Mulholland Hwy
Decker Rd
Kelp bed area
Leo Carillo Kelp: 0.1501 km²
Nicolas Canyon Kelp: 0.0375 km²
El Pescador & La Piedra Kelp: 0.0627 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
2


118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
N
34°3'N
34°2'N
34°1'N
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
El Pescador State Beach
Mulholland Hwy
Decker Rd
10
20
30
Kelp bed area
Leo Carillo Kelp: 0.1449 Km²
Nicolas Canyon Kelp: 0.4732 Km²
El Pescador & La Piedra Kelp: 0.2545 Km²
June 12, 2007
1 stat. mi.
1 Km.
Depth contours in meters
2

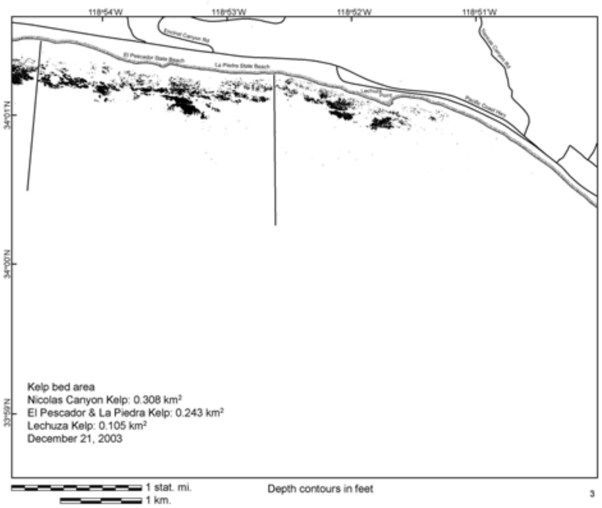

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
N
34°3'N
34°2'N
34°1'N
10
20
30
Kelp bed area
Leo Carillo Kelp: 0.2071 Km²
Nicolas Canyon Kelp: 0.2677 Km²
El Pescador & La Piedra Kelp: 0.1725 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
2

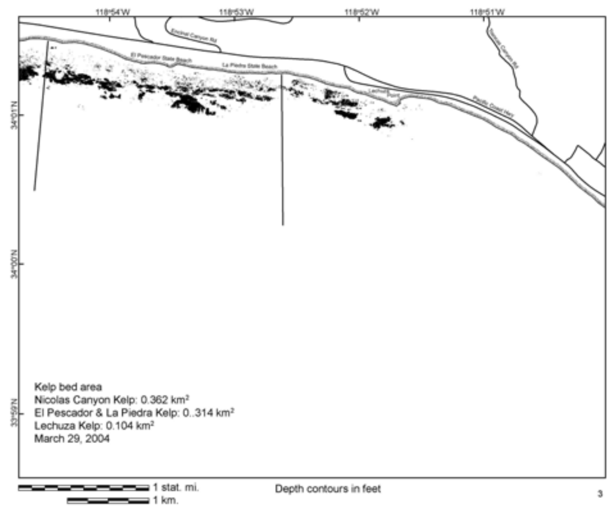

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°3'N
34°2'N
34°1'N
N
Mulholland Hwy
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Decker Rd
El Pescador State Beach
10
20
30
Kelp bed area
March 10, 2009
Leo Carillo Kelp: 0.2551 Km²
June 4, 2009
Nicolas Canyon Kelp: 0.4325 Km²
El Pescador & La Piedra Kelp: 0.2384 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

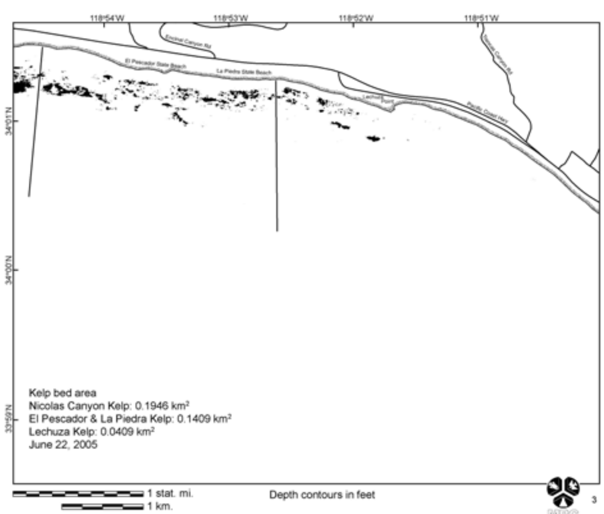
2

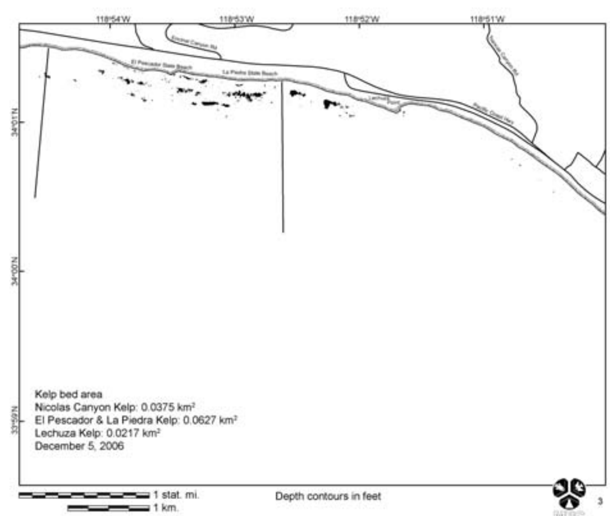

118°58'W
118°57'W
118°56'W
118°55'W
118°54'W
34°3'N
34°2'N
34°1'N
N
Mulholland Hwy
Leo Carillo State Beach
Sequit Point
Nicolas Canyon County Beach
Pacific Coast Hwy
Decker Rd
El Pescador State Beach
10
20
30
Kelp bed area
December 31, 2010
Leo Carillo Kelp: 0.2320 Km²
Nicolas Canyon Kelp: 0.2907 Km²
El Pescador & La Piedra Kelp: 0.1636 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

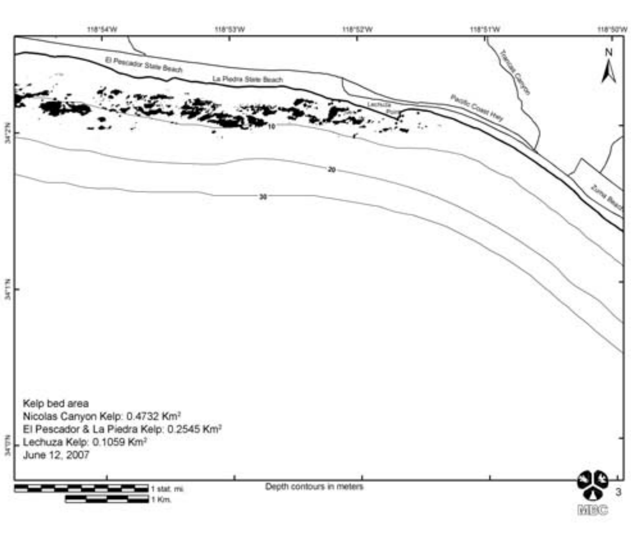
2

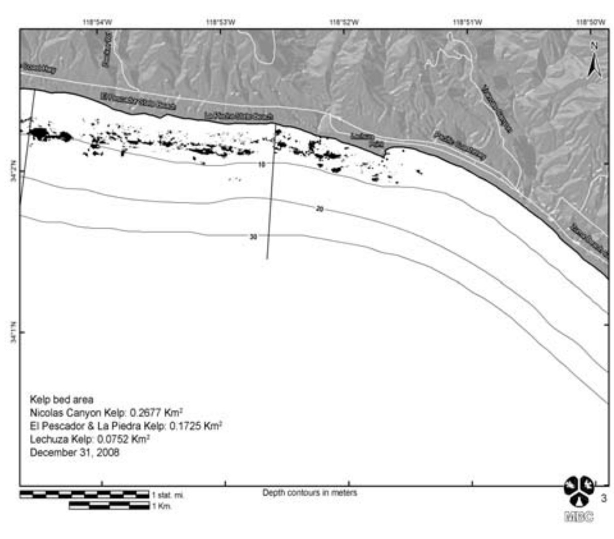

118°54'W
118°53'W
118°52'W
118°51'W
34°01'N
34°00'N
33°59'N
Kelp bed area
Nicolas Canyon Kelp: 0.308 km²
El Pescador & La Piedra Kelp: 0.243 km²
Lechuza Kelp: 0.105 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
3

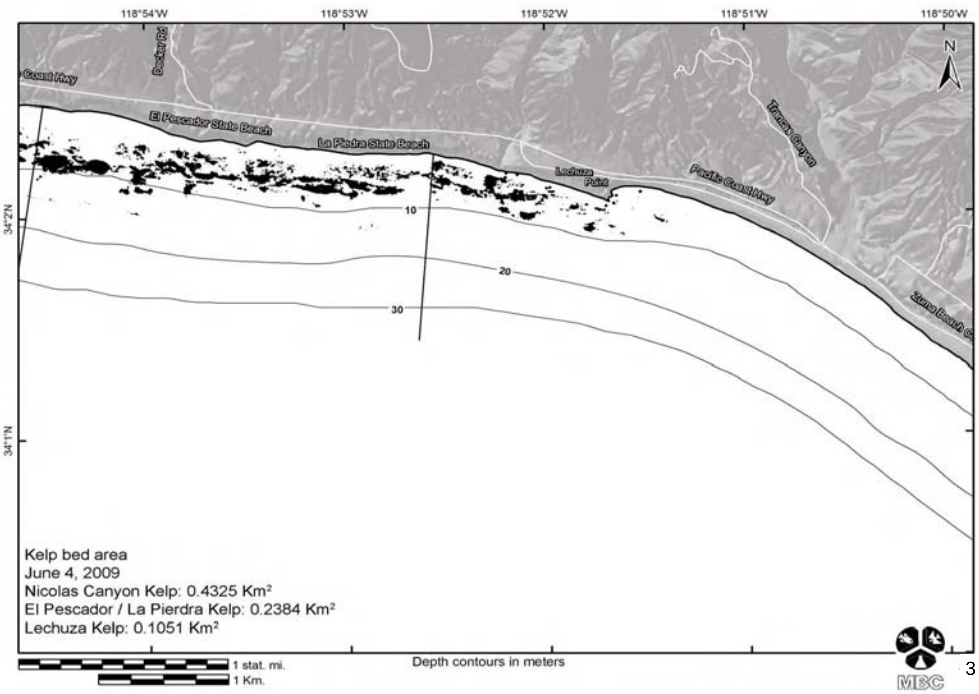

118°54'W
118°53'W
118°52'W
118°51'W
34°01'N
34°00'N
33°59'N
Kelp bed area
Nicolas Canyon Kelp: 0.362 km²
El Pescador & La Piedra Kelp: 0..314 km²
Lechuza Kelp: 0.104 km²
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
3

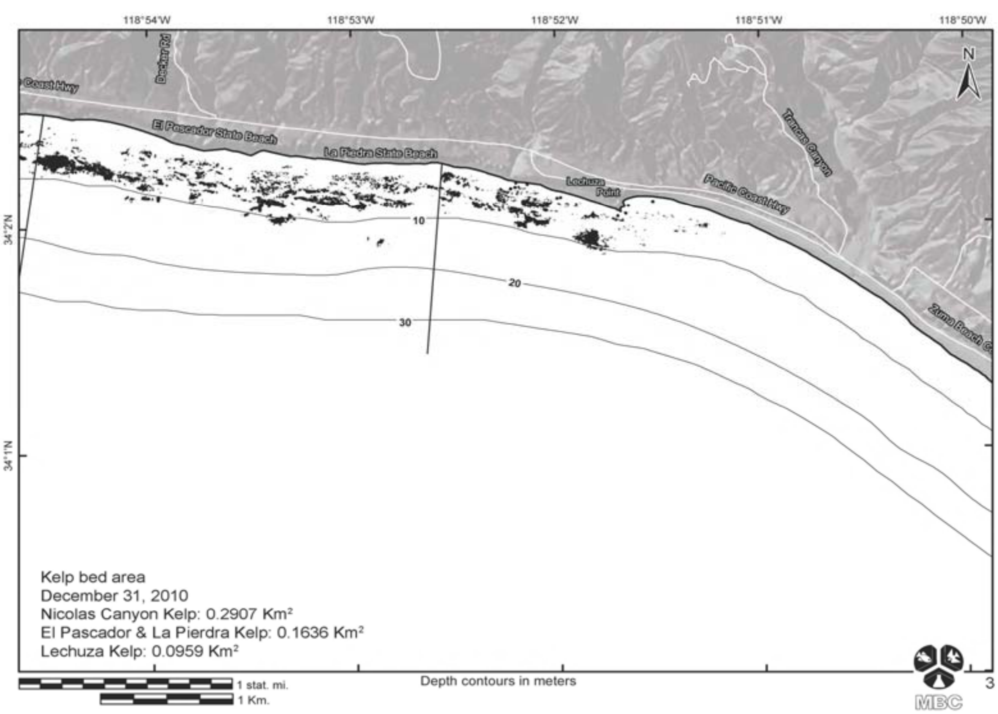

118°54'W
118°53'W
118°52'W
118°51'W
34°01'N
34°00'N
33°59'N
Kelp bed area
Nicolas Canyon Kelp: 0.1946 km²
El Pescador & La Piedra Kelp: 0.1409 km²
Lechuza Kelp: 0.0409 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
3

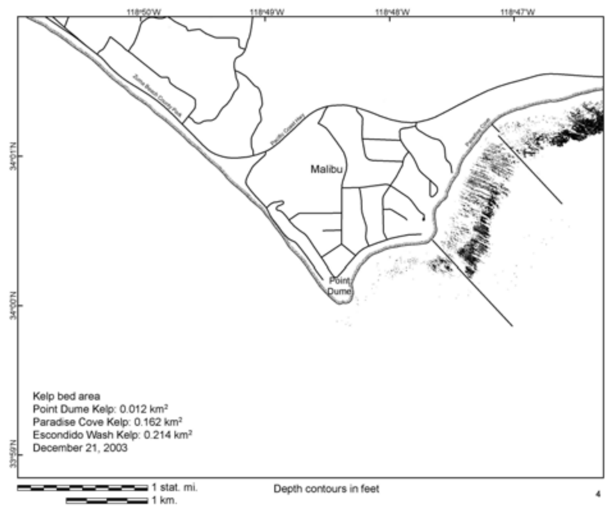

118°54'W
118°53'W
118°52'W
118°51'W
34°01'N
34°00'N
33°59'N
Kelp bed area
Nicolas Canyon Kelp: 0.0375 km²
El Pescador & La Piedra Kelp: 0.0627 km²
Lechuza Kelp: 0.0217 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
3

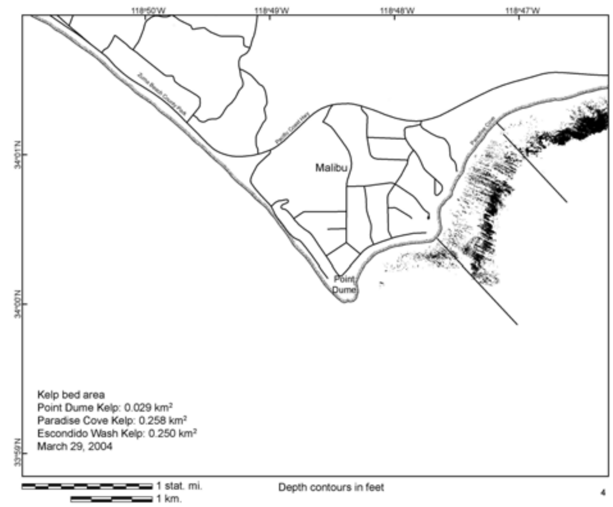

118°54'W
118°53'W
118°52'W
118°51'W
118°50'W
El Pescador State Beach
La Piedra State Beach
Pacific Coast Hwy
N
10
20
30
34°2'N
34°1'N
34°0'N
Kelp bed area
Nicolas Canyon Kelp: 0.4732 Km²
El Pescador & La Piedra Kelp: 0.2545 Km²
Lechuza Kelp: 0.1059 Km²
June 12, 2007
1 stat. mi.
1 Km.
Depth contours in meters
3

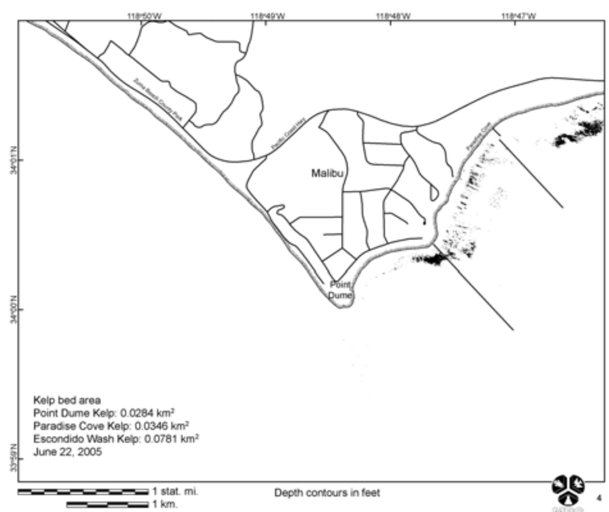

118°54'W
118°53'W
118°52'W
118°51'W
118°50'W
N
10
20
30
34°2'N
34°1'N
Kelp bed area
Nicolas Canyon Kelp: 0.2677 Km²
El Pescador & La Piedra Kelp: 0.1725 Km²
Lechuza Kelp: 0.0752 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
3

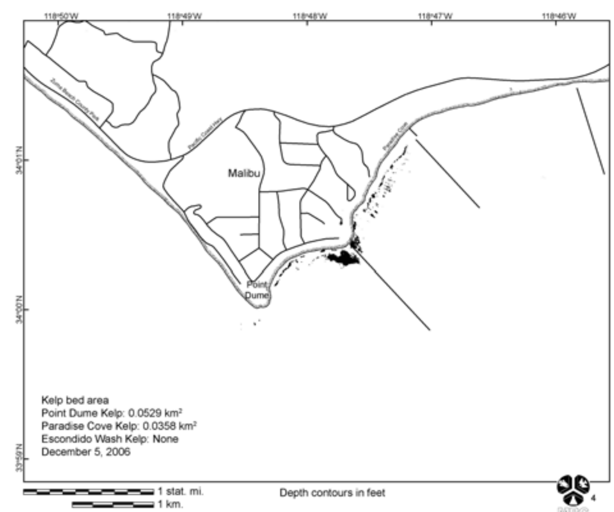

118°54'W
118°53'W
118°52'W
118°51'W
118°50'W
N
Decker Rd
Coast Hwy
El Pescador State Beach
La Piedra State Beach
Lechuza Point
Pacific Coast Hwy
Trancas Canyon
10
20
30
34°2'N
34°1'N
Kelp bed area
June 4, 2009
Nicolas Canyon Kelp: 0.4325 Km²
El Pescador / La Pierdra Kelp: 0.2384 Km²
Lechuza Kelp: 0.1051 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
3


118°54'W
118°53'W
118°52'W
118°51'W
118°50'W
N
Decker Rd
Coast Hwy
El Pescador State Beach
La Piedra State Beach
Lechuza Point
Pacific Coast Hwy
Trancas Canyon
10
20
30
34°2'N
34°1'N
Kelp bed area
December 31, 2010
Nicolas Canyon Kelp: 0.2907 Km²
El Pascador & La Pierdra Kelp: 0.1636 Km²
Lechuza Kelp: 0.0959 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
3


118°50'W
118°49'W
118°48'W
118°47'W
34°01'N
34°00'N
33°59'N
Malibu
Point Dume
Kelp bed area
Point Dume Kelp: 0.012 km²
Paradise Cove Kelp: 0.162 km²
Escondido Wash Kelp: 0.214 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
4


118°50'W
118°49'W
118°48'W
118°47'W
34°01'N
34°00'N
33°59'N
Malibu
Point Dume
Kelp bed area
Point Dume Kelp: 0.029 km²
Paradise Cove Kelp: 0.258 km²
Escondido Wash Kelp: 0.250 km²
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
4


118°50'W
118°49'W
118°48'W
118°47'W
34°01'N
34°00'N
33°59'N
Malibu
Point Dume
Kelp bed area
Point Dume Kelp: 0.0284 km²
Paradise Cove Kelp: 0.0346 km²
Escondido Wash Kelp: 0.0781 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
4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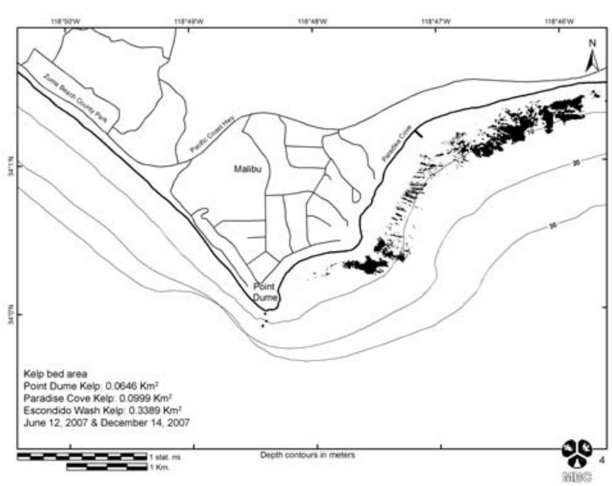
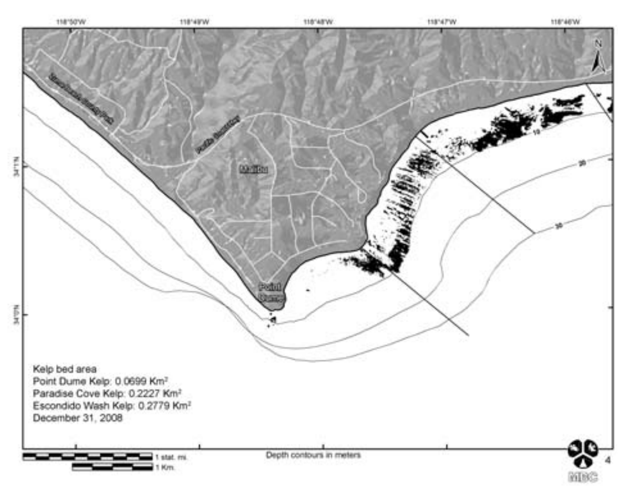
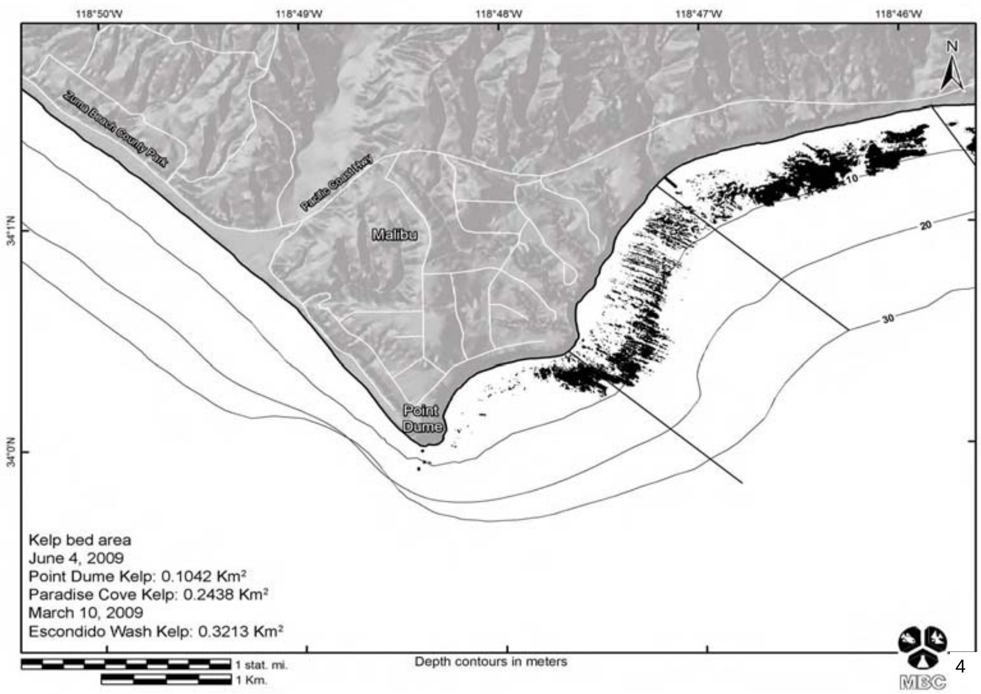
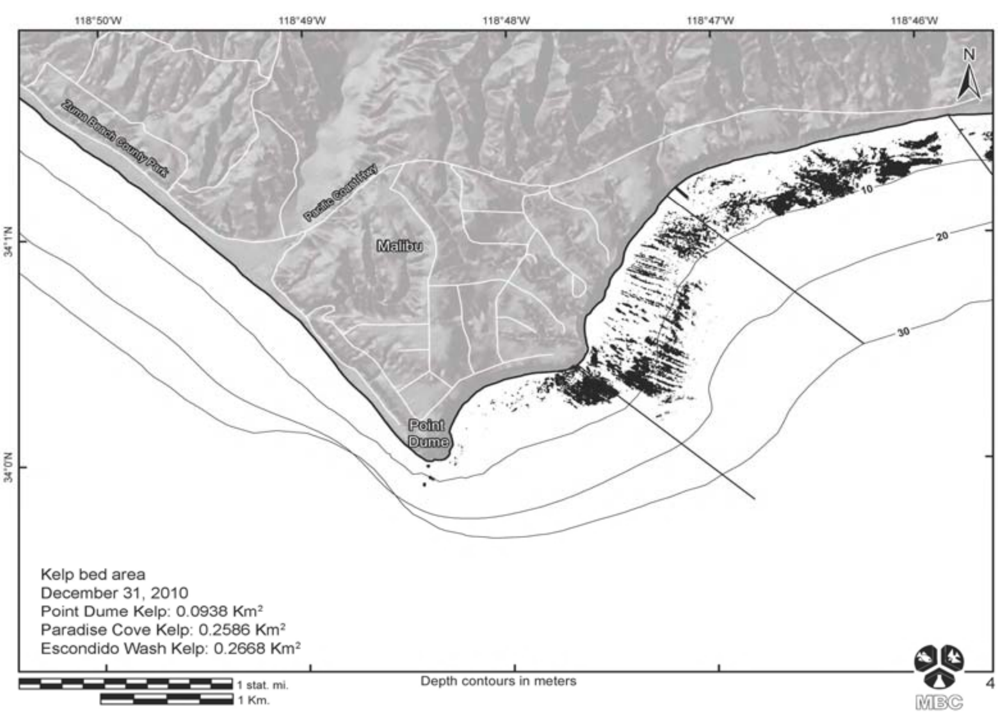
118°49'W
118°48'W
118°47'W
118°46'W
34°01'N
34°00'N
33°59'N
Malibu
Point Dume
Kelp bed area
Point Dume Kelp: 0.0529 km²
Paradise Cove Kelp: 0.0358 km²
Escondido Wash Kelp: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
4


118°50'W
118°49'W
118°48'W
118°47'W
118°46'W
34°1'N
34°0'N
N
Malibu
Point Dume
Kelp bed area
Point Dume Kelp: 0.0646 Km²
Paradise Cove Kelp: 0.0999 Km²
Escondido Wash Kelp: 0.3389 Km²
June 12, 2007 & December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
4


118°50'W
118°49'W
118°48'W
118°47'W
118°46'W
34°1'N
34°0'N
N
Malibu
Kelp bed area
Point Dume Kelp: 0.0699 Km²
Paradise Cove Kelp: 0.2227 Km²
Escondido Wash Kelp: 0.2779 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
4


118°50'W
118°49'W
118°48'W
118°47'W
118°46'W
34°1'N
34°0'N
Zuma Beach County Park
Pacific Coast Hwy
Malibu
Point Dume
10
20
30
Kelp bed area
June 4, 2009
Point Dume Kelp: 0.1042 Km²
Paradise Cove Kelp: 0.2438 Km²
March 10, 2009
Escondido Wash Kelp: 0.3213 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
4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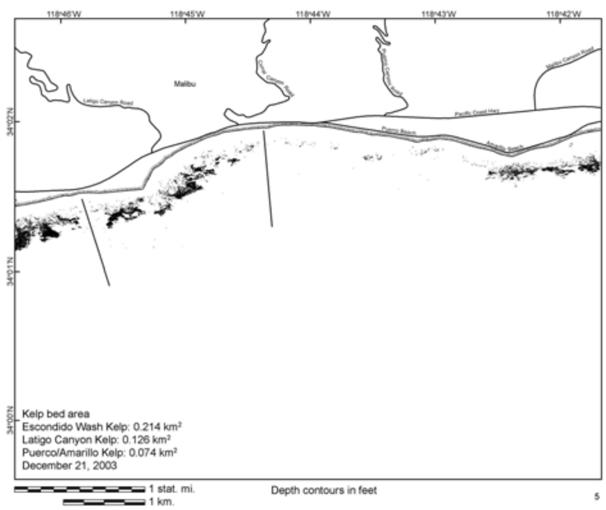
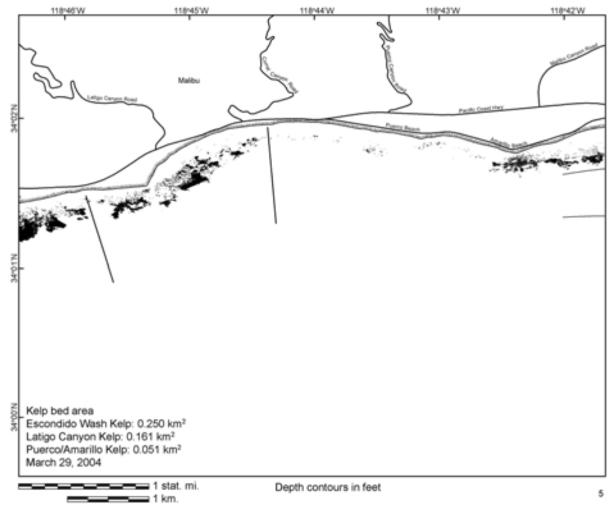
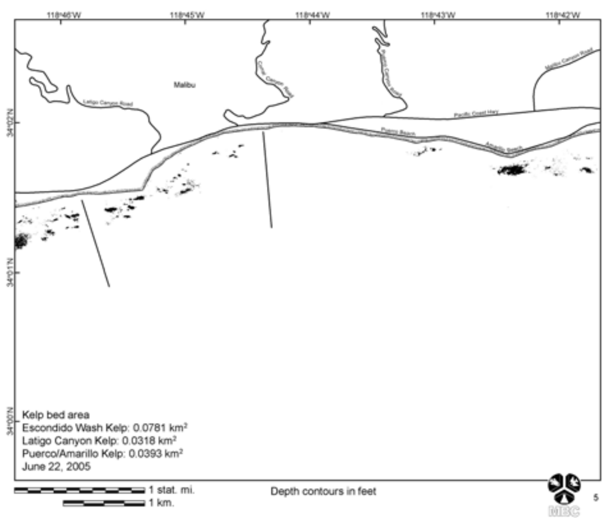
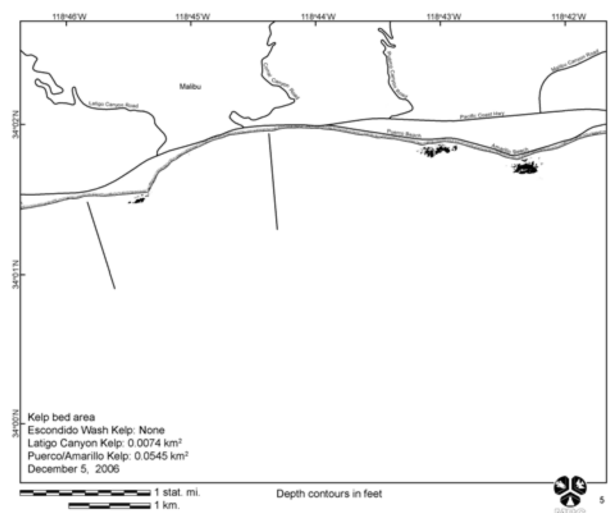
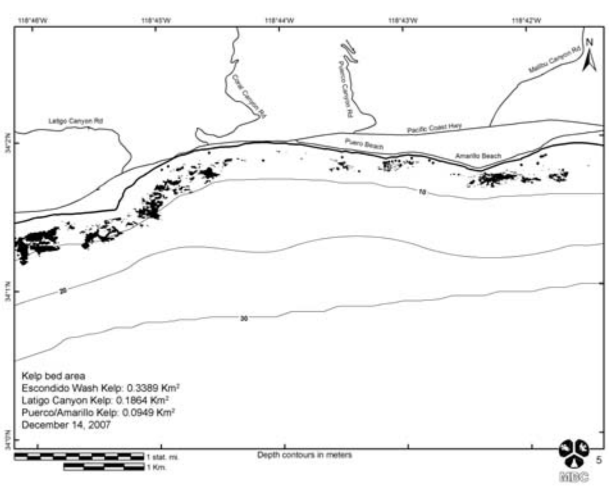
118°47'W
118°46'W
34°1'N
34°0'N
Zuma Beach County Park
Pacific Coast Hwy
Malibu
Point Dume
10
20
30
Kelp bed area
December 31, 2010
Point Dume Kelp: 0.0938 Km²
Paradise Cove Kelp: 0.2586 Km²
Escondido Wash Kelp: 0.2668 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
4

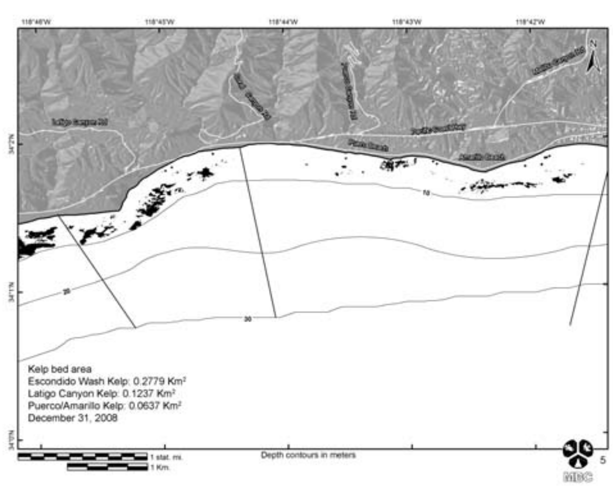

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°02'N
34°01'N
34°00'N
Malibu
Kelp bed area
Escondido Wash Kelp: 0.214 km²
Latigo Canyon Kelp: 0.126 km²
Puerco/Amarillo Kelp: 0.074 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
5

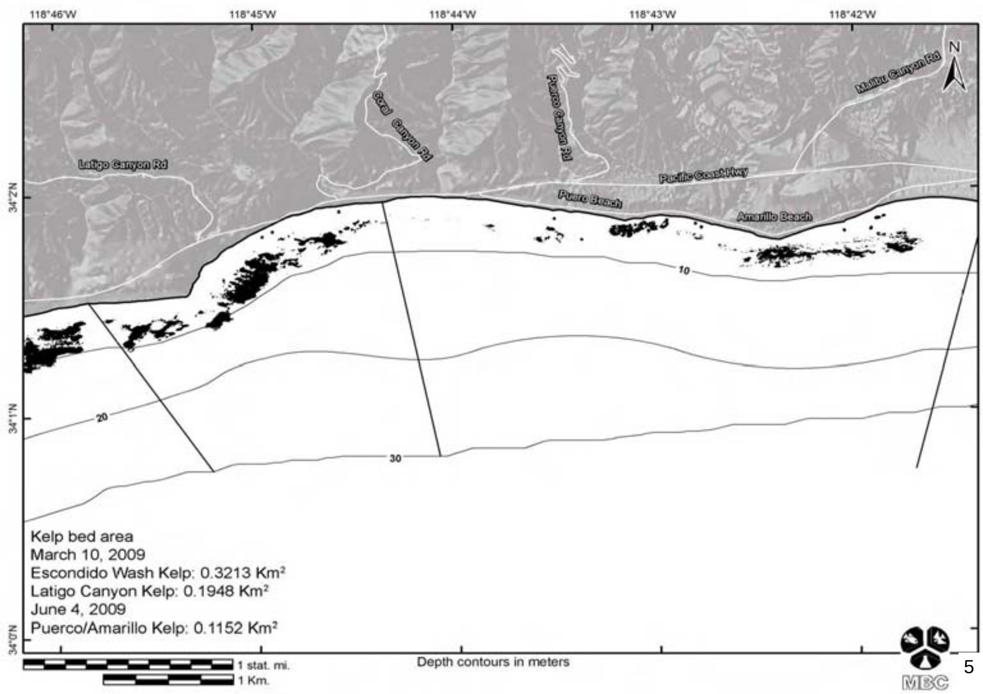

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°02'N
34°01'N
34°00'N
Malibu
Kelp bed area
Escondido Wash Kelp: 0.250 km²
Latigo Canyon Kelp: 0.161 km²
Puerco/Amarillo Kelp: 0.051 km²
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
5


118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°02'N
34°01'N
34°00'N
Malibu
Kelp bed area
Escondido Wash Kelp: 0.0781 km²
Latigo Canyon Kelp: 0.0318 km²
Puerco/Amarillo Kelp: 0.0393 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
5

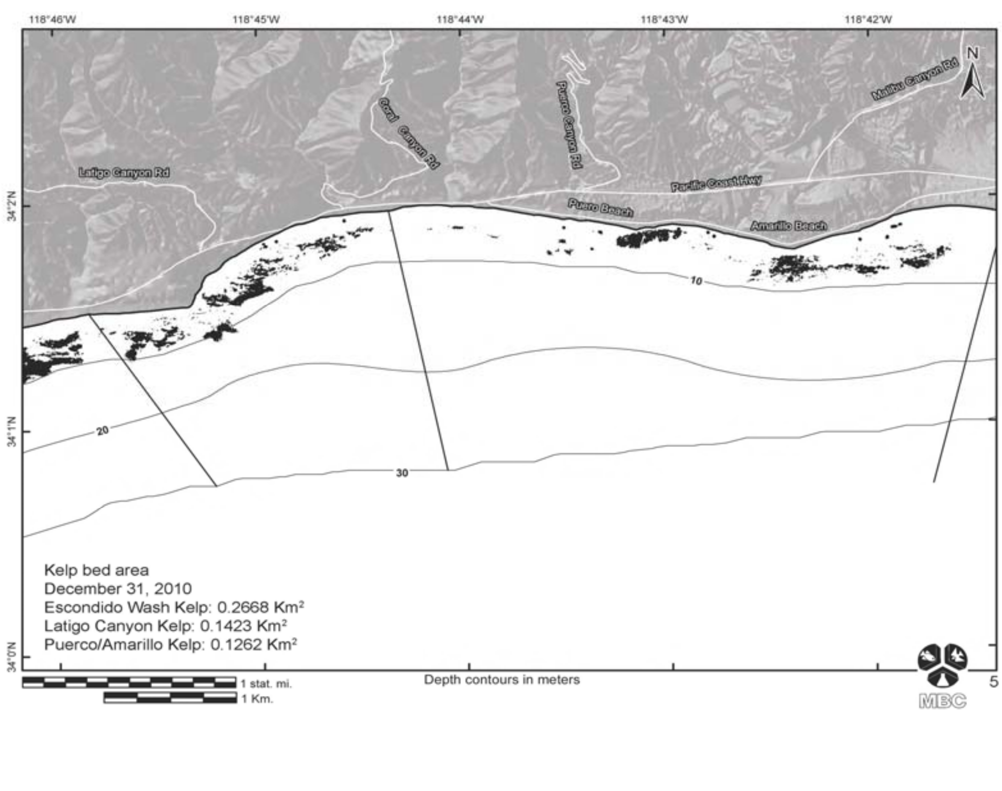

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°02'N
34°01'N
34°00'N
Malibu
Kelp bed area
Escondido Wash Kelp: None
Latigo Canyon Kelp: 0.0074 km²
Puerco/Amarillo Kelp: 0.0545 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
5


118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°2'N
34°1'N
34°0'N
N
Latigo Canyon Rd
Malibu Canyon Rd
Pacific Coast Hwy
Puerco Beach
Amarillo Beach
10
20
30
Kelp bed area
Escondido Wash Kelp: 0.3389 Km²
Latigo Canyon Kelp: 0.1864 Km²
Puerco/Amarillo Kelp: 0.0949 Km²
December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
5

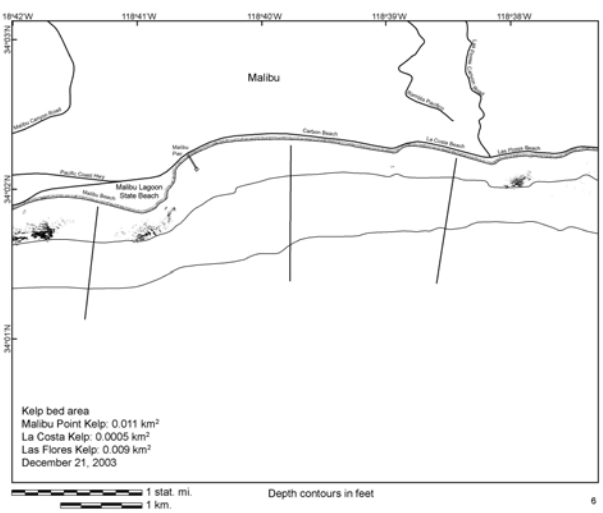

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°2'N
34°1'N
34°0'N
N
10
20
30
Kelp bed area
Escondido Wash Kelp: 0.2779 Km²
Latigo Canyon Kelp: 0.1237 Km²
Puerco/Amarillo Kelp: 0.0637 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
5

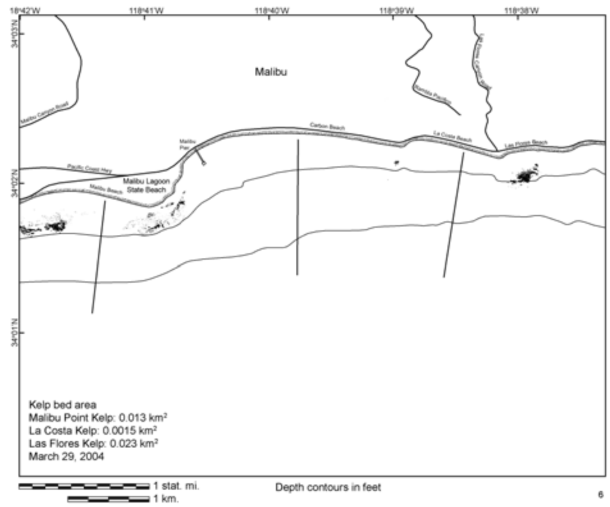

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°2'N
34°1'N
34°0'N
N
Malibu Canyon Rd
Coral Canyon Rd
Puerco Canyon Rd
Latigo Canyon Rd
Pacific Coast Hwy
Puerco Beach
Amarillo Beach
10
20
30
Kelp bed area
March 10, 2009
Escondido Wash Kelp: 0.3213 Km²
Latigo Canyon Kelp: 0.1948 Km²
June 4, 2009
Puerco/Amarillo Kelp: 0.1152 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

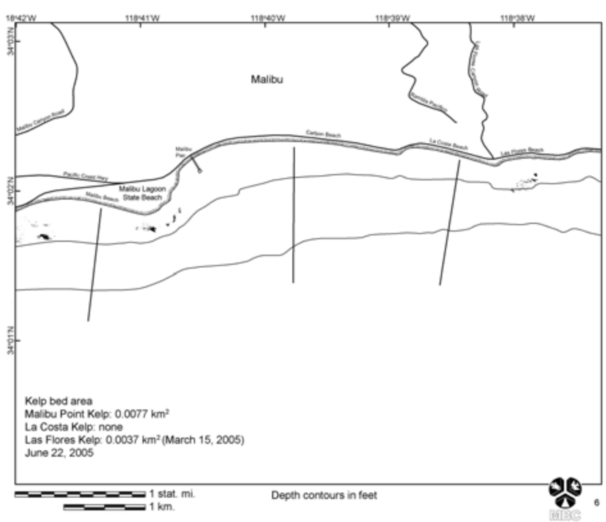
5

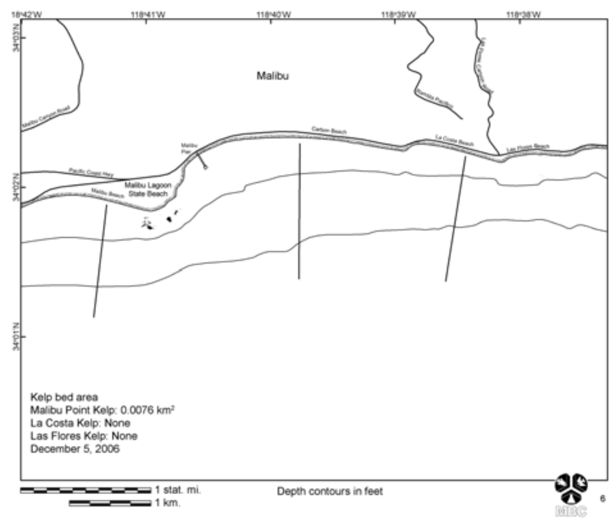

118°46'W
118°45'W
118°44'W
118°43'W
118°42'W
34°2'N
34°1'N
34°0'N
N
Malibu Canyon Rd
Coral Canyon Rd
Puerco Canyon Rd
Latigo Canyon Rd
Pacific Coast Hwy
Puerco Beach
Amarillo Beach
10
20
30
Kelp bed area
December 31, 2010
Escondido Wash Kelp: 0.2668 Km²
Latigo Canyon Kelp: 0.1423 Km²
Puerco/Amarillo Kelp: 0.1262 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

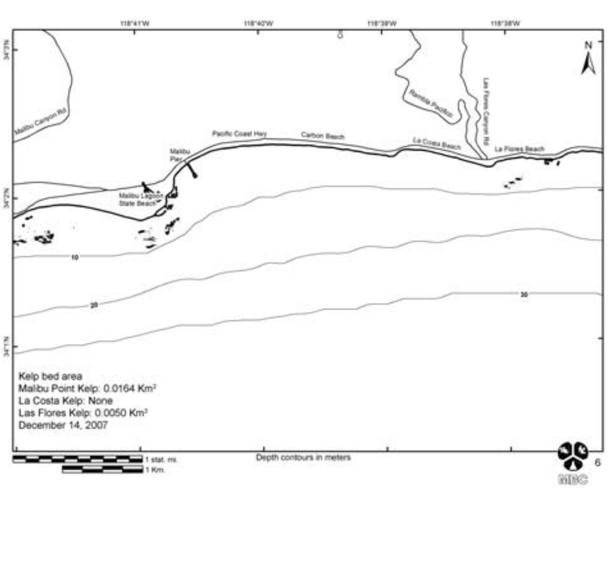
5

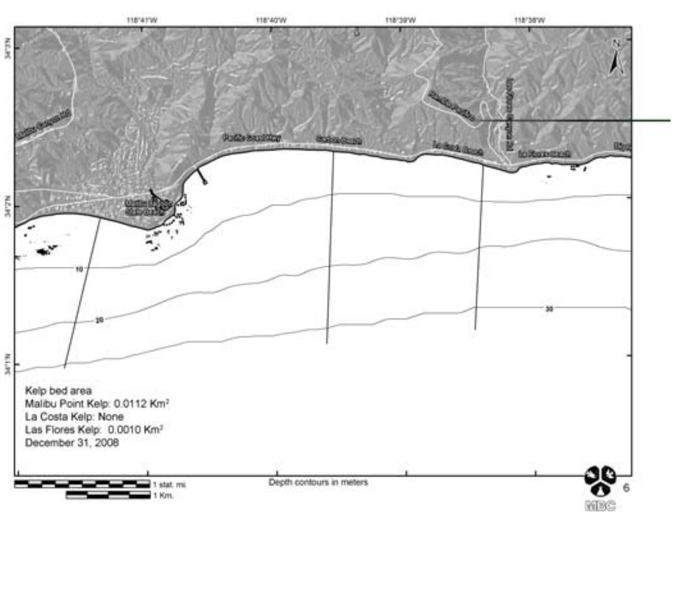

Malibu
Carbon Beach
La Costa Beach
Las Flores Beach
Pacific Coast Hwy
Malibu Lagoon State Beach
Malibu Pier
Kelp bed area
Malibu Point Kelp: 0.011 km²
La Costa Kelp: 0.0005 km²
Las Flores Kelp: 0.009 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
6

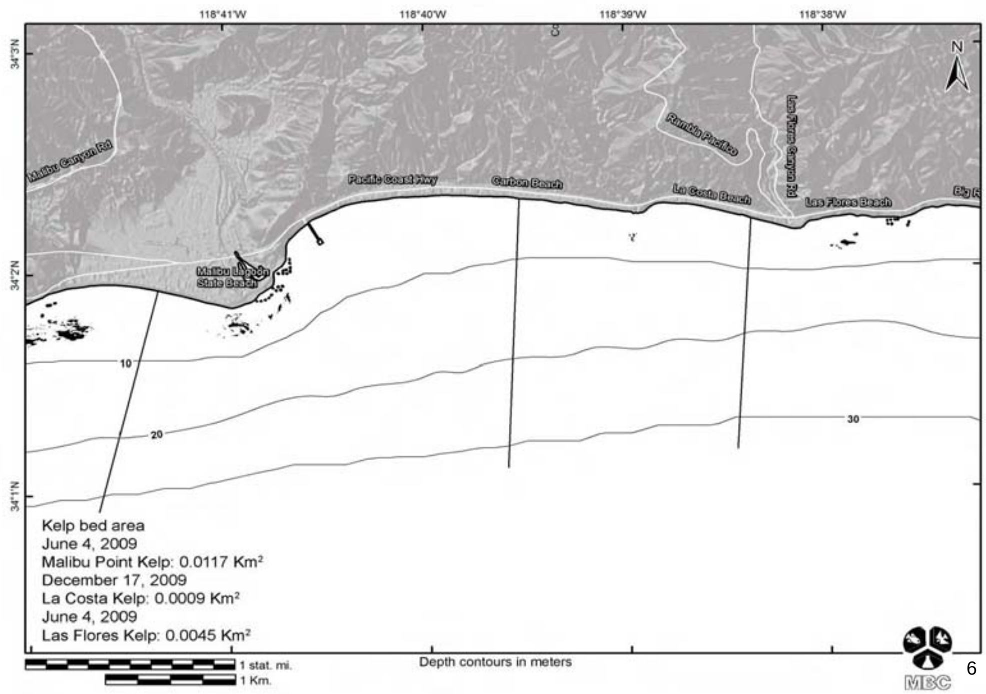

Malibu
Carbon Beach
La Costa Beach
Las Flores Beach
Pacific Coast Hwy
Malibu Lagoon State Beach
Malibu Pier
Kelp bed area
Malibu Point Kelp: 0.013 km²
La Costa Kelp: 0.0015 km²
Las Flores Kelp: 0.023 km²
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
6

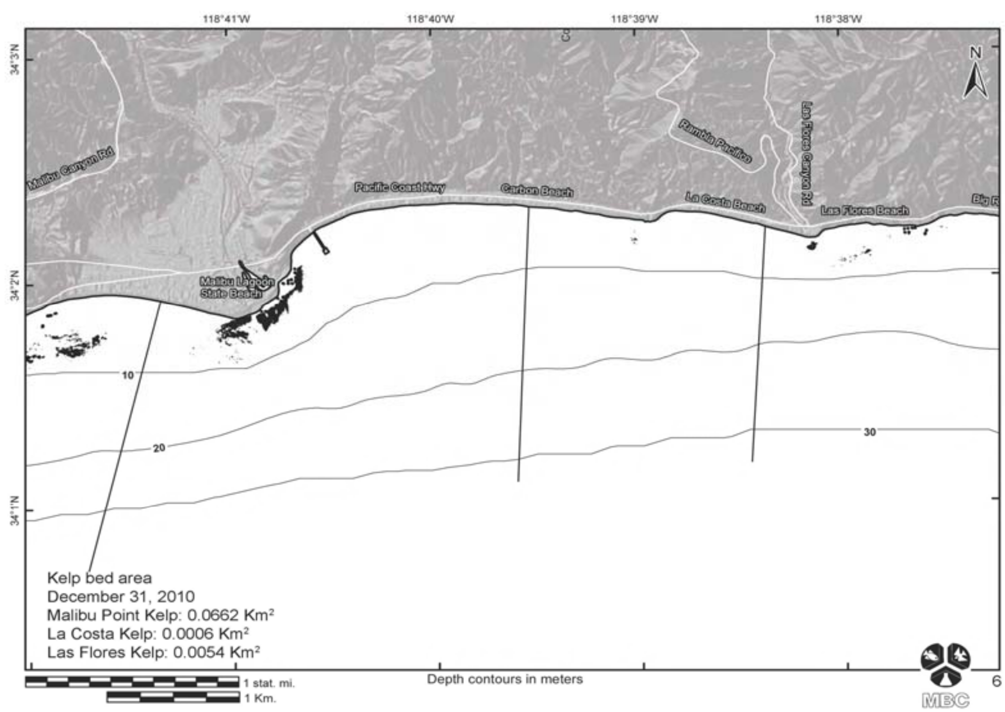

Malibu
Carbon Beach
La Costa Beach
Las Flores Beach
Pacific Coast Hwy
Malibu Lagoon State Beach
Malibu Pier
Kelp bed area
Malibu Point Kelp: 0.0077 km²
La Costa Kelp: none
Las Flores Kelp: 0.0037 km² (March 15, 2005)
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
6

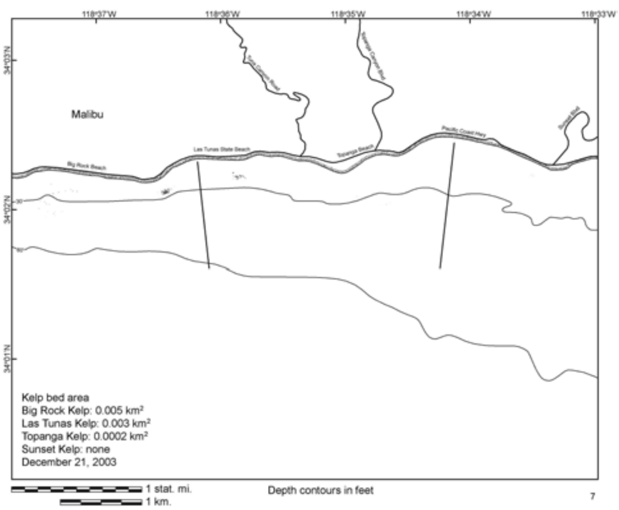

Malibu
Carbon Beach
La Costa Beach
Las Flores Beach
Pacific Coast Hwy
Malibu Lagoon State Beach
Malibu Pier
Kelp bed area
Malibu Point Kelp: 0.0076 km²
La Costa Kelp: None
Las Flores Kelp: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
6

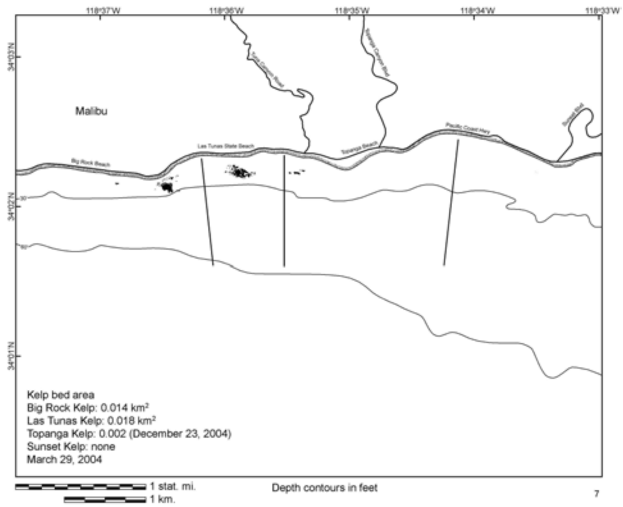

Pacific Coast Hwy
Carbon Beach
La Costa Beach
La Flores Beach
Malibu Pier
Malibu Lagoon State Beach
Kelp bed area
Malibu Point Kelp: 0.0164 Km²
La Costa Kelp: None
Las Flores Kelp: 0.0050 Km²
December 14, 2007
1 stat. mi
1 Km.
Depth contours in meters
6

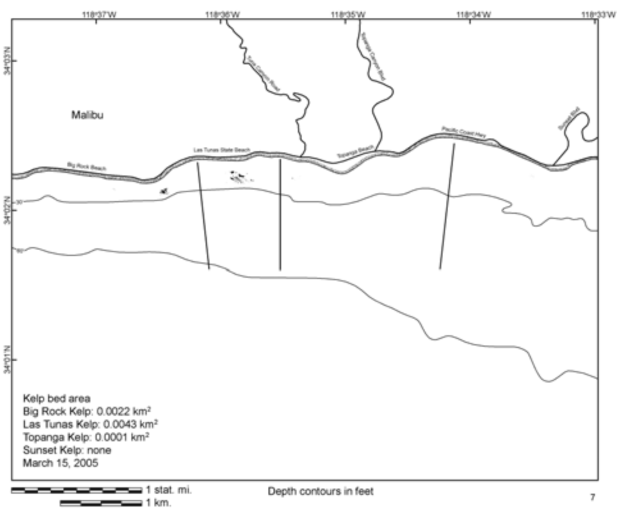

Pacific Coast Hwy
Carbon Beach
La Costa Beach
La Flores Beach
Kelp bed area
Malibu Point Kelp: 0.0112 Km²
La Costa Kelp: None
Las Flores Kelp: 0.0010 Km²
December 31, 2008
1 stat. mi
1 Km.
Depth contours in meters
6

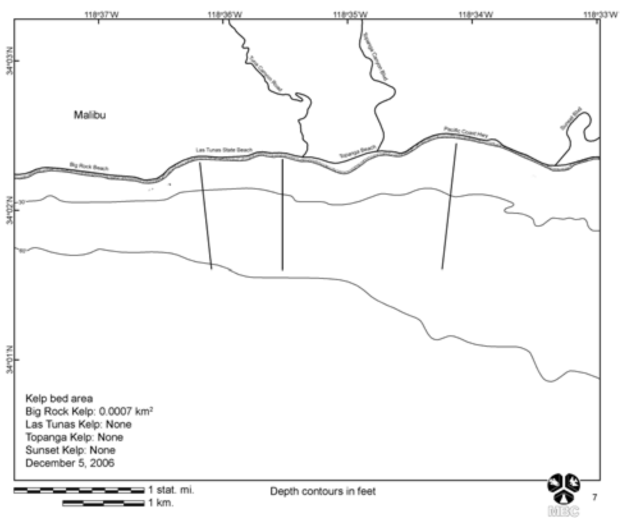

118°41'W
118°40'W
118°39'W
118°38'W
34°3'N
34°2'N
34°1'N
N
Malibu Canyon Rd
Pacific Coast Hwy
Carbon Beach
La Costa Beach
Las Flores Beach
Rambla Pacifico
Las Flores Canyon Rd
Malibu Lagoon State Beach
10
20
30
Kelp bed area
June 4, 2009
Malibu Point Kelp: 0.0117 Km²
December 17, 2009
La Costa Kelp: 0.0009 Km²
June 4, 2009
Las Flores Kelp: 0.0045 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
6

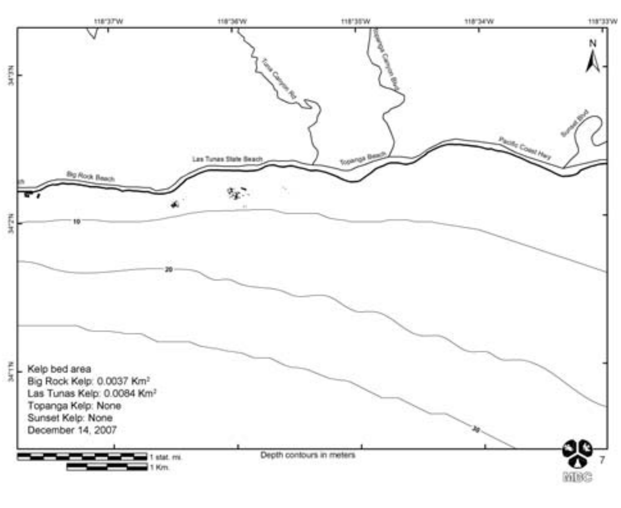

118°41'W
118°40'W
118°39'W
118°38'W
34°3'N
34°2'N
34°1'N
N
Malibu Canyon Rd
Pacific Coast Hwy
Carbon Beach
La Costa Beach
Las Flores Beach
Rambla Pacifico
Las Flores Canyon Rd
Malibu Lagoon State Beach
10
20
30
Kelp bed area
December 31, 2010
Malibu Point Kelp: 0.0662 Km²
La Costa Kelp: 0.0006 Km²
Las Flores Kelp: 0.0054 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
6

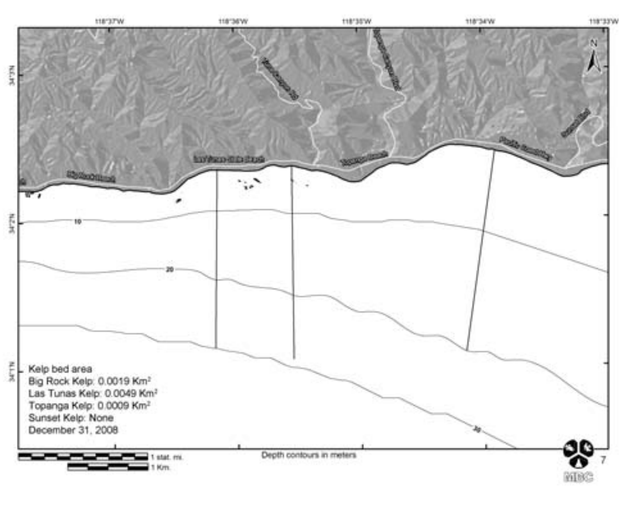

118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°03'N
34°02'N
34°01'N
Malibu
Big Rock Beach
Las Tunas State Beach
Topanga Beach
Pacific Coast Hwy
Kelp bed area
Big Rock Kelp: 0.005 km²
Las Tunas Kelp: 0.003 km²
Topanga Kelp: 0.0002 km²
Sunset Kelp: none
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
7

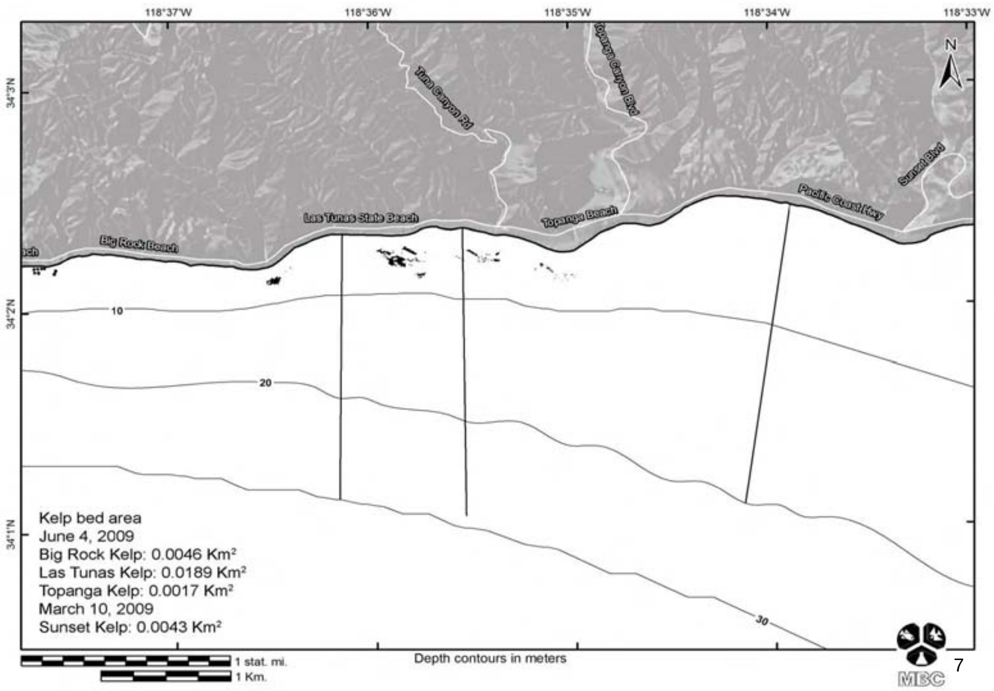

118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°03'N
34°02'N
34°01'N
Malibu
Big Rock Beach
Las Tunas State Beach
Topanga Beach
Pacific Coast Hwy
Kelp bed area
Big Rock Kelp: 0.014 km²
Las Tunas Kelp: 0.018 km²
Topanga Kelp: 0.002 (December 23, 2004)
Sunset Kelp: none
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
7


118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°03'N
34°02'N
34°01'N
Malibu
Big Rock Beach
Las Tunas State Beach
Topanga Beach
Pacific Coast Hwy
Kelp bed area
Big Rock Kelp: 0.0022 km²
Las Tunas Kelp: 0.0043 km²
Topanga Kelp: 0.0001 km²
Sunset Kelp: none
March 15, 2005
1 stat. mi.
1 km.
Depth contours in feet
7


118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°03'N
34°02'N
34°01'N
Malibu
Big Rock Beach
Las Tunas State Beach
Topanga Beach
Pacific Coast Hwy
Kelp bed area
Big Rock Kelp: 0.0007 km²
Las Tunas Kelp: None
Topanga Kelp: None
Sunset Kelp: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
7
MBC

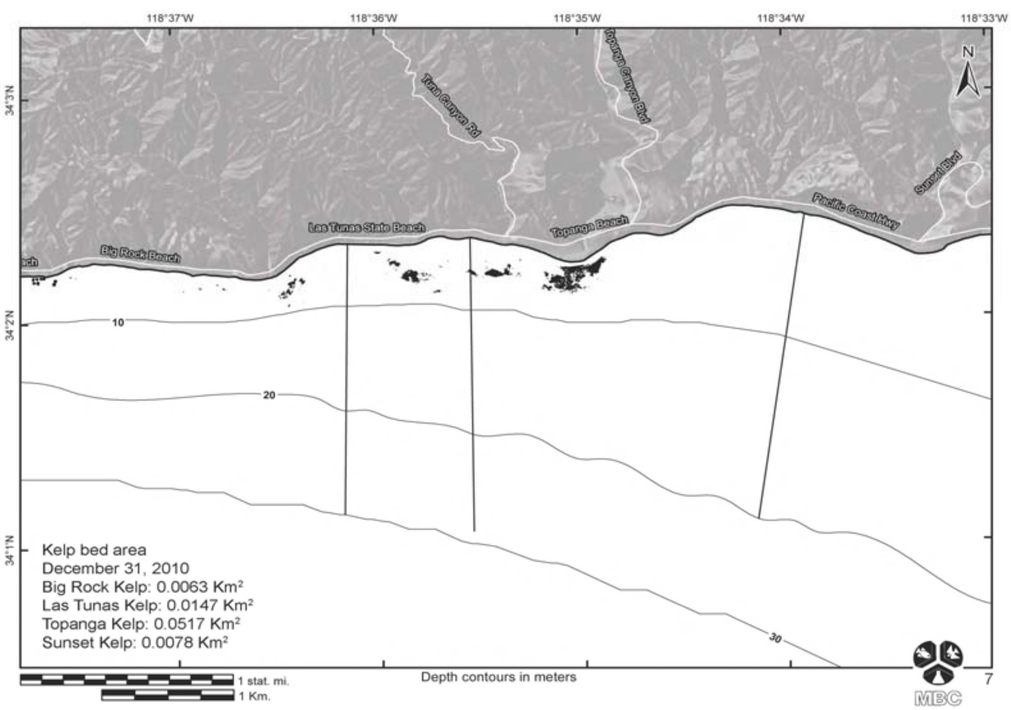

118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°3'N
34°2'N
34°1'N
N
Big Rock Beach
Las Tunas State Beach
Topanga Beach
Pacific Coast Hwy
Sunset Blvd
10
20
30
Kelp bed area
Big Rock Kelp: 0.0037 Km²
Las Tunas Kelp: 0.0084 Km²
Topanga Kelp: None
Sunset Kelp: None
December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
7
MBC


118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°3'N
34°2'N
34°1'N
N
10
20
30
Kelp bed area
Big Rock Kelp: 0.0019 Km²
Las Tunas Kelp: 0.0049 Km²
Topanga Kelp: 0.0009 Km²
Sunset Kelp: None
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
7
MBC



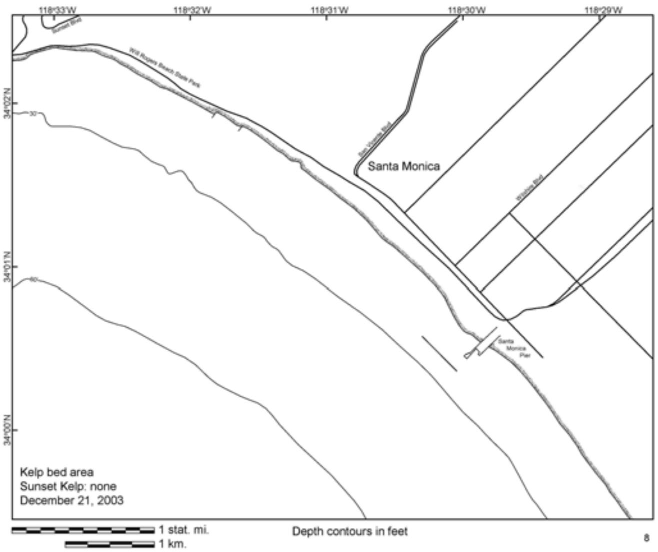
118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°3'N
34°2'N
34°1'N
Tuna Canyon Rd
Topanga Canyon Blvd
Sunset Blvd
Pacific Coast Hwy
Las Tunas State Beach
Topanga Beach
Big Rock Beach
10
20
30
Kelp bed area
June 4, 2009
Big Rock Kelp: 0.0046 Km²
Las Tunas Kelp: 0.0189 Km²
Topanga Kelp: 0.0017 Km²
March 10, 2009
Sunset Kelp: 0.0043 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

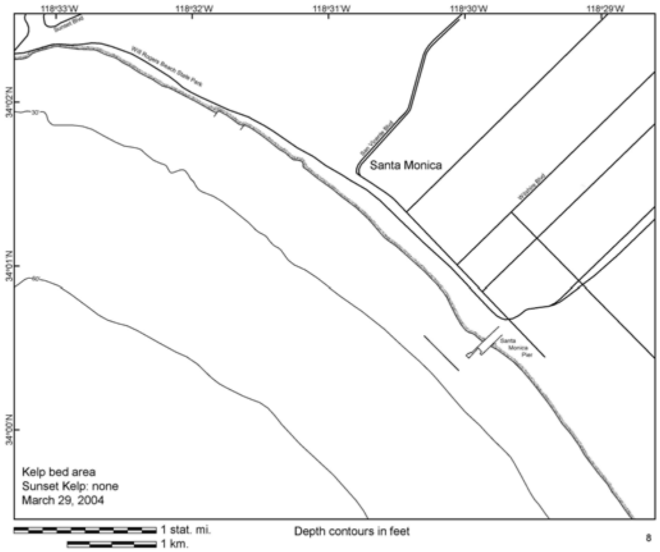
7

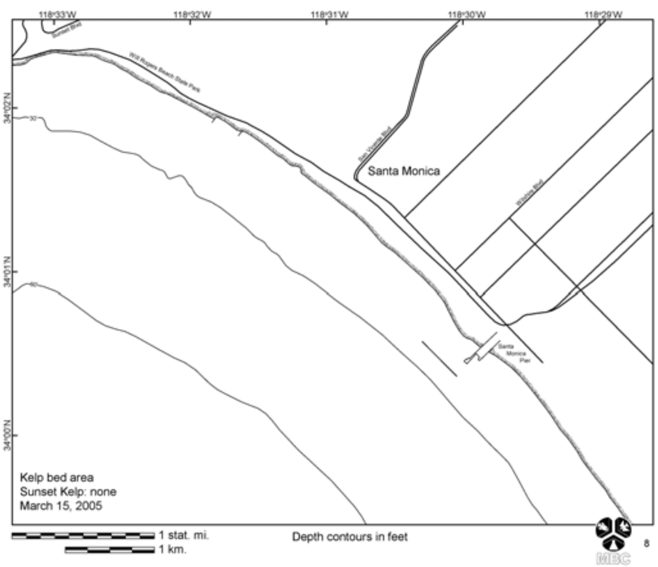


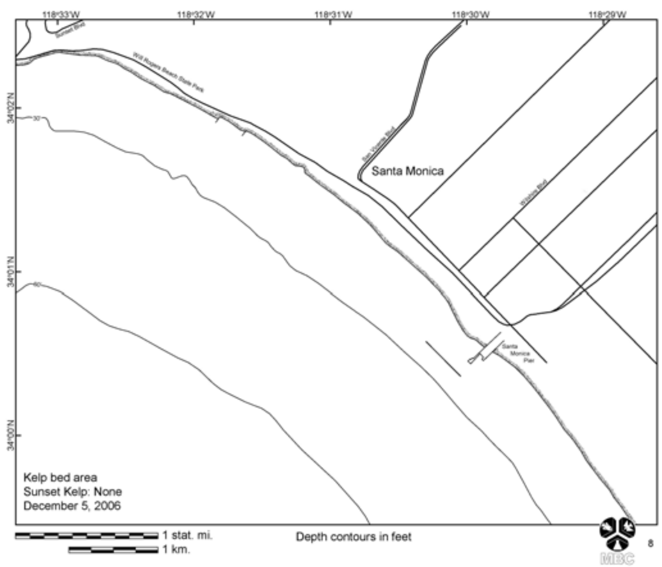
118°37'W
118°36'W
118°35'W
118°34'W
118°33'W
34°3'N
34°2'N
34°1'N
Tuna Canyon Rd
Topanga Canyon Blvd
Sunset Blvd
Pacific Coast Hwy
Las Tunas State Beach
Topanga Beach
Big Rock Beach
10
20
30
Kelp bed area
December 31, 2010
Big Rock Kelp: 0.0063 Km²
Las Tunas Kelp: 0.0147 Km²
Topanga Kelp: 0.0517 Km²
Sunset Kelp: 0.0078 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

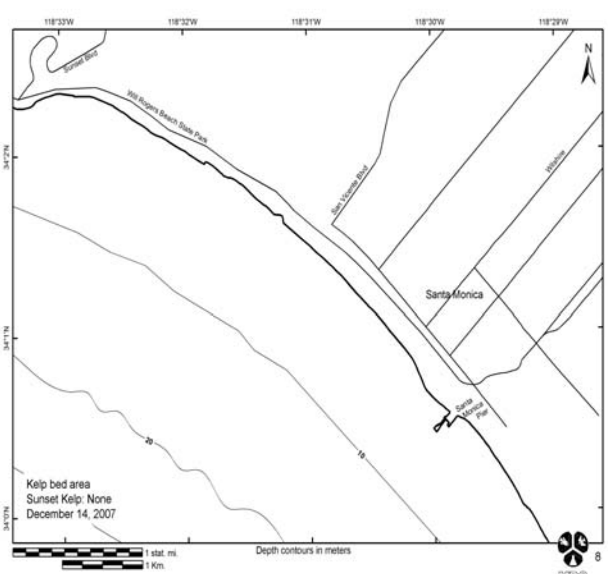
7

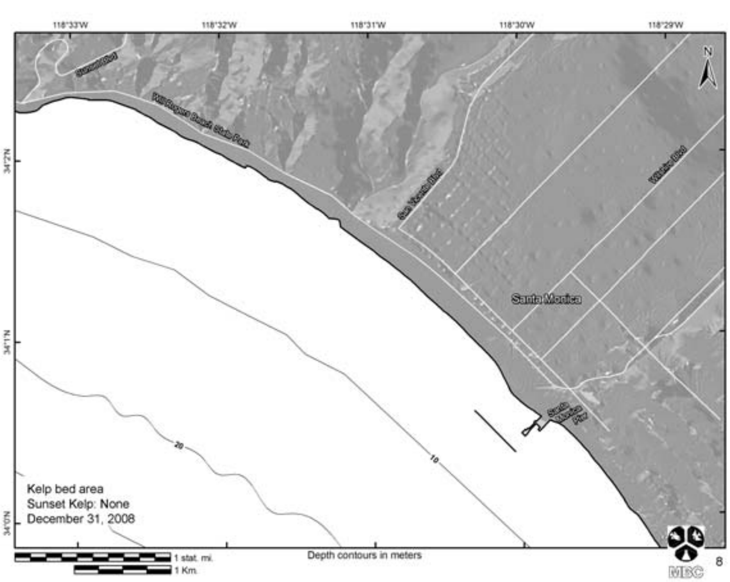

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°02'N
34°01'N
34°00'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Santa Monica
Wilshire Blvd
Santa Monica Pier
30
60
Kelp bed area
Sunset Kelp: none
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
8

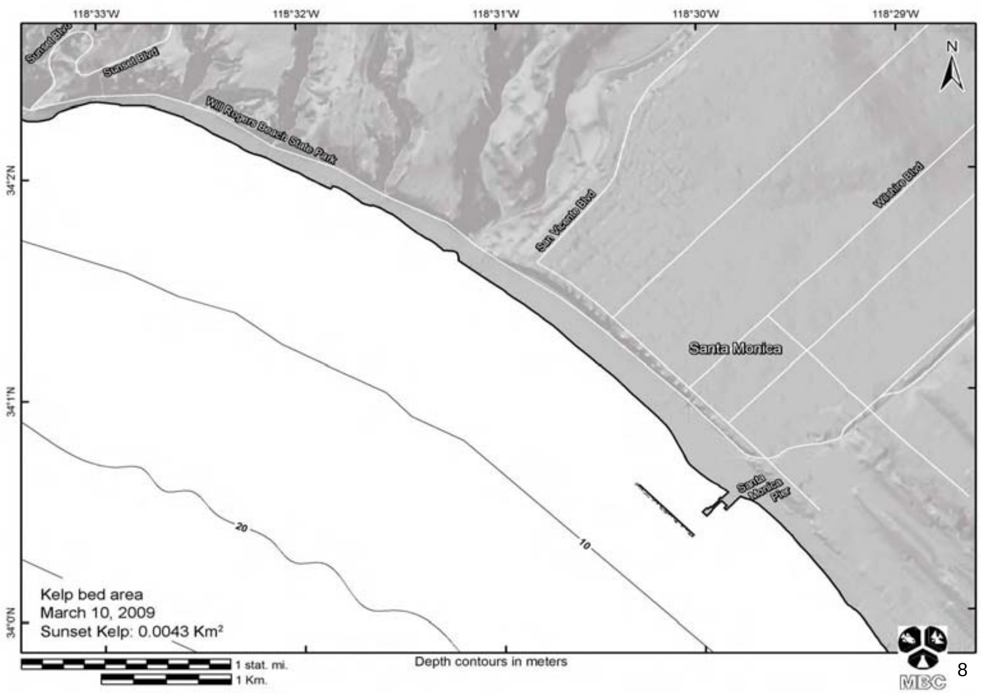

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°02'N
34°01'N
34°00'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Santa Monica
Wilshire Blvd
Santa Monica Pier
30
60
Kelp bed area
Sunset Kelp: none
March 29, 2004
1 stat. mi.
1 km.
Depth contours in feet
8


118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°02'N
34°01'N
34°00'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Santa Monica
Wilshire Blvd
Santa Monica Pier
30
60
Kelp bed area
Sunset Kelp: none
March 15, 2005
1 stat. mi.
1 km.
Depth contours in feet
8
MBC

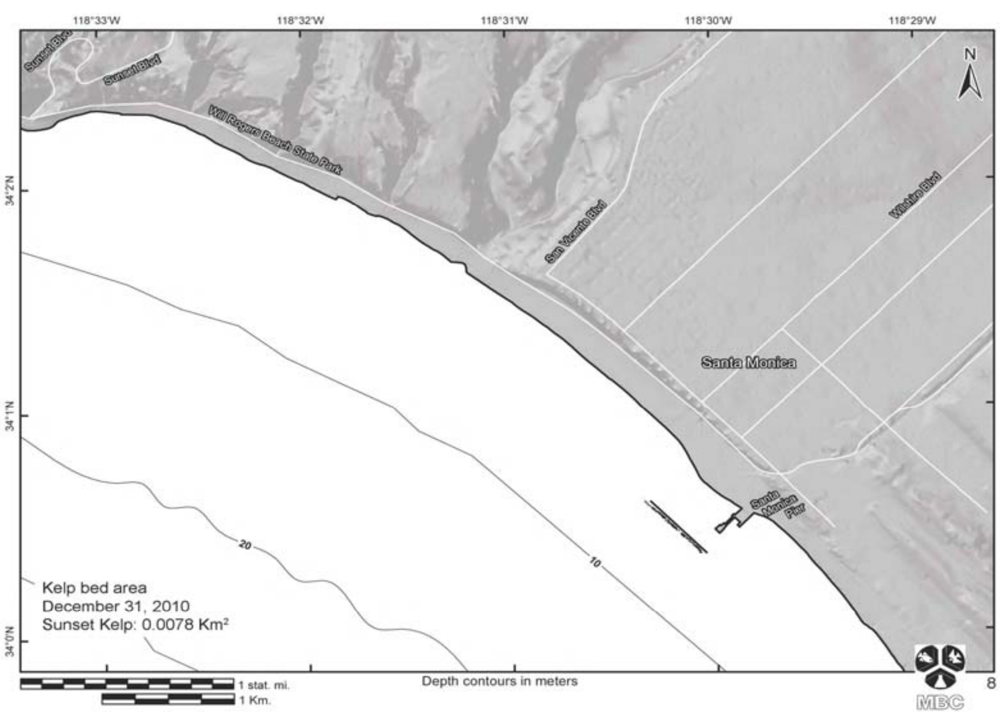

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°02'N
34°01'N
34°00'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Santa Monica
Wilshire Blvd
Santa Monica Pier
30
60
Kelp bed area
Sunset Kelp: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
8
MBC


118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
N
34°2'N
34°1'N
34°0'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Wilshire
Santa Monica
Santa Monica Pier
20
10
Kelp bed area
Sunset Kelp: None
December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
8
MBC

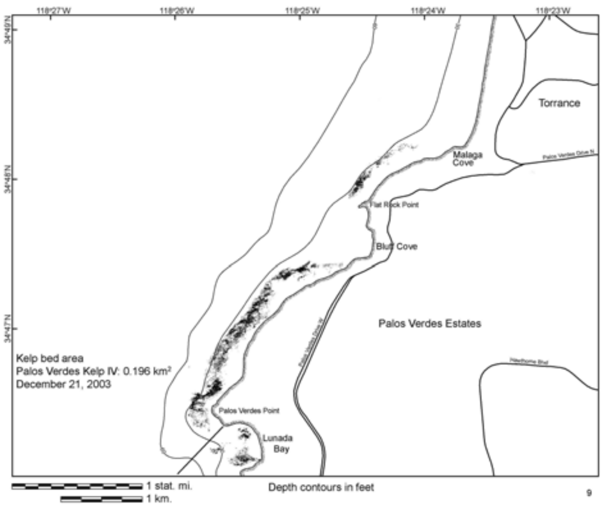

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
N
34°2'N
34°1'N
34°0'N
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Wilshire Blvd
Santa Monica
Santa Monica Pier
20
10
Kelp bed area
Sunset Kelp: None
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
8
MBC

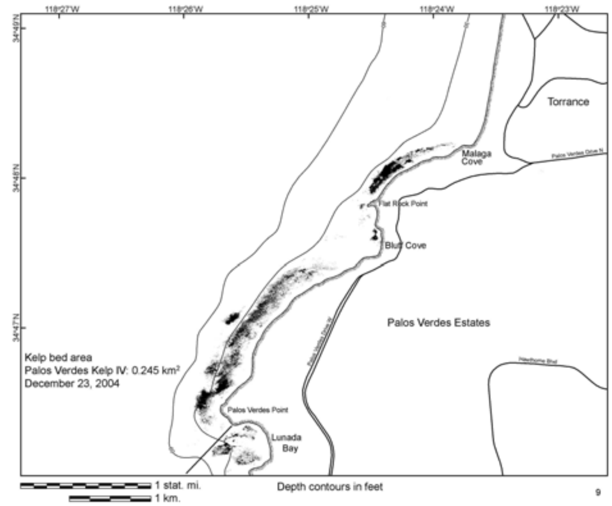

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°2'N
34°1'N
34°0'N
N
Sunset Blvd
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Wilshire Blvd
Santa Monica
Santa Monica Pier
20
10
Kelp bed area
March 10, 2009
Sunset Kelp: 0.0043 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

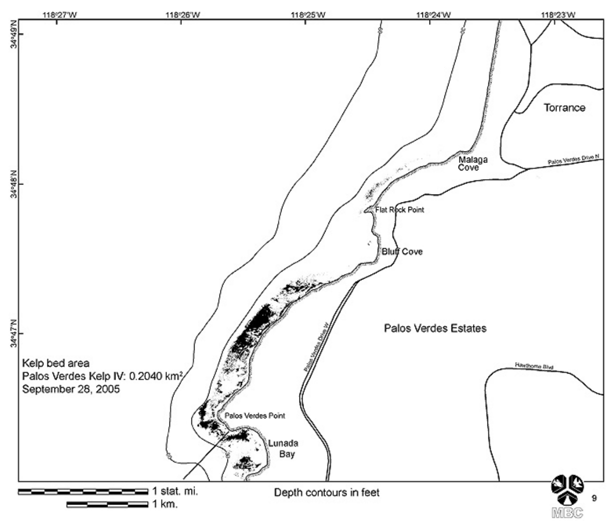
8

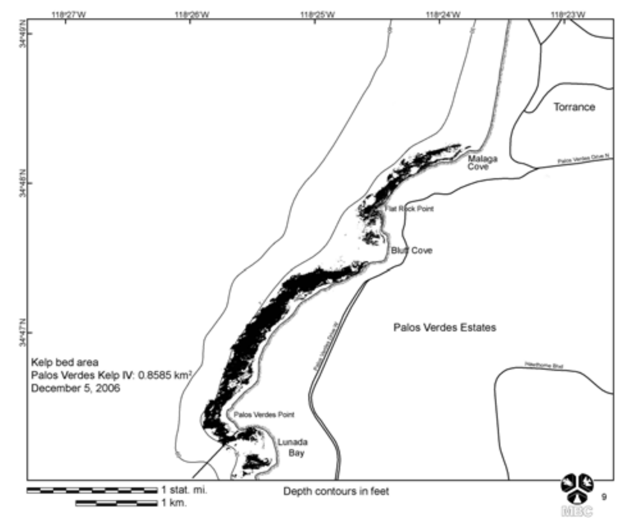

118°33'W
118°32'W
118°31'W
118°30'W
118°29'W
34°2'N
34°1'N
34°0'N
N
Sunset Blvd
Sunset Blvd
Will Rogers Beach State Park
San Vicente Blvd
Wilshire Blvd
Santa Monica
Santa Monica Pier
20
10
Kelp bed area
December 31, 2010
Sunset Kelp: 0.0078 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

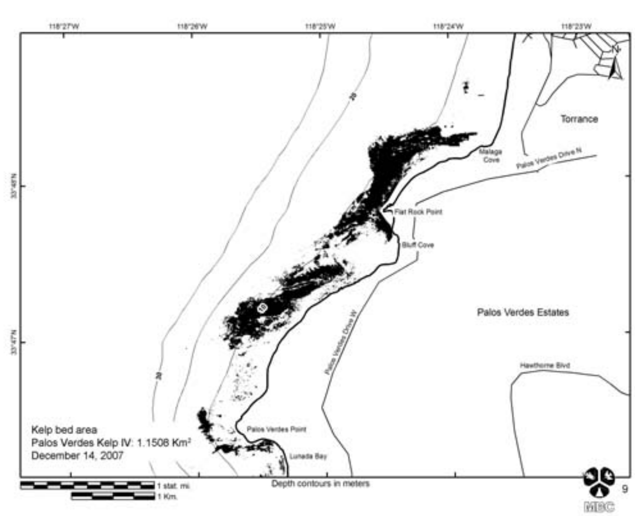
8

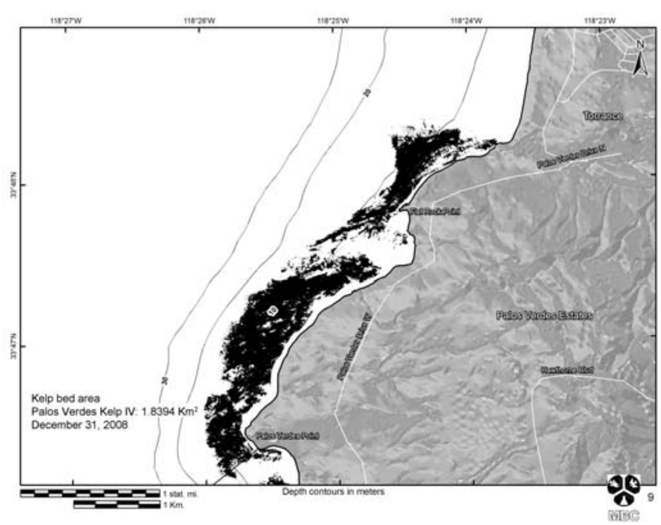

118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Malaga Cove
Flat Rock Point
Bluff Cove
Palos Verdes Estates
Kelp bed area
Palos Verdes Kelp IV: 0.196 km²
December 21, 2003
Palos Verdes Point
Lunada Bay
1 stat. mi.
1 km.
Depth contours in feet
9

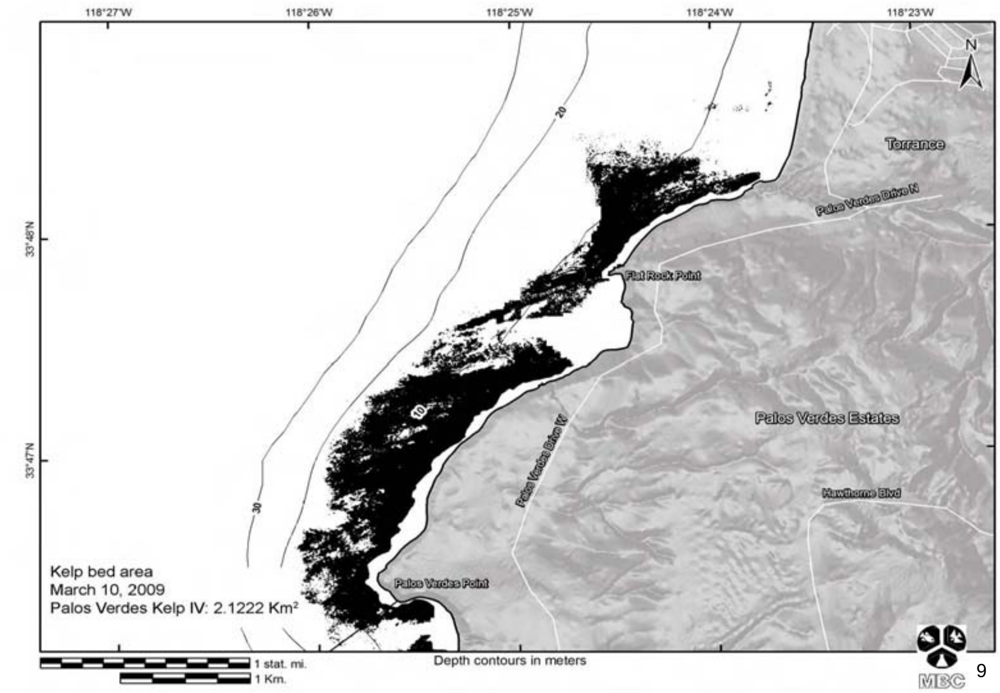

118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Malaga Cove
Flat Rock Point
Bluff Cove
Palos Verdes Estates
Kelp bed area
Palos Verdes Kelp IV: 0.245 km²
December 23, 2004
Palos Verdes Point
Lunada Bay
1 stat. mi.
1 km.
Depth contours in feet
9

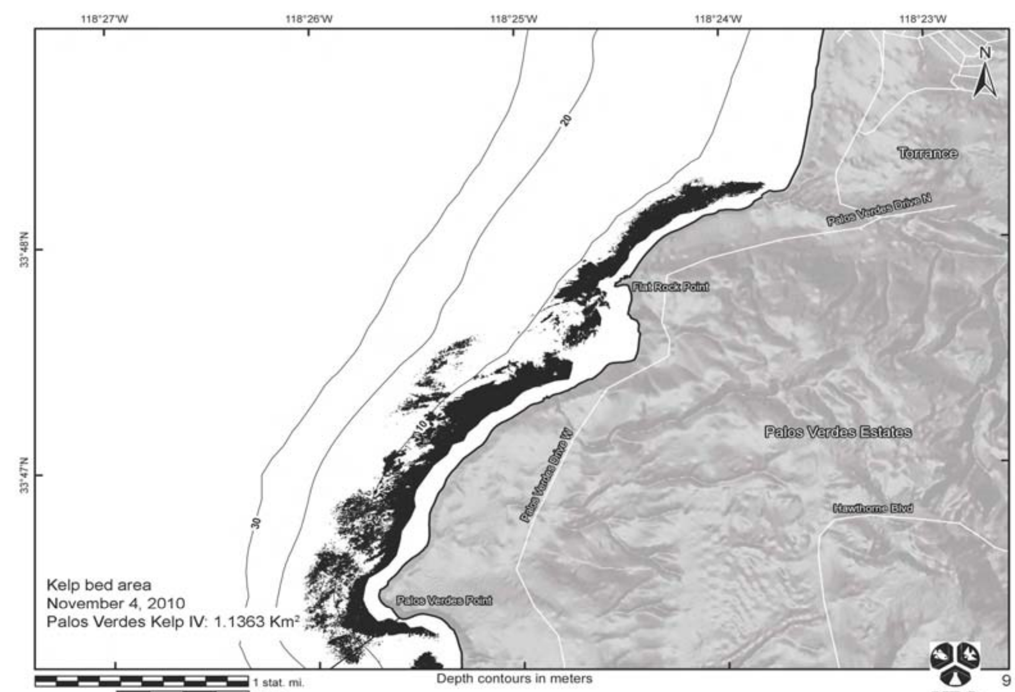

118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Malaga Cove
Flat Rock Point
Bluff Cove
Palos Verdes Estates
Kelp bed area
Palos Verdes Kelp IV: 0.2040 km²
September 28, 2005
Palos Verdes Point
Lunada Bay
1 stat. mi.
1 km.
Depth contours in feet
9
MBC

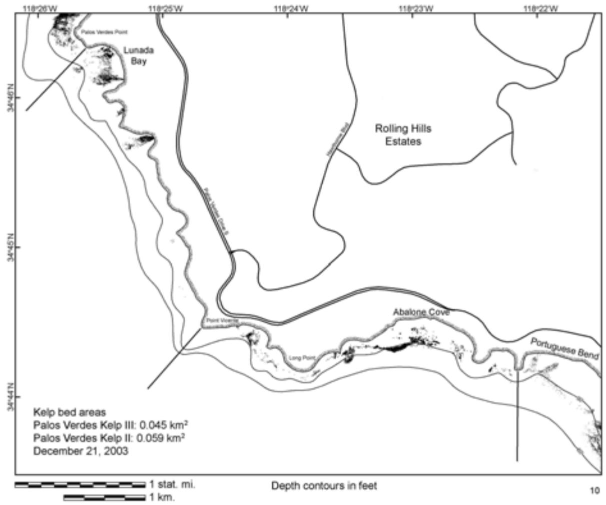

118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Malaga Cove
Flat Rock Point
Bluff Cove
Palos Verdes Estates
Kelp bed area
Palos Verdes Kelp IV: 0.8585 km²
December 5, 2006
Palos Verdes Point
Lunada Bay
1 stat. mi.
1 km.
Depth contours in feet
9
MBC


118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Malaga Cove
Palos Verdes Drive N
Flat Rock Point
Bluff Cove
Palos Verdes Estates
Hawthorne Blvd
Kelp bed area
Palos Verdes Kelp IV: 1.1508 Km²
December 14, 2007
Palos Verdes Point
Lunada Bay
1 stat. mi.
1 Km.
Depth contours in meters
9
MBC


118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
Torrance
Palos Verdes Drive N
Flat Rock Point
Palos Verdes Estates
Hawthorne Blvd
Kelp bed area
Palos Verdes Kelp IV: 1.8394 Km²
December 31, 2008
Palos Verdes Point
1 stat. mi.
1 Km.
Depth contours in meters
9
MBC


118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
N
33°48'N
33°47'N
20
10
30
Torrance
Palos Verdes Drive N
Flat Rock Point
Palos Verdes Estates
Palos Verdes Drive W
Hawthorne Blvd
Palos Verdes Point
Kelp bed area
March 10, 2009
Palos Verdes Kelp IV: 2.1222 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC


118°27'W
118°26'W
118°25'W
118°24'W
118°23'W
N
33°48'N
33°47'N
20
10
30
Torrance
Palos Verdes Drive N
Flat Rock Point
Palos Verdes Estates
Palos Verdes Drive W
Hawthorne Blvd
Palos Verdes Point
Kelp bed area
November 4, 2010
Palos Verdes Kelp IV: 1.1363 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC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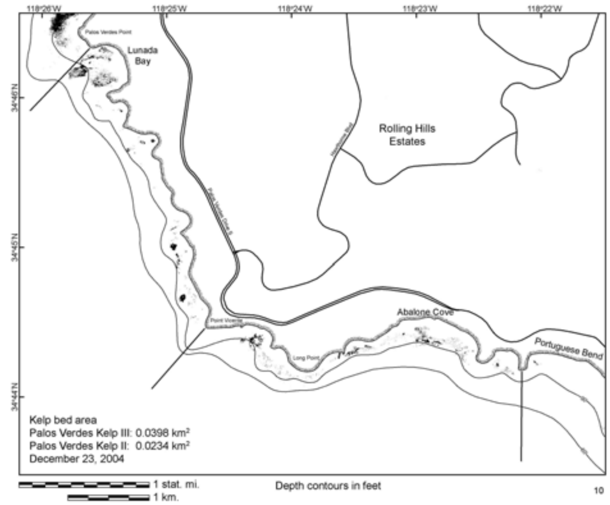
118°24'W
118°23'W
118°22'W
34°46'N
34°45'N
34°44'N
Palos Verdes Point
Lunada Bay
Rolling Hills Estates
Abalone Cove
Point Vicente
Long Point
Portuguese Bend
Kelp bed areas
Palos Verdes Kelp III: 0.045 km²
Palos Verdes Kelp II: 0.059 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
10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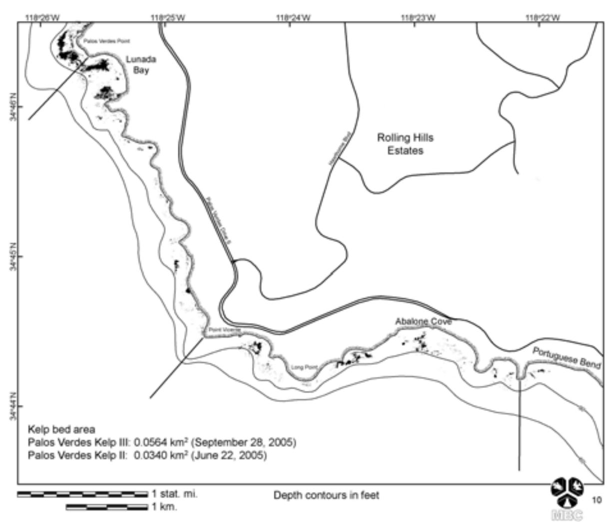
118°24'W
118°23'W
118°22'W
34°46'N
34°45'N
34°44'N
Palos Verdes Point
Lunada Bay
Rolling Hills Estates
Abalone Cove
Point Vicente
Long Point
Portuguese Bend
Kelp bed area
Palos Verdes Kelp III: 0.0398 km²
Palos Verdes Kelp II: 0.0234 km²
December 23, 2004
1 stat. mi.
1 km.
Depth contours in feet
10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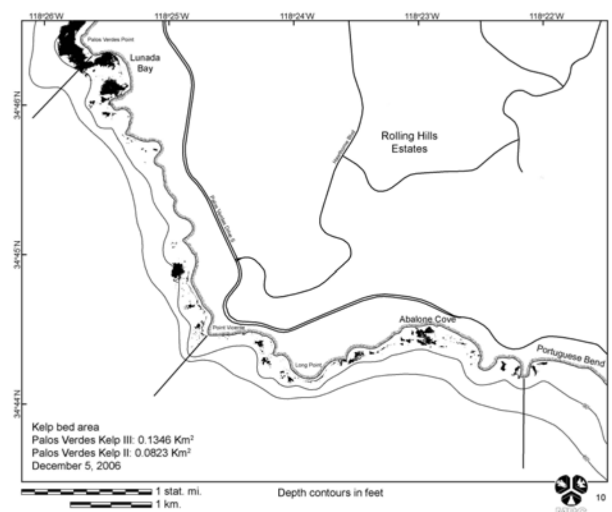
118°24'W
118°23'W
118°22'W
34°46'N
34°45'N
34°44'N
Palos Verdes Point
Lunada Bay
Rolling Hills Estates
Abalone Cove
Point Vicente
Long Point
Portuguese Bend
Kelp bed area
Palos Verdes Kelp III: 0.0564 km² (September 28, 2005)
Palos Verdes Kelp II: 0.0340 km² (June 22, 2005)
1 stat. mi.
1 km.
Depth contours in feet
10
MBC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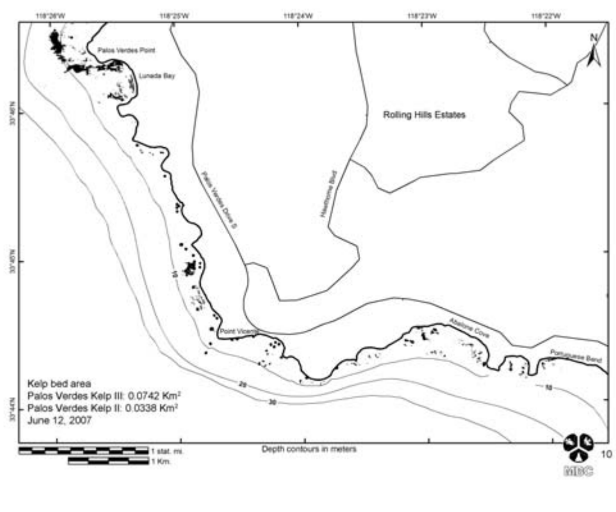
118°24'W
118°23'W
118°22'W
34°46'N
34°45'N
34°44'N
Palos Verdes Point
Lunada Bay
Rolling Hills Estates
Abalone Cove
Point Vicente
Long Point
Portuguese Bend
Kelp bed area
Palos Verdes Kelp III: 0.1346 Km²
Palos Verdes Kelp II: 0.0823 Km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
10
MBC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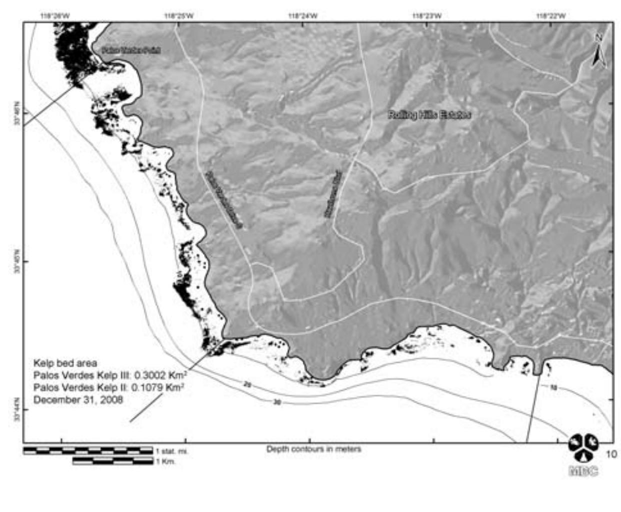
118°24'W
118°23'W
118°22'W
N
Palos Verdes Point
Lunada Bay
Rolling Hills Estates
Palos Verdes Drive S
Hawthorne Blvd
Point Vicente
Abalone Cove
Portuguese Bend
10
20
30
Kelp bed area
Palos Verdes Kelp III: 0.0742 Km²
Palos Verdes Kelp II: 0.0338 Km²
June 12, 2007
1 stat. mi.
1 Km.
Depth contours in meters
MBC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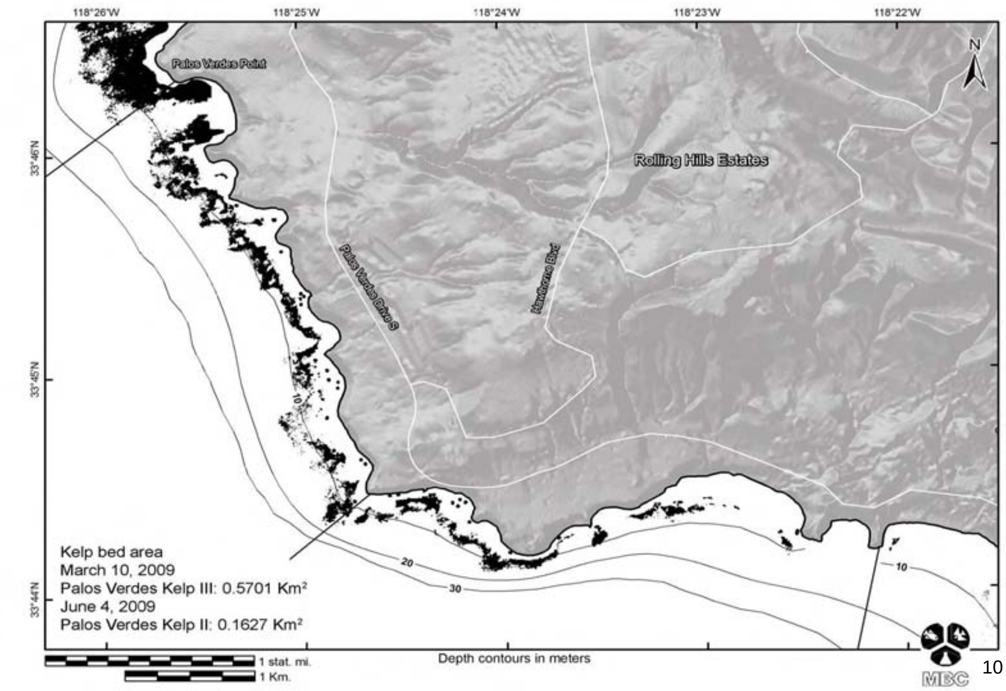
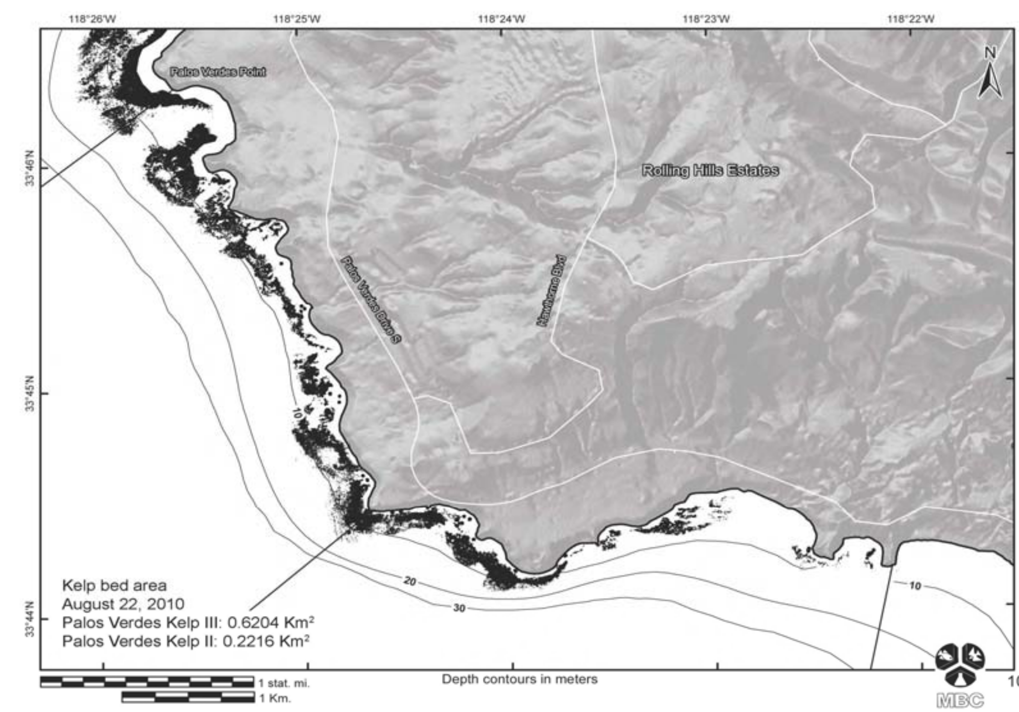
118°25'W
118°24'W
118°23'W
118°22'W
N
Palos Verdes Point
Rolling Hills Estates
20
30
10
Kelp bed area
Palos Verdes Kelp III: 0.3002 Km²
Palos Verdes Kelp II: 0.1079 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
10
MBC


118°26'W
118°25'W
118°24'W
118°23'W
118°22'W
33°46'N
33°45'N
33°44'N
Palos Verdes Point
Rolling Hills Estates
Palos Verdes Drive S
Hawthorne Blvd
N
10
20
30
Kelp bed area
March 10, 2009
Palos Verdes Kelp III: 0.5701 Km²
June 4, 2009
Palos Verdes Kelp II: 0.1627 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

10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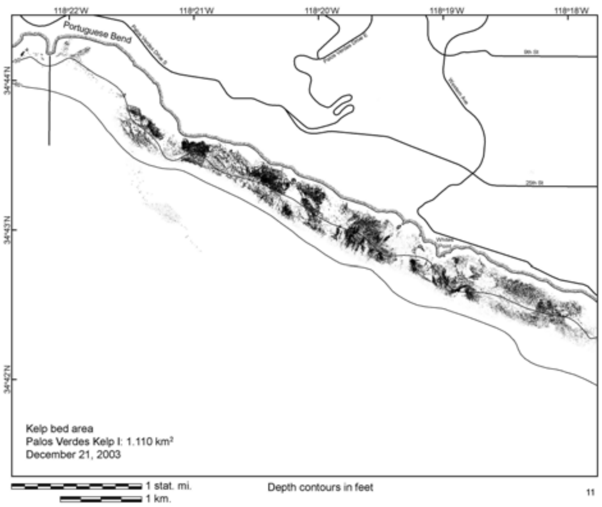
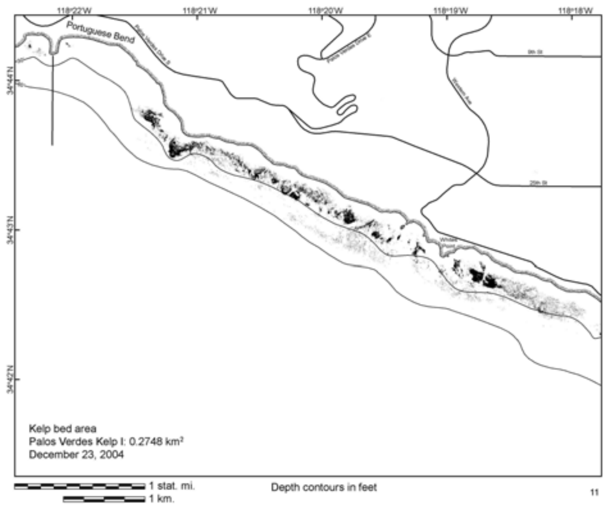
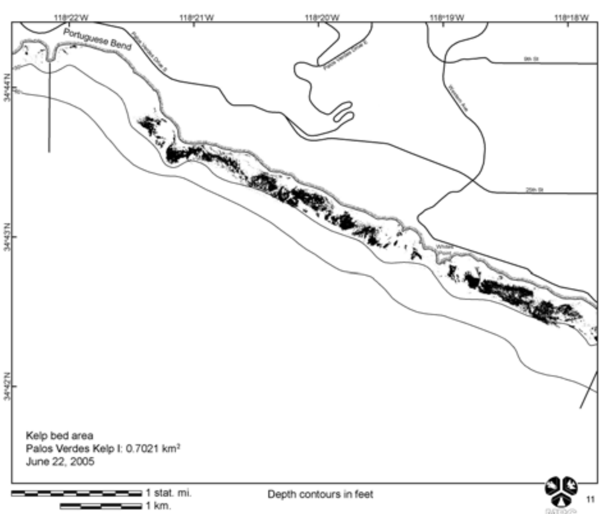
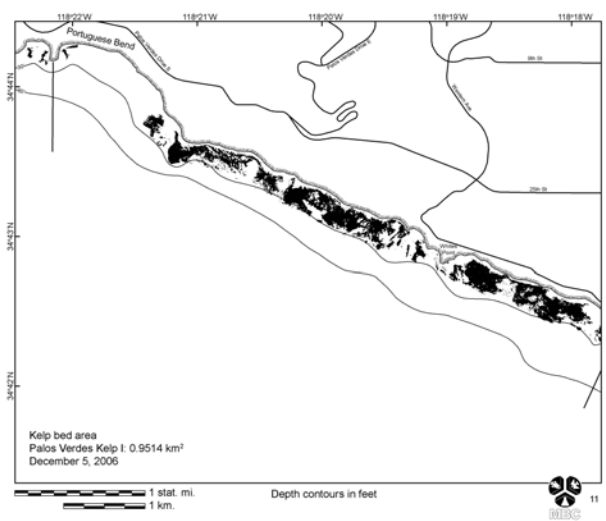
118°25'W
118°24'W
118°23'W
118°22'W
33°46'N
33°45'N
33°44'N
Palos Verdes Point
Rolling Hills Estates
Palos Verdes Drive S
Hawthorne Blvd
N
10
20
30
Kelp bed area
August 22, 2010
Palos Verdes Kelp III: 0.6204 Km²
Palos Verdes Kelp II: 0.2216 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

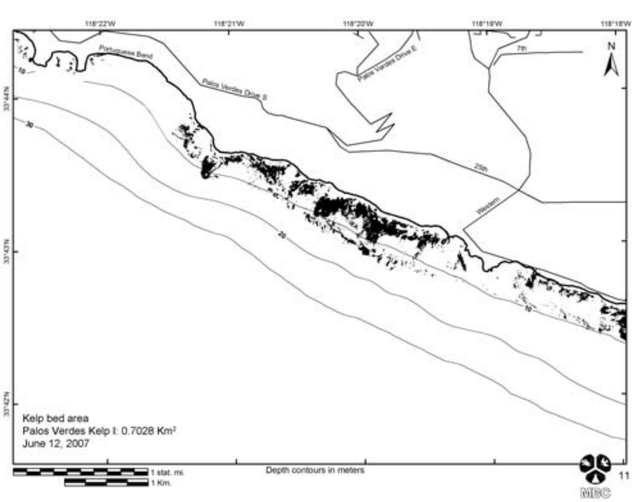
10

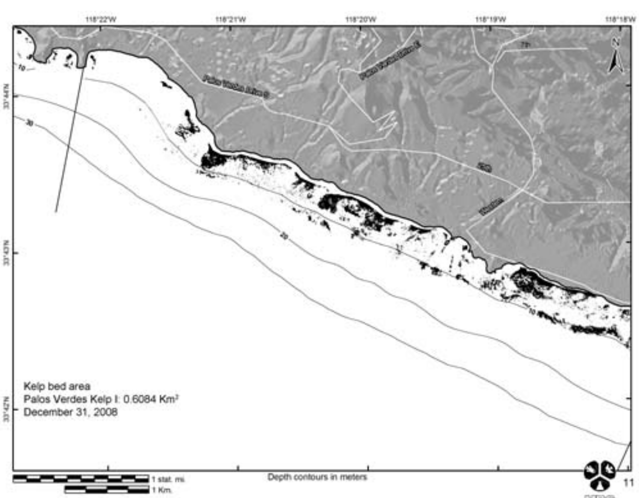

118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
Portuguese Bend
34°44'N
34°43'N
34°42'N
Kelp bed area
Palos Verdes Kelp I: 1.110 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
11

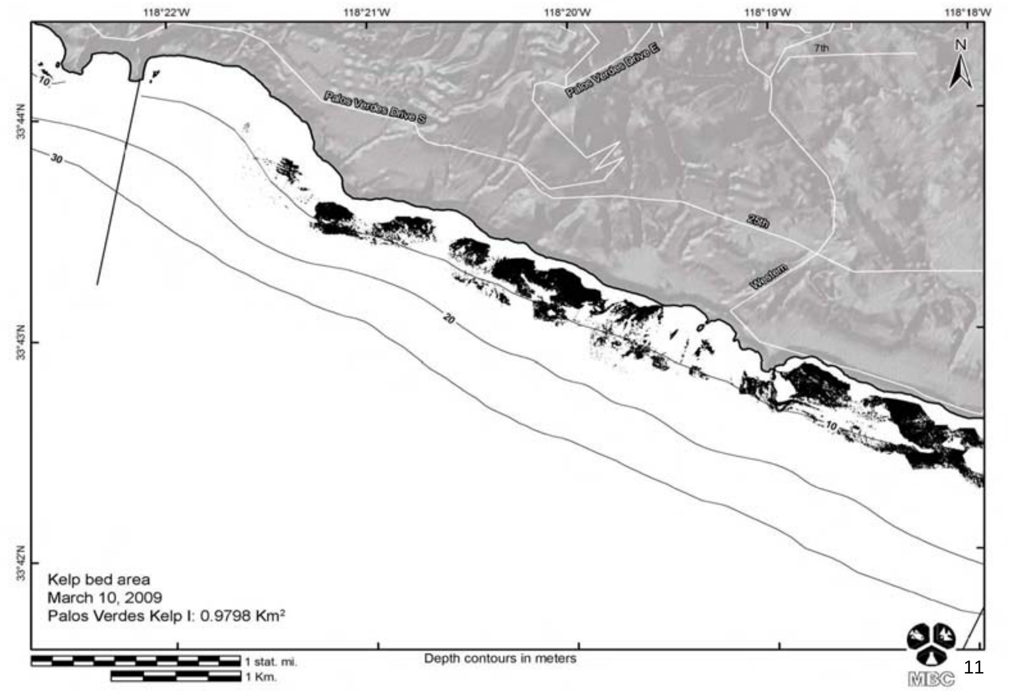

118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
Portuguese Bend
34°44'N
34°43'N
34°42'N
Kelp bed area
Palos Verdes Kelp I: 0.2748 km²
December 23, 2004
1 stat. mi.
1 km.
Depth contours in feet
11


118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
Portuguese Bend
34°44'N
34°43'N
34°42'N
Kelp bed area
Palos Verdes Kelp I: 0.7021 km²
June 22, 2005
1 stat. mi.
1 km.
Depth contours in feet
11
MBC

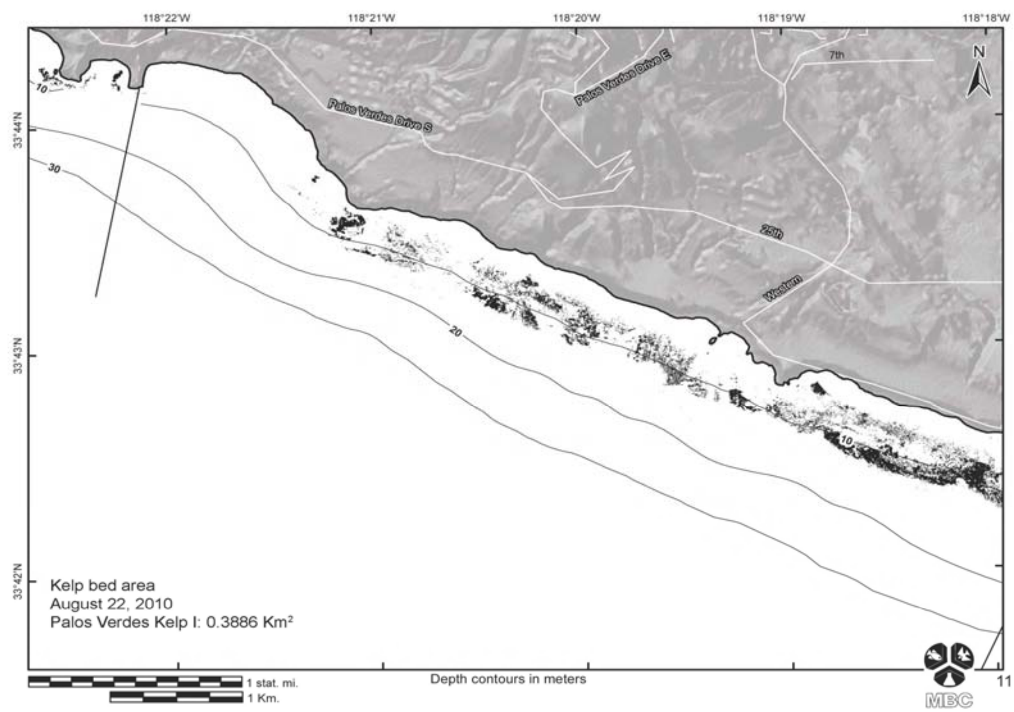

118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
Portuguese Bend
34°44'N
34°43'N
34°42'N
Kelp bed area
Palos Verdes Kelp I: 0.9514 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
11
MBC


118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
Portuguese Bend
Palos Verdes Drive S
7th
25th
Western
N
33°44'N
33°43'N
33°42'N
Kelp bed area
Palos Verdes Kelp I: 0.7028 Km²
June 12, 2007
1 stat. mi.
1 Km.
Depth contours in meters
11
MBC

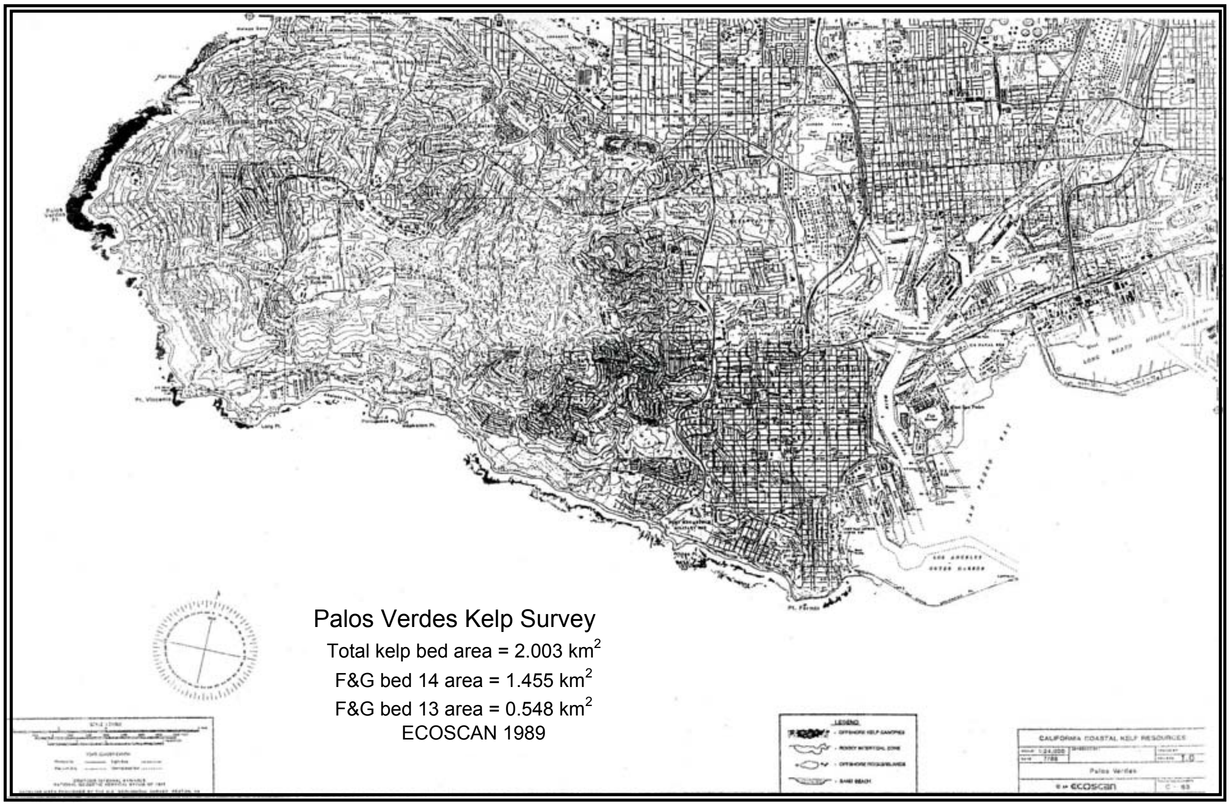

118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
N
33°44'N
33°43'N
33°42'N
Kelp bed area
Palos Verdes Kelp I: 0.6084 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
11
MBC

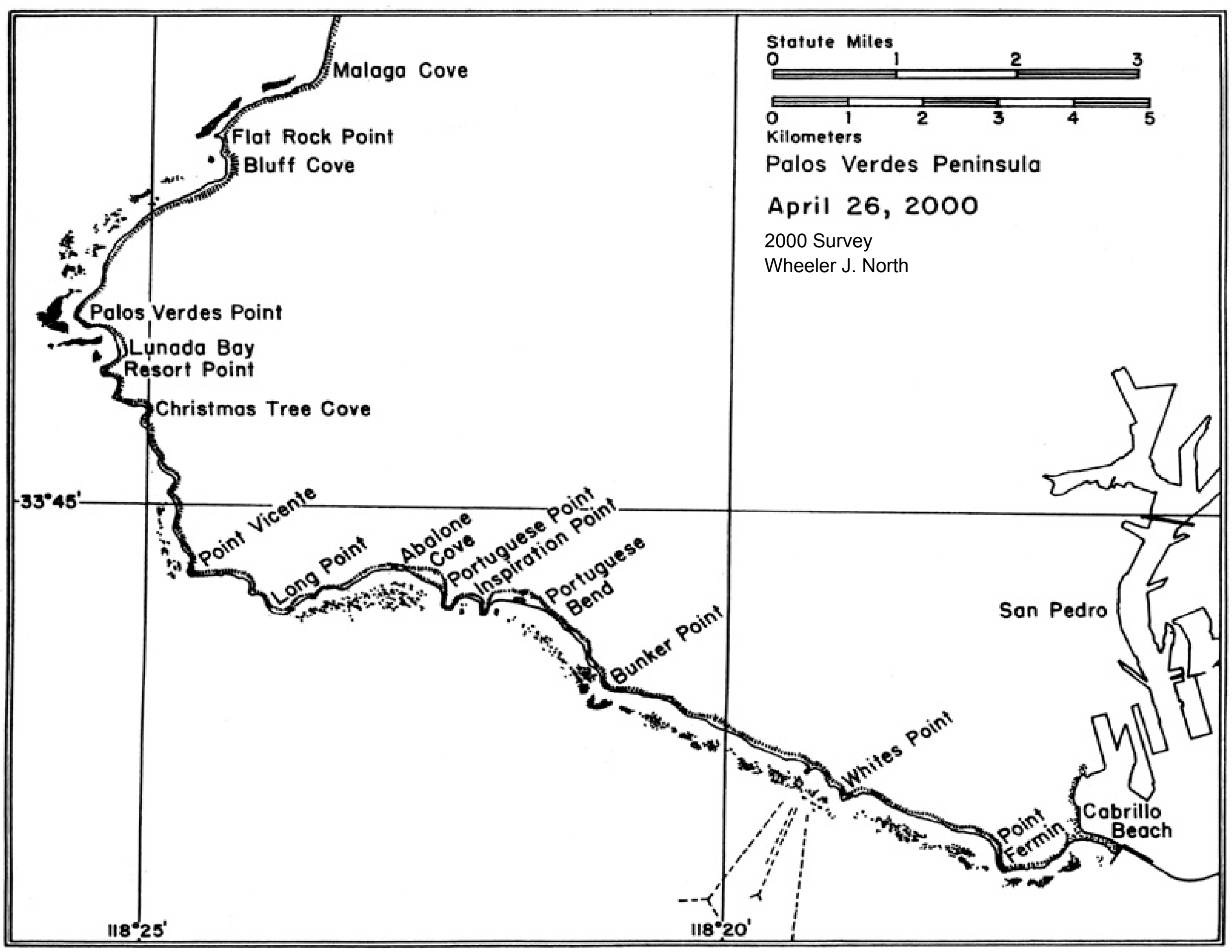

118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
33°44'N
33°43'N
33°42'N
Palos Verdes Drive S
Palos Verdes Drive E
7th
25th
Western
10
20
30
N
Kelp bed area
March 10, 2009
Palos Verdes Kelp I: 0.9798 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

11


118°22'W
118°21'W
118°20'W
118°19'W
118°18'W
33°44'N
33°43'N
33°42'N
Palos Verdes Drive S
Palos Verdes Drive E
7th
25th
Western
10
20
30
N
Kelp bed area
August 22, 2010
Palos Verdes Kelp I: 0.3886 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

11


Palos Verdes Kelp Survey
Total kelp bed area = 2.003 km^2
F&G bed 14 area = 1.455 km^2
F&G bed 13 area = 0.548 km^2
ECOSCAN 1989


Statute Miles
0
1
2
3
0
1
2
3
4
5
Kilometers
Palos Verdes Peninsula
April 26, 2000
2000 Survey
Wheeler J. North
Malaga Cove
Flat Rock Point
Bluff Cove
Palos Verdes Point
Lunada Bay
Resort Point
Christmas Tree Cove
33°45'
Point Vicente
Long Point
Abalone Cove
Portuguese Point
Inspiration Point
Portuguese Bend
Bunker Point
Whites Point
Point Fermin
Cabrillo Beach
San Pedro
118°25'
118°20'

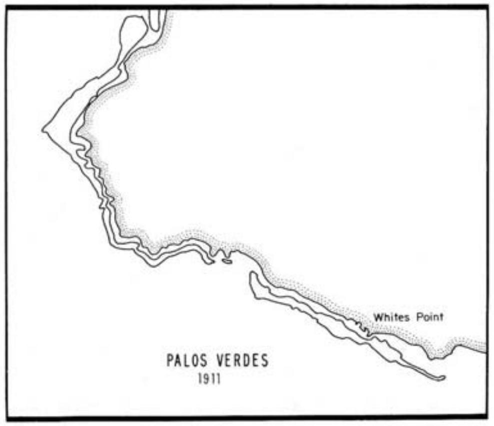


Figure 15. Chart of the Palos Verdes coast in 1911. The area of the kelp beds shown was estimated as 2.42 square miles.

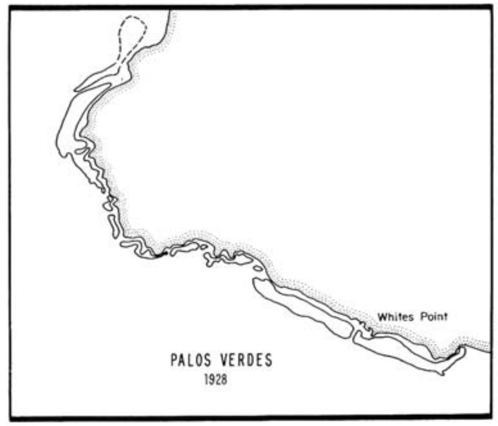


Figure 16. Chart of the Palos Verdes coast in 1928. The area of the kelp beds shown was estimated as less than 2.89 square miles.

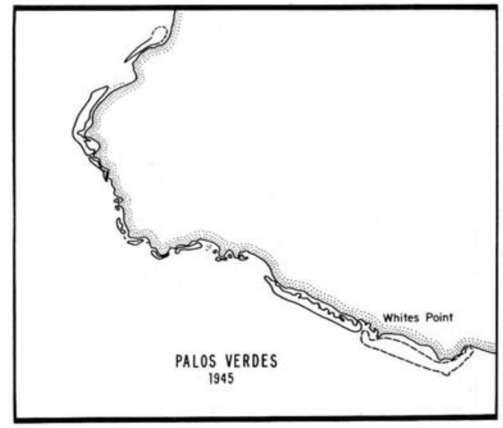


Figure 17. Chart of the Palos Verdes coast in 1945. The area of the kelp beds shown was estimated as less than 1.63 square miles.

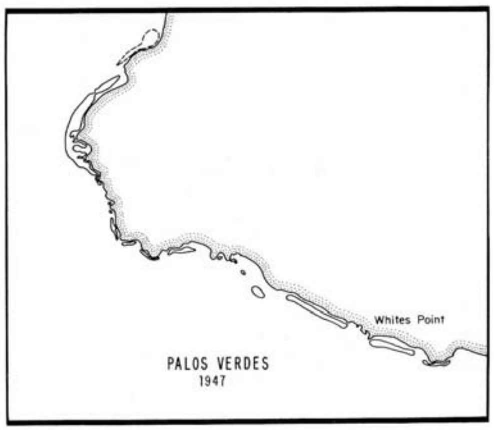


Figure 18. Chart of the Palos Verdes coast in 1947. The area of the kelp beds shown was estimated as less than 1.05 square miles.

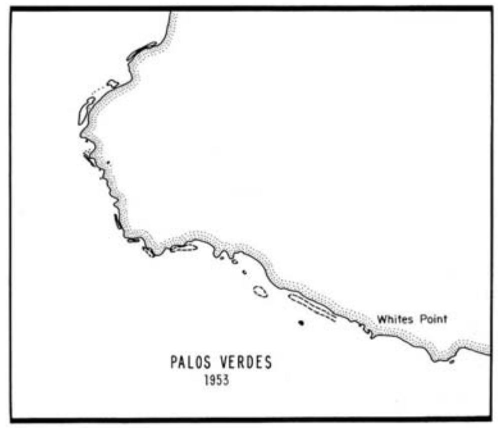


Figure 19. Chart of the Palos Verdes coast in 1953. The area of the kelp beds shown was estimated as greater than 0.44 square mile.

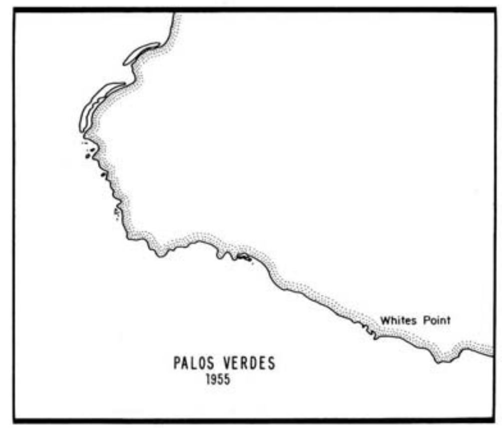


Figure 20. Chart of the Palos Verdes coast in 1955. The area of the kelp beds shown was estimated as 0.24 square mile.

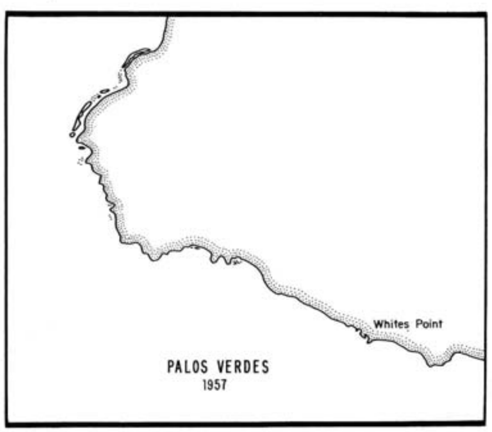


Figure 21. Chart of the Palos Verdes coast in 1957. The area of the kelp beds shown was estimated as 0.13 square mile.

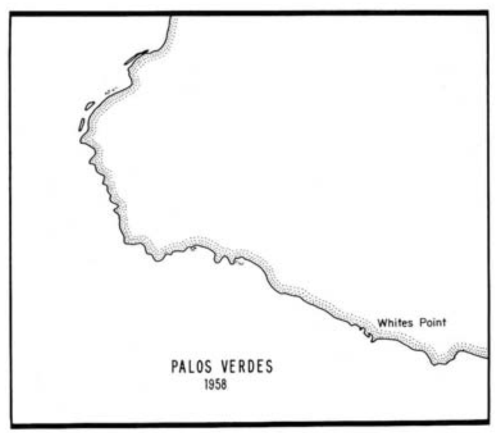


Figure 22. Chart of the Palos Verdes coast in 1958. The area of the kelp beds shown was estimated as 0.05 square mile.

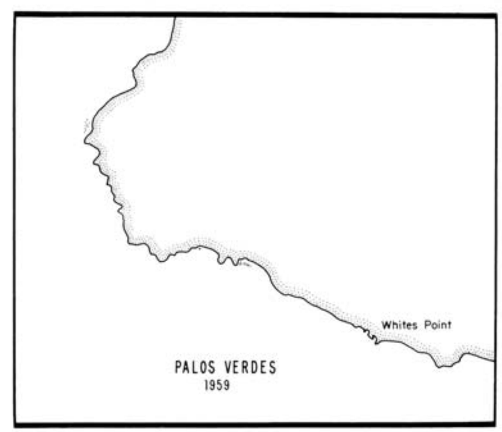
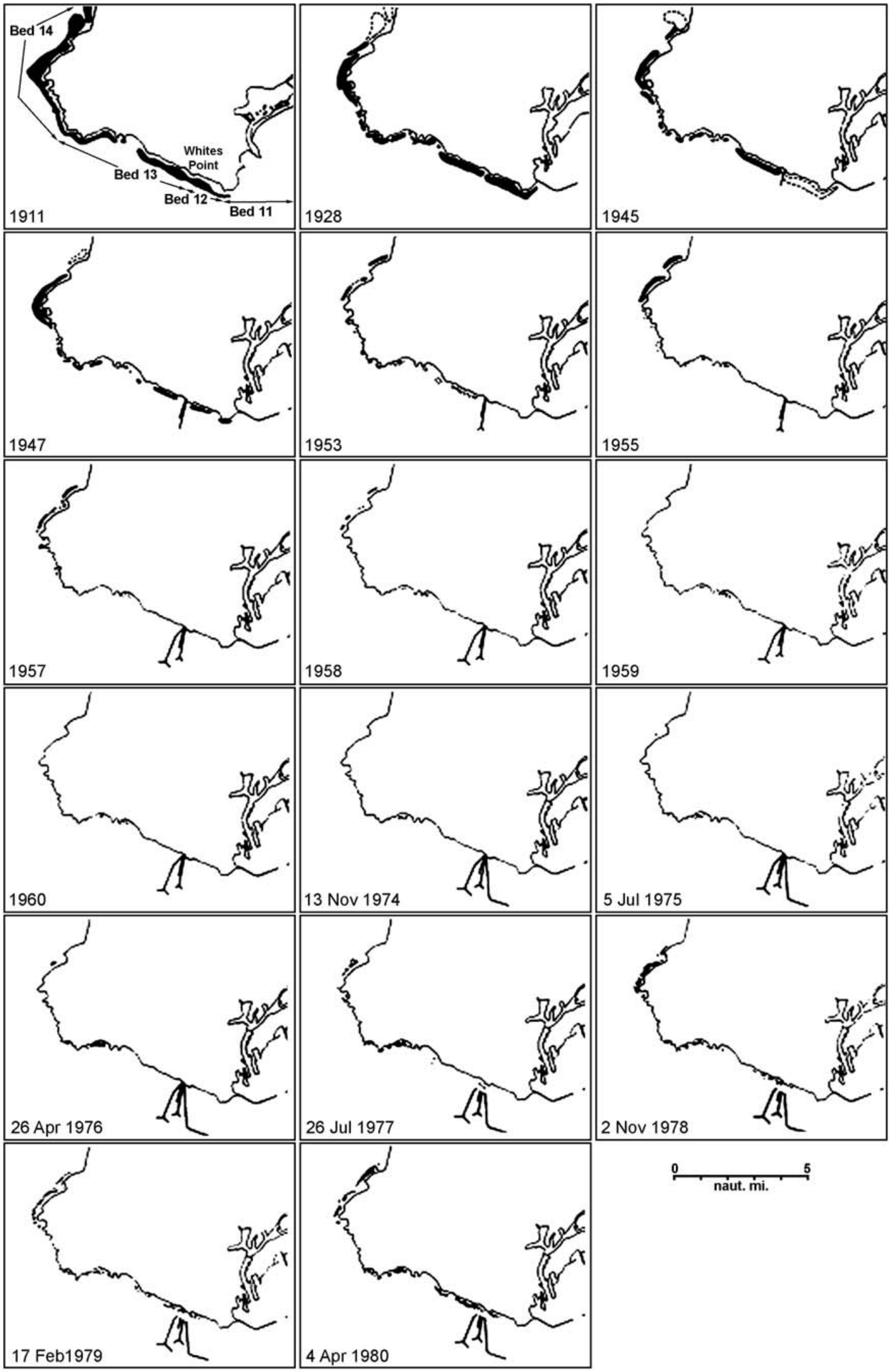
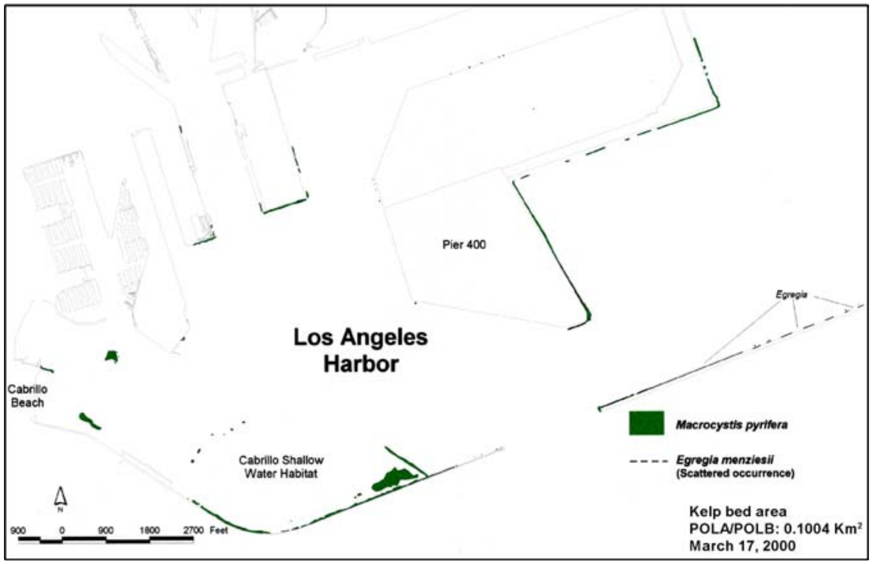


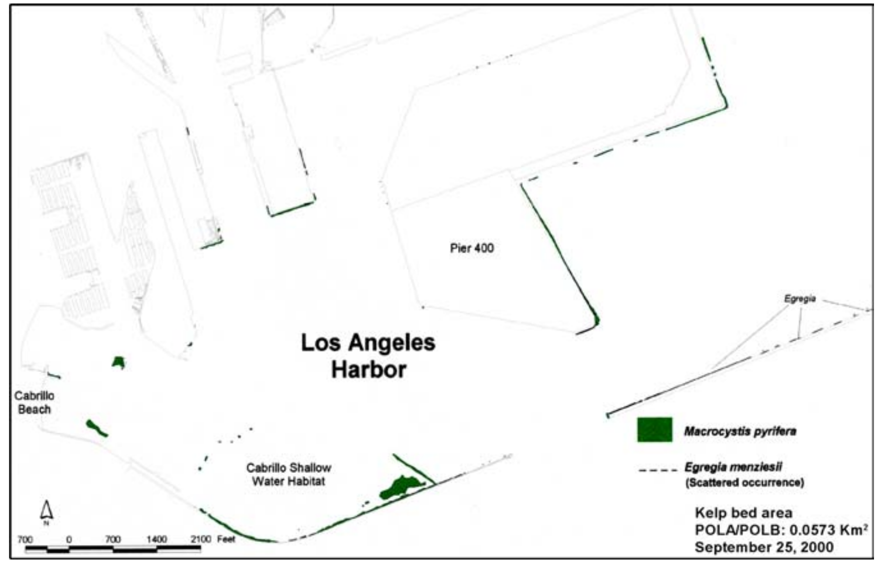
Figure 23. Chart of the Palos Verdes coast in 1959. The area of the kelp beds shown was estimated as less than 0.01 square mile.

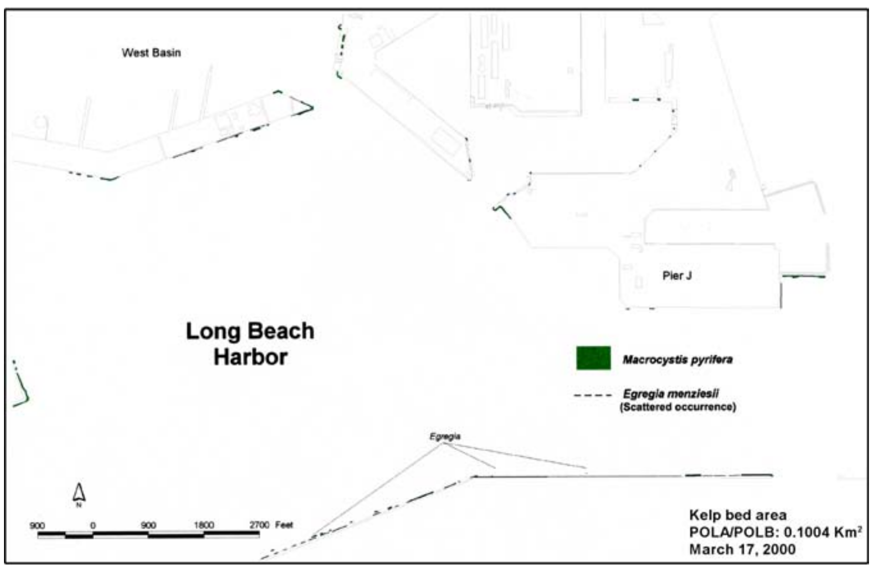
Adapted from SWQCB, 1964.

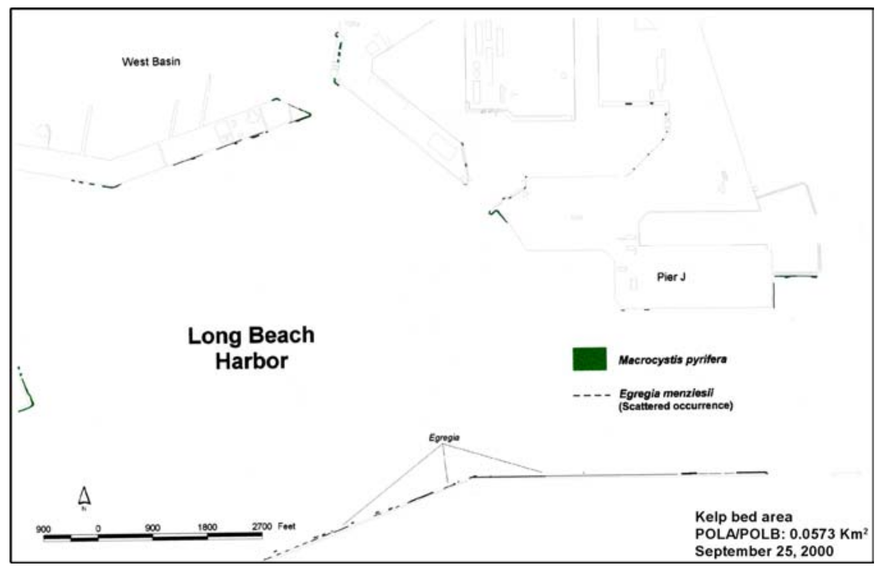


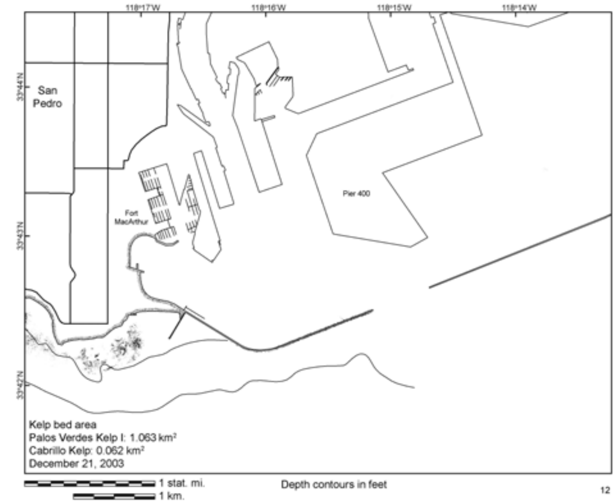
Source: W.J. North, 26 April 2000. Bed labels in the first panel are historical and do not reflect the current designation.

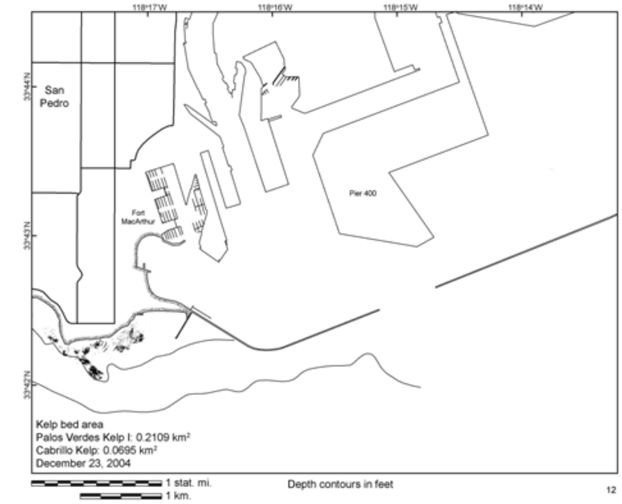

Pier 400
Egregia
Los Angeles Harbor
Cabrillo Beach
Macrocystis pyrifera
Egregia menziesii (Scattered occurrence)
Cabrillo Shallow Water Habitat
900 0 900 1800 2700 Feet
Kelp bed area
POLA/POLB: 0.1004 Km²
March 17, 2000

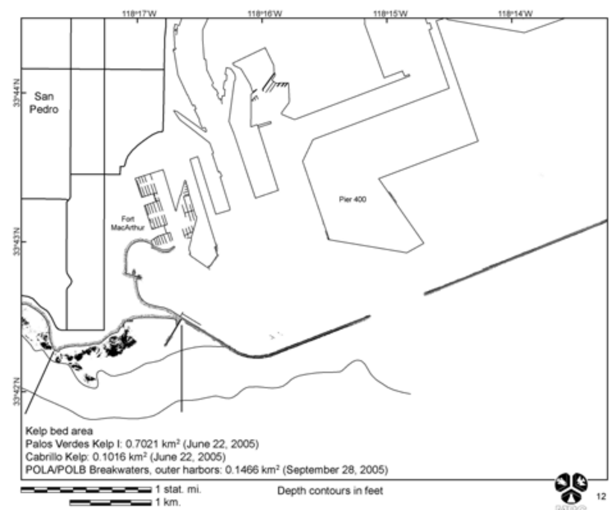

Pier 400
Egregia
Los Angeles Harbor
Cabrillo Beach
Macrocystis pyrifera
Egregia menziesii (Scattered occurrence)
Cabrillo Shallow Water Habitat
700 0 700 1400 2100 Feet
Kelp bed area
POLA/POLB: 0.0573 Km²
September 25, 2000

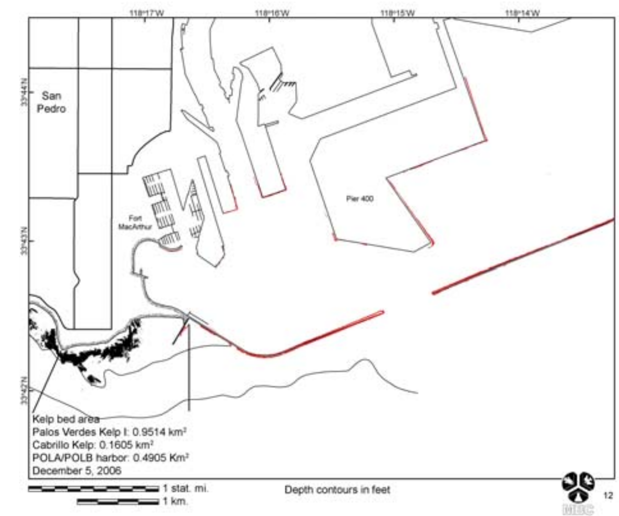

West Basin
Pier J
Long Beach Harbor
Macrocystis pyrifera
Egregia menziesii (Scattered occurrence)
Egregia
900 0 900 1800 2700 Feet
Kelp bed area
POLA/POLB: 0.1004 Km²
March 17, 2000

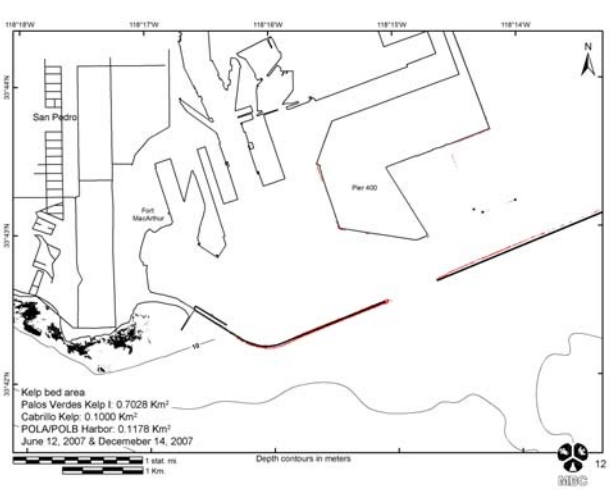

West Basin
Pier J
Long Beach Harbor
Macrocystis pyrifera
Egregia menziesii (Scattered occurrence)
Egregia
900 0 900 1800 2700 Feet
Kelp bed area
POLA/POLB: 0.0573 Km²
September 25, 2000

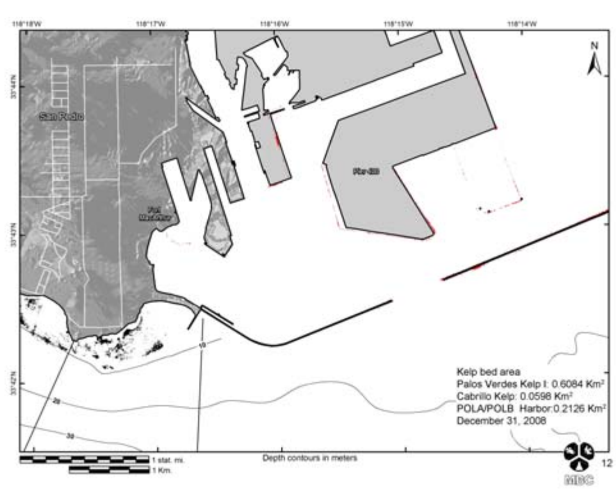

118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
San Pedro
Fort MacArthur
Pier 400
Kelp bed area
Palos Verdes Kelp I: 1.063 km²
Cabrillo Kelp: 0.062 km²
December 21, 2003
1 stat. mi.
1 km.
Depth contours in feet
12

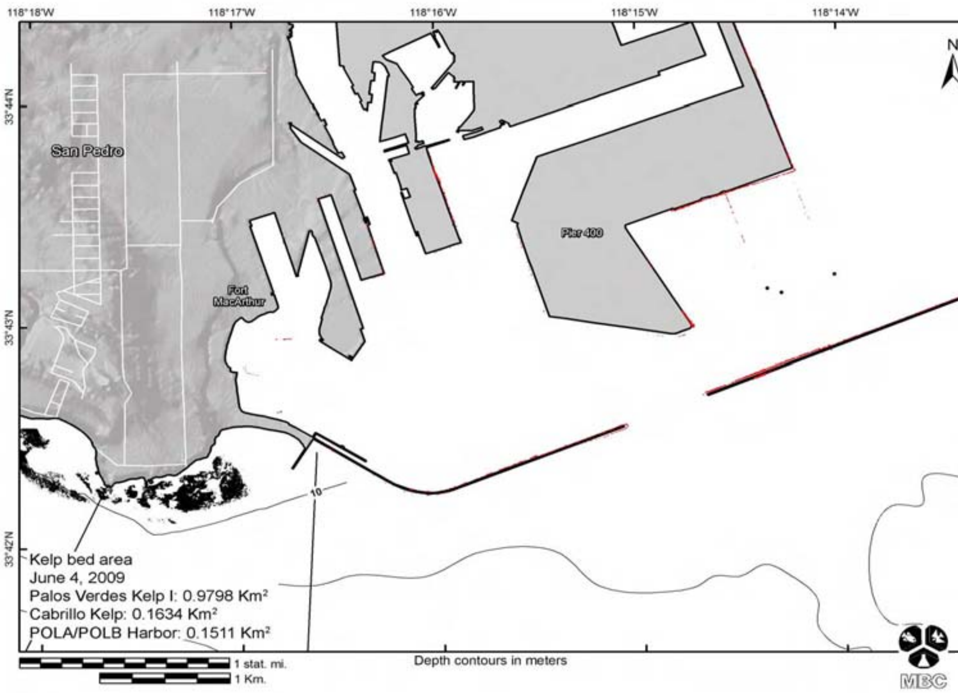

118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
San Pedro
Fort MacArthur
Pier 400
Kelp bed area
Palos Verdes Kelp I: 0.2109 km²
Cabrillo Kelp: 0.0695 km²
December 23, 2004
1 stat. mi.
1 km.
Depth contours in feet
12


118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
San Pedro
Fort MacArthur
Pier 400
Kelp bed area
Palos Verdes Kelp I: 0.7021 km² (June 22, 2005)
Cabrillo Kelp: 0.1016 km² (June 22, 2005)
POLA/POLB Breakwaters, outer harbors: 0.1466 km² (September 28, 2005)
1 stat. mi.
1 km.
Depth contours in feet
12

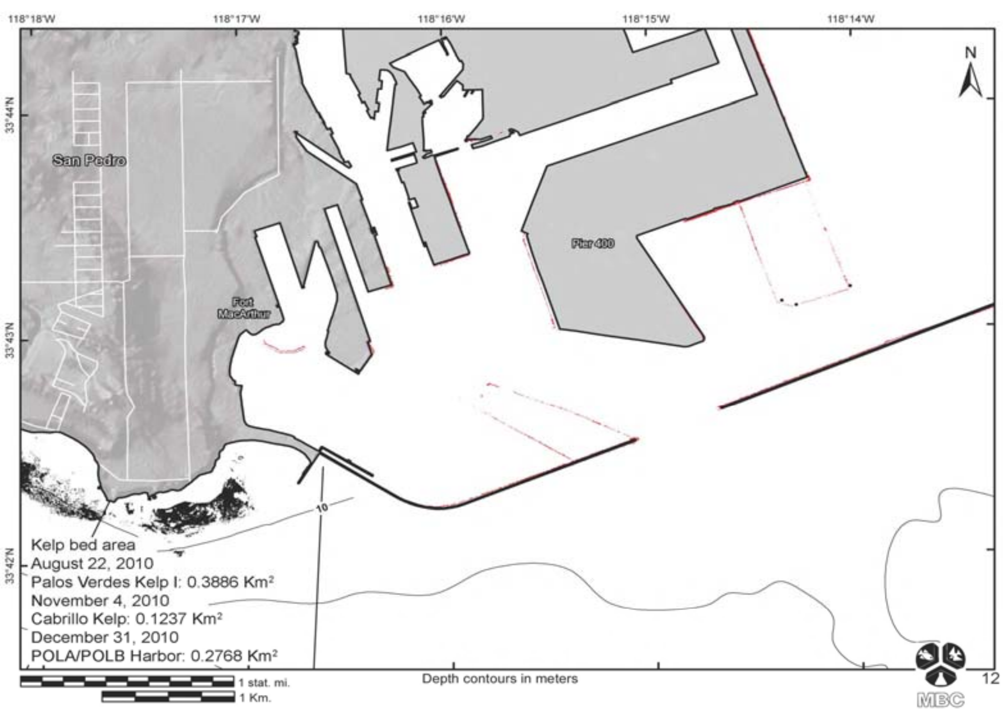

118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
San Pedro
Fort MacArthur
Pier 400
Kelp bed area
Palos Verdes Kelp I: 0.9514 km²
Cabrillo Kelp: 0.1605 km²
POLA/POLB harbor: 0.4905 Km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
12


118°18'W
118°17'W
118°16'W
118°15'W
118°14'W
N
33°44'N
33°43'N
33°42'N
San Pedro
Fort MacArthur
Pier 400
Kelp bed area
Palos Verdes Kelp I: 0.7028 Km²
Cabrillo Kelp: 0.1000 Km²
POLA/POLB Harbor: 0.1178 Km²
June 12, 2007 & Decemeber 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
12


118°18'W
118°17'W
118°16'W
118°15'W
118°14'W
N
San Pedro
Fort MacArthur
Kelp bed area
Palos Verdes Kelp I: 0.6084 Km²
Cabrillo Kelp: 0.0598 Km²
POLA/POLB Harbor:0.2126 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
12


118°18'W
118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
N
San Pedro
Fort MacArthur
Pier 400
10
Kelp bed area
June 4, 2009
Palos Verdes Kelp I: 0.9798 Km²
Cabrillo Kelp: 0.1634 Km²
POLA/POLB Harbor: 0.1511 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

12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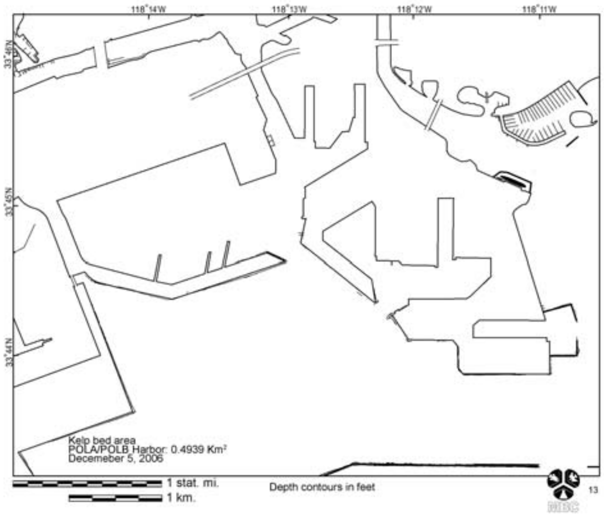
118°17'W
118°16'W
118°15'W
118°14'W
33°44'N
33°43'N
33°42'N
N
San Pedro
Fort MacArthur
Pier 400
10
Kelp bed area
August 22, 2010
Palos Verdes Kelp I: 0.3886 Km²
November 4, 2010
Cabrillo Kelp: 0.1237 Km²
December 31, 2010
POLA/POLB Harbor: 0.2768 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC

12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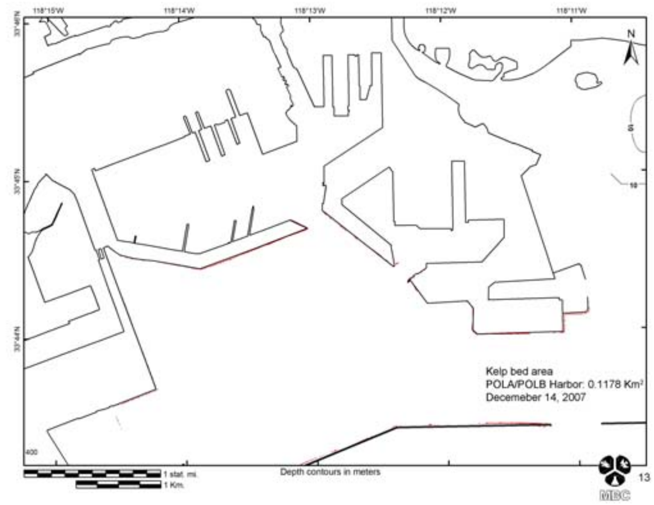
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
Kelp bed area
POLA/POLB Harbor: 0.4939 Km²
Decemeber 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
13
MBC


118°15'W
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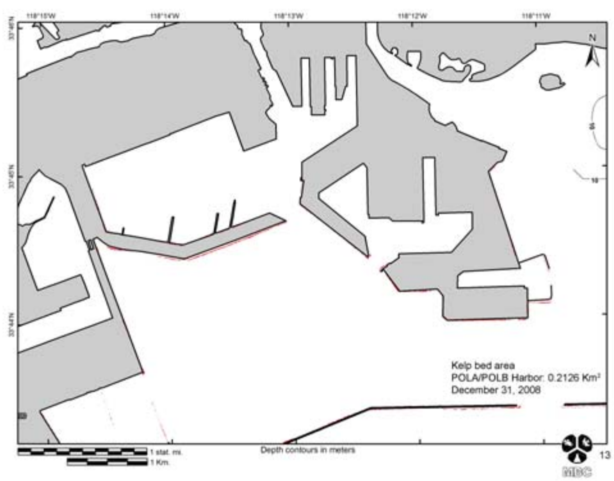
118°13'W
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
N
Kelp bed area
POLA/POLB Harbor: 0.1178 Km²
Decemeber 14, 2007
400
1 stat. mi.
1 Km.
Depth contours in meters
13
MBC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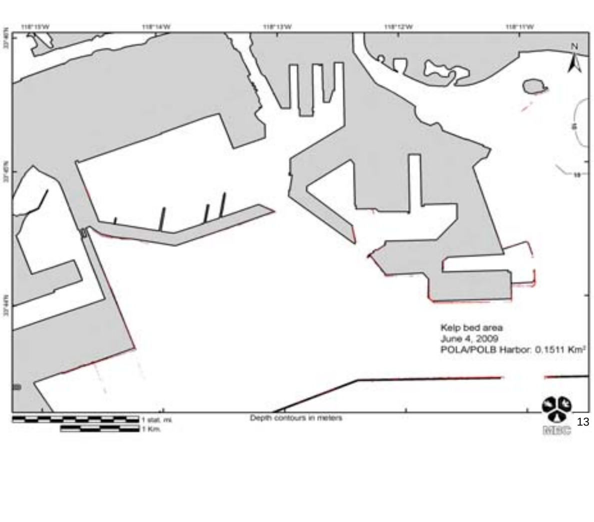
118°14'W
118°13'W
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
N
Kelp bed area
POLA/POLB Harbor: 0.2126 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
13
MBC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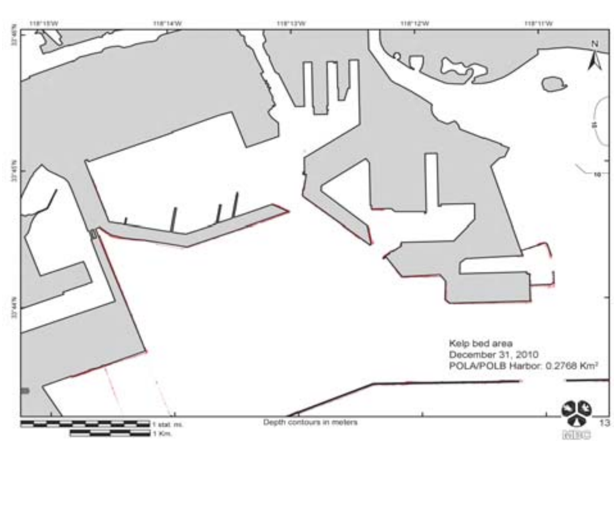
118°14'W
118°13'W
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
N
Kelp bed area
June 4, 2009
POLA/POLB Harbor: 0.1511 Km²
1 stat. mi.
1 Km.
Depth contours in meters
13
MBC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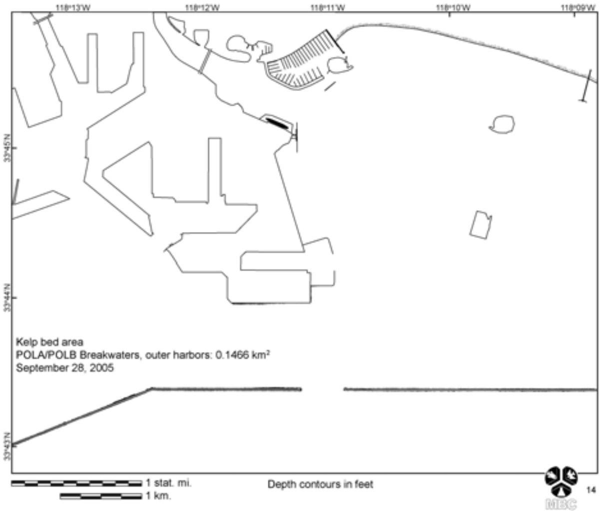
118°13'W
118°12'W
118°11'W
33°46'N
33°45'N
33°44'N
N
Kelp bed area
December 31, 2010
POLA/POLB Harbor: 0.2768 Km²
1 stat. mi.
1 Km.
Depth contours in meters
13
MBC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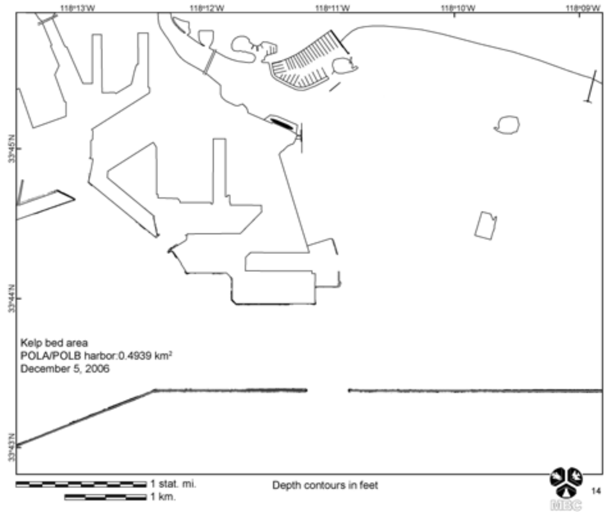
118°11'W
118°10'W
118°09'W
33°45'N
33°44'N
33°43'N
Kelp bed area
POLA/POLB Breakwaters, outer harbors: 0.1466 km²
September 28, 2005
1 stat. mi.
1 km.
Depth contours in feet
14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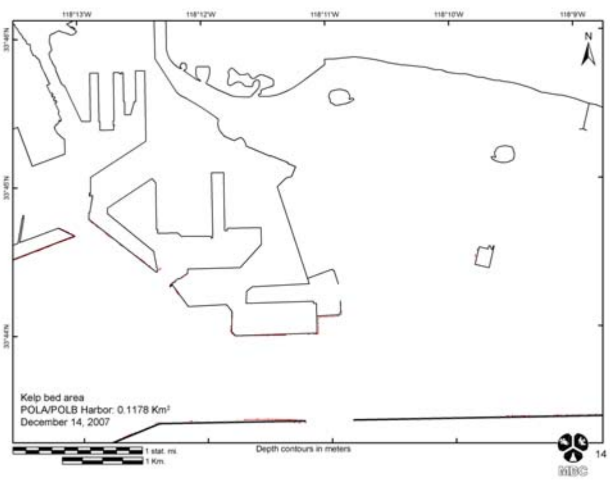
118°12'W
118°11'W
118°10'W
118°09'W
33°45'N
33°44'N
33°43'N
Kelp bed area
POLA/POLB harbor:0.4939 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
14


118°13'W
118°12'W
118°11'W
118°10'W
118°9'W
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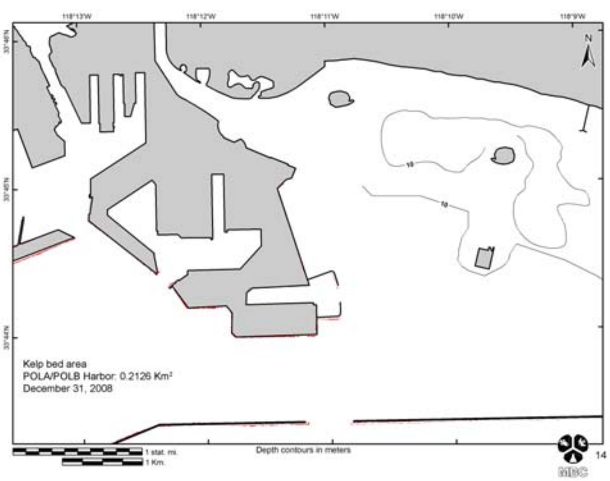
Kelp bed area
POLA/POLB Harbor: 0.1178 Km²
December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
14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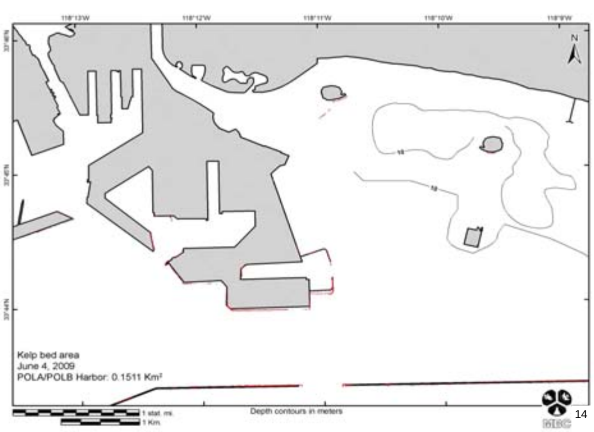
118°11'W
118°10'W
118°9'W
N
10
10
Kelp bed area
POLA/POLB Harbor: 0.2126 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
14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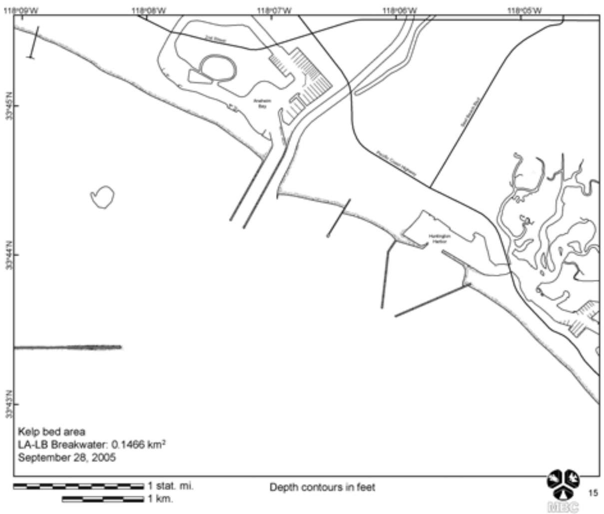
118°12'W
118°11'W
118°10'W
118°9'W
N
10
10
Kelp bed area
June 4, 2009
POLA/POLB Harbor: 0.1511 Km²
1 stat. mi.
1 Km.
Depth contours in meters
14


118°13'W
118°12'W
118°11'W
118°10'W
118°9'W
N
10
10
Kelp bed area
December 31, 2010
POLA/POLB Harbor: 0.2768 Km²
1 stat. mi.
1 Km.
Depth contours in meters
14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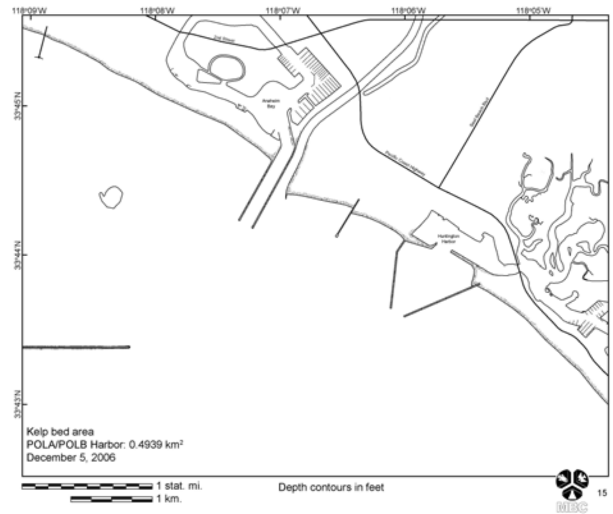
118°07'W
118°06'W
118°05'W
33°45'N
33°44'N
33°43'N
Kelp bed area
LA-LB Breakwater: 0.1466 km²
September 28, 2005
1 stat. mi.
1 km.
Depth contours in feet
MBC
15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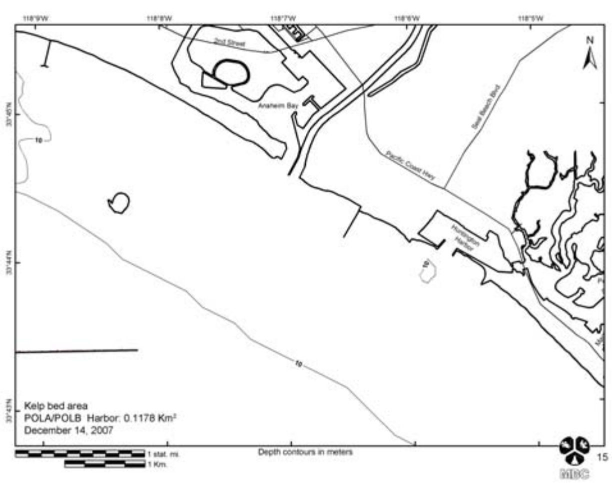
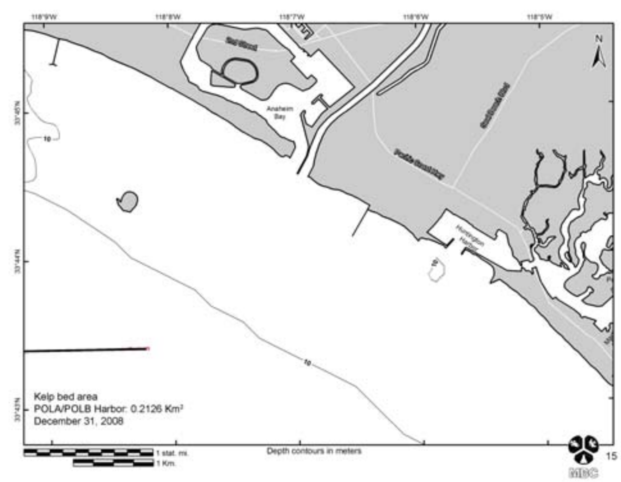
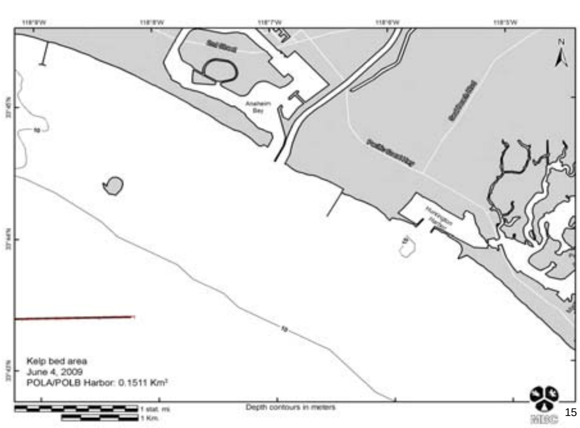
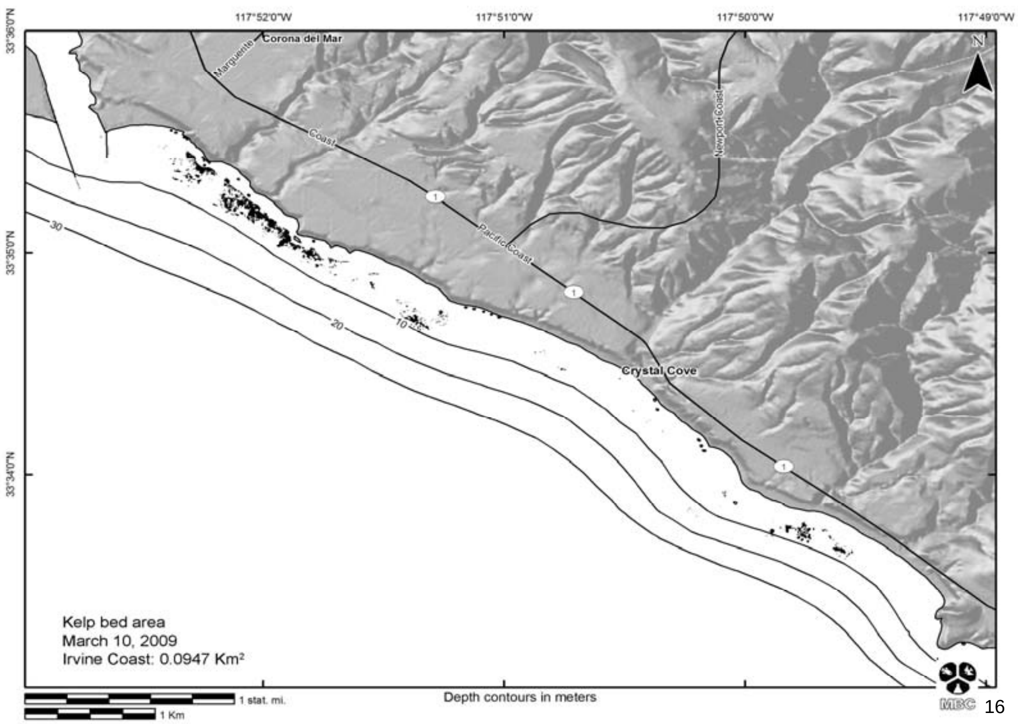
118°06'W
118°05'W
33°45'N
33°44'N
33°43'N
Kelp bed area
POLA/POLB Harbor: 0.4939 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
15


118°9'W
118°8'W
118°7'W
118°6'W
118°5'W
2nd Street
Anaheim Bay
Pacific Coast Hwy
Seal Beach Blvd
Huntington Harbor
10
Kelp bed area
POLA/POLB Harbor: 0.1178 Km²
December 14, 2007
1 stat. mi.
1 Km.
Depth contours in meters
MBC
15


118°9'W
118°8'W
118°7'W
118°6'W
118°5'W
Anaheim Bay
Huntington Harbor
10
Kelp bed area
POLA/POLB Harbor: 0.2126 Km²
December 31, 2008
1 stat. mi.
1 Km.
Depth contours in meters
MBC
15


118°9'W
118°8'W
118°7'W
118°6'W
118°5'W
Anaheim Bay
10
Kelp bed area
June 4, 2009
POLA/POLB Harbor: 0.1511 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
15


118°9'W
118°8'W
118°7'W
118°6'W
118°5'W
Anaheim Bay
10
Kelp bed area
December 31, 2010
POLA/POLB Harbor: 0.2768 Km²
1 stat. mi.
1 Km.
Depth contours in meters
MBC
15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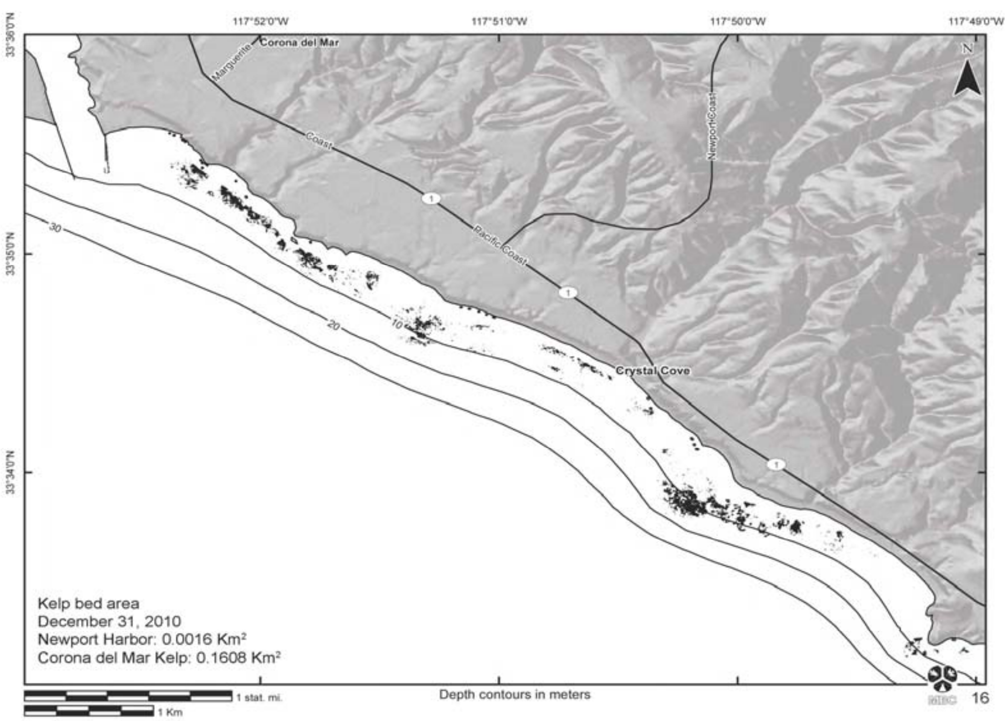
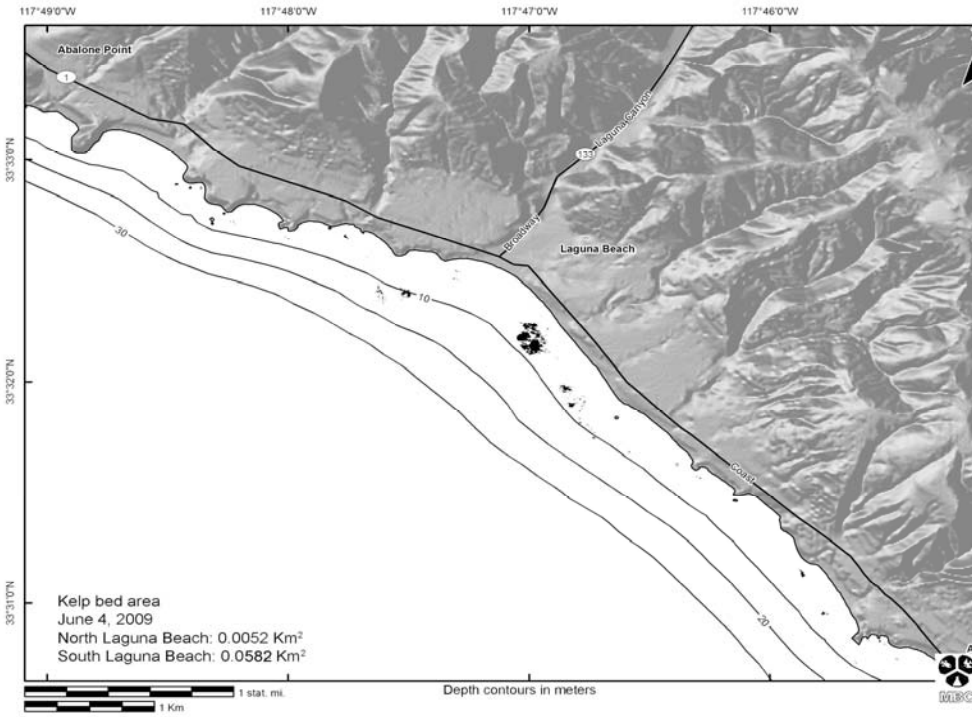
33°36'0"N
33°35'0"N
33°34'0"N
Marguerite
Corona del Mar
Coast
Pacific Coast
Newport Coast
Crystal Cove
N
30
20
10
Kelp bed area
March 10, 2009
Irvine Coast: 0.0947 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

16


117°52'0"W
117°51'0"W
117°50'0"W
117°49'0"W
33°36'0"N
33°35'0"N
33°34'0"N
Marguerite
Corona del Mar
Coast
Pacific Coast
Newport Coast
Crystal Cove
N
30
20
10
Kelp bed area
December 31, 2010
Newport Harbor: 0.0016 Km²
Corona del Mar Kelp: 0.1608 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

16


117°49'0"W
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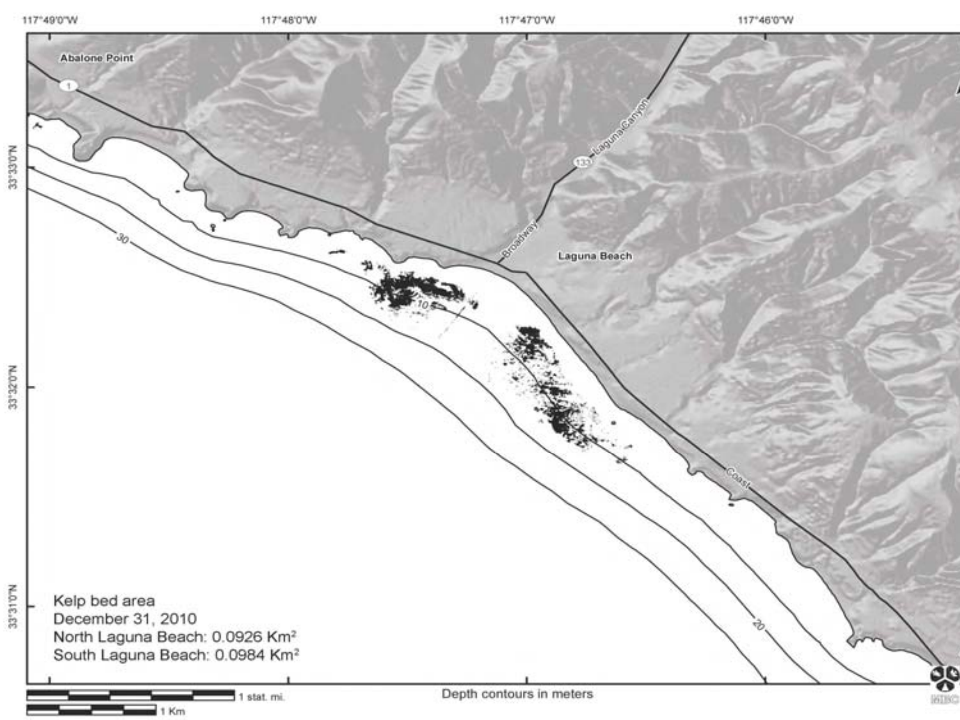
117°47'0"W
117°46'0"W
33°33'0"N
33°32'0"N
33°31'0"N
Abalone Point
Laguna Canyon
Broadway
Laguna Beach
Coast
Aliso
30
10
20
N
Kelp bed area
June 4, 2009
North Laguna Beach: 0.0052 Km²
South Laguna Beach: 0.0582 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

17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117°48'0"W
117°47'0"W
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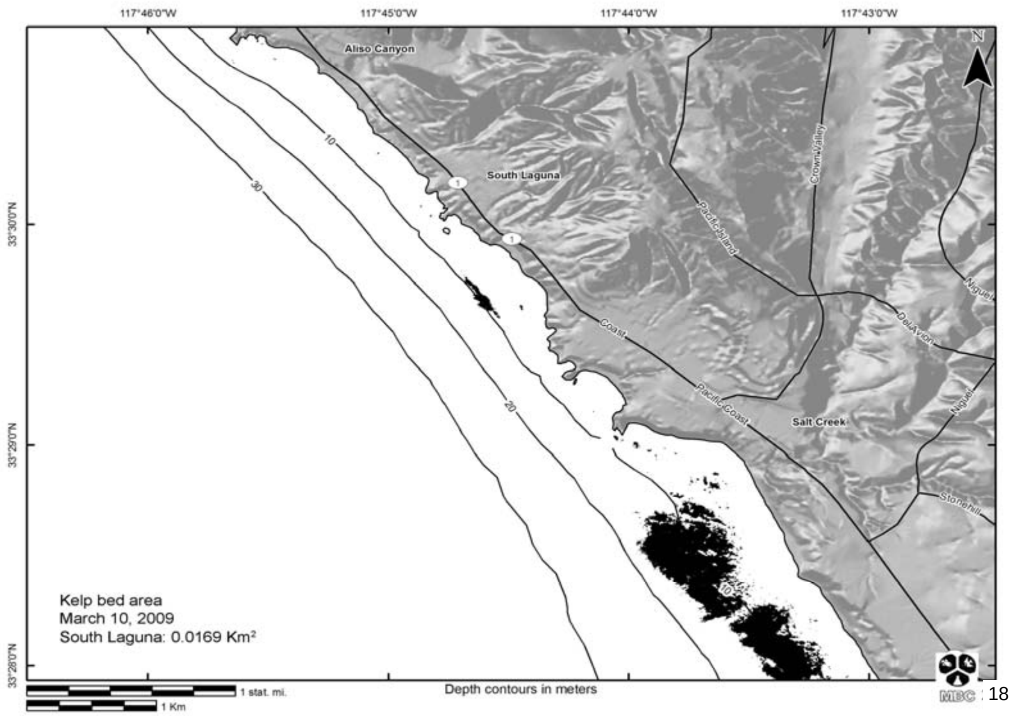
33°33'0"N
33°32'0"N
33°31'0"N
Abalone Point
Laguna Canyon
Broadway
Laguna Beach
Coast
Aliso
30
10
20
N
Kelp bed area
December 31, 2010
North Laguna Beach: 0.0926 Km²
South Laguna Beach: 0.0984 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

17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117°43'0"W
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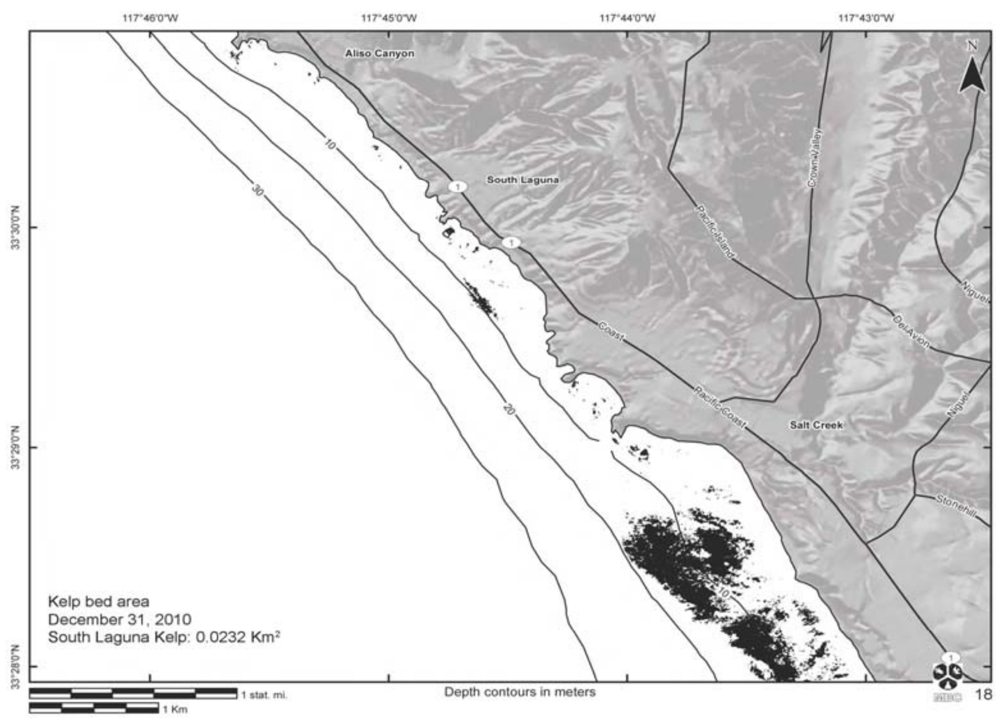
33°29'0"N
33°28'0"N
Aliso Canyon
South Laguna
Crown Valley
Pacific Island
Niguel
Del Avion
Coast
Pacific Coast
Salt Creek
Stonehill
10
20
30
Kelp bed area
March 10, 2009
South Laguna: 0.0169 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18


117°46'0"W
117°45'0"W
117°44'0"W
117°43'0"W
33°30'0"N
33°29'0"N
33°28'0"N
Aliso Canyon
South Laguna
Crown Valley
Pacific Island
Niguel
Del Avion
Coast
Pacific Coast
Salt Creek
Stonehill
10
20
30
Kelp bed area
December 31, 2010
South Laguna Kelp: 0.0232 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18

APPENDIX C

Flight Data Reports

2011 Quarterly Kelp Survey Flight Schedule

Mid-March	Tide (Scripps Pier)	Sea/Swell (feet)	Wind (knots)	Weather	Flight Status	Reason/Comments
16-Mar-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
17-Mar-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
18-Mar-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast partial range	Survey Cancelled	Cloud cover
19-Mar-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
28-Mar-11	Less than 1' MLLW	7 Feet	15 - 20 knots	Partly cloudy entire range	Survey Cancelled	Winds, seas, cloud cover
29-Mar-11	Less than 1' MLLW	7 Feet	15 - 20 knots	Partly cloudy entire range	Survey Cancelled	Winds, seas, cloud cover
30-Mar-11	Less than 1' MLLW	7 Feet	15 - 20 knots	Partly cloudy entire range	Survey Cancelled	Winds, seas, cloud cover
31-Mar-11	Less than 1' MLLW	7 Feet	15 - 20 knots	Partly cloudy entire range	Survey Cancelled	Winds, seas, cloud cover
14-Apr-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast partial range	Survey Cancelled	Cloud cover
15-Apr-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
16-Apr-11	0.0' - 0.7' MLLW	3-5 Feet	Calm	Clear	Survey Flown	Optimum Conditions
Mid-June	**Tide (Scripps Pier)**	**Sea/Swell (feet)**	**Wind (knots)**	**Weather**	**Flight Status**	**Reason/Comments**
15-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
16-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
17-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
18-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
19-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
29-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
30-Jun-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
1-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
2-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
3-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
4-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
14-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
15-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
16-Jul-11	Less than 1.5' MLLW	Less than 5 Feet	Less than 10 knots	Overcast entire range	Survey Cancelled	Cloud cover
1-Aug-11	1.2' - 1.4' MLLW	3-5 Feet	Calm	Clear	Survey Flown	Optimum Conditions
Mid-Sept. - Mid Oct.	**Tide (Scripps Pier)**	**Sea/Swell (feet)**	**Wind (knots)**	**Weather**	**Flight Status**	**Reason/Comments**
23-Oct-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
24-Oct-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
25-Oct-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
26-Oct-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
27-Oct-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy entire range	Survey Cancelled	Cloud cover
28-Oct-11	2.4' - 0.2' MLLW	3-5 Feet	Calm	Clear	Survey Flown	Optimum Conditions
Mid-December	**Tide (Scripps Pier)**	**Sea/Swell (feet)**	**Wind (knots)**	**Weather**	**Flight Status**	**Reason/Comments**
19-Dec-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy partial range	Survey Cancelled	Cloud cover
20-Dec-11	Less than 1' MLLW	Less than 5 Feet	Less than 10 knots	Partly cloudy partial range	Survey Cancelled	Cloud cover
21-Dec-11	0.9' - 0.0' MLLW	3-5 Feet	Calm	Clear	Survey Flown	Optimum Conditions

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	**Calendar**	
Address:	3000 Redhill Ave.	Services Ordered:	3/2011
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	4/16/2011
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	5/2011

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - April 16, 2011**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	Acquisition	Vertical color IR digital imagery of all coastal kelp canopies within the survey range
	Processing	Survey imagery indexed and delivered to MBC for further processing and analysis
	Analysis	
	Presentation	All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		April 16, 2011			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear to partly overcast
	Photographic Film Imagery - 35 mm	Altitude:	12,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	Calm
	Videography	Lenses:	30mm (see note)	Sea/Swell:	3-5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1150-1306
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.0' to 0.7' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Optimum Conditions

Range (s) Surveyed	Ventura to Imperial Beach Note: This quarterly survey scheduled for March 2011 could not be completed within the month due to adverse weather from 3/10-3/31/11. Excellent weather/tidal conditions were present on the selected survey date (4/16/11).	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the survey range were well developed throughout and larger than normal spring extent.
Imagery Quality/ Comments	Excellent	All surface kelp canopies, were photographed within the above range and 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.
	Lens Note	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:

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	**Calendar**	
Address:	3000 Redhill Ave.	Services Ordered:	6/2011
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	8/1/2011
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	8/2011

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - August 1, 2011**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	Acquisition	Vertical color IR digital imagery of all coastal kelp canopies within the survey range
	Processing	Survey imagery indexed and delivered to MBC for further processing and analysis
	Analysis	
	Presentation	All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		August 1, 2011			
Survey Type		Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear to partly overcast
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	Calm
	Videography	Lenses:	30mm (see note)	Sea/Swell:	3-5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1615-1800
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.2' (+) to 1.4' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Optimum Conditions

Range (s) Surveyed	Ventura to Imperial Beach Note: This quarterly survey scheduled for June 2011 could not be completed within the month due to adverse weather (mainly coastal fog). Optimum weather/tidal conditions were present on the selected survey date (8/1/11).	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the survey range were well developed.
Imagery Quality/ Comments	Excellent	All surface kelp canopies, were photographed within the above range and 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.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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Watsonville, CA 95076
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Signed: ____________________ Bob Van Wagenen, Director

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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	**Calendar**	
Address:	3000 Redhill Ave.	Services Ordered:	10/2011
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	10/28/2011
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	11/2011

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - October 28, 2011**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	Acquisition	Vertical color IR digital imagery of all coastal kelp canopies within the survey range
	Processing	Survey imagery indexed and delivered to MBC for further processing and analysis
	Analysis	
	Presentation	All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for: October 28, 2011

	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:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	Calm
	Videography	Lenses:	30mm (see note)	Sea/Swell:	3-5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1404-1543
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	3.0' (+) to 0.2' (-) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Optimum Conditions

Range (s) Surveyed	Ventura to Imperial Beach	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the survey range were well developed.
Imagery Quality/ Comments	Excellent	All surface kelp canopies, were photographed within the above range and 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.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ______________________ Bob Van Wagenen, Director

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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	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	12/2011
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/11/2011
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	1/2012

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - December 21, 2011**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	**Acquisition**	Vertical color IR digital imagery of all coastal kelp canopies within the survey range
	Processing	Survey imagery indexed and delivered to MBC for further processing and analysis
	Analysis	
	Presentation	All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**December 21, 2011**			
	Survey Type	**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear (some patchy fog)
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
√	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	Calm
	Videography	Lenses:	30mm (see note)	Sea/Swell:	3-5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1330-1500
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.9' (-) to 0.0' MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Optimum Conditions

Range (s) Surveyed	Ventura to Imperial Beach	
Target Resource Observations	Kelp Canopies	The kelp canopies throughout the survey range were well developed.
Imagery Quality/ Comments	Excellent	All surface kelp canopies, were photographed within the above range and 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.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ____________________ Bob Van Wagenen, Director

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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	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	3/12
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	4/6/12
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	4/2012

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow	
Project Title	**California Coastal Kelp Resources - Ventura to Imperial Beach - April 6, 2012**
Target Resource (s)/ Survey Range (s)	Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow — **Acquisition**	Vertical color IR digital imagery of all coastal kelp canopies within the survey range
Processing	Survey imagery indexed and delivered to MBC for further processing and analysis
Analysis	
Presentation	All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**April 6, 2012**			
	Survey Type	**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear (some patchy fog)
	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:	Calm
	Videography	Lenses:	30mm (see note)	Sea/Swell:	6-8 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1403-1540
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.0' (+) to 0.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	Low-medium glare present
	Other 3:	Photographer:	Van Wagenen	Comments:	Good/Excellent Conditions

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

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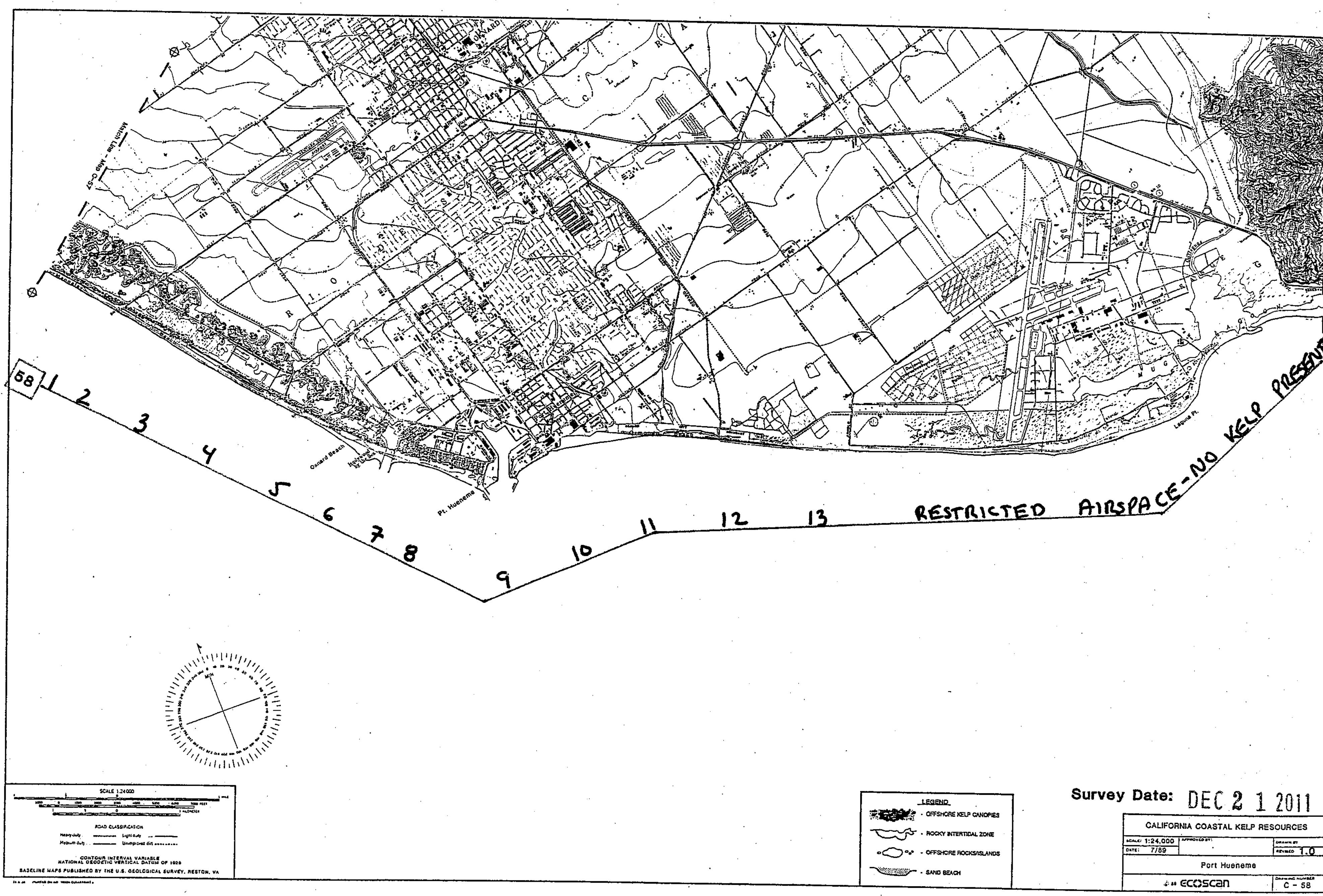
Watsonville, CA 95076
(831) 728-5900 (ph./fax)

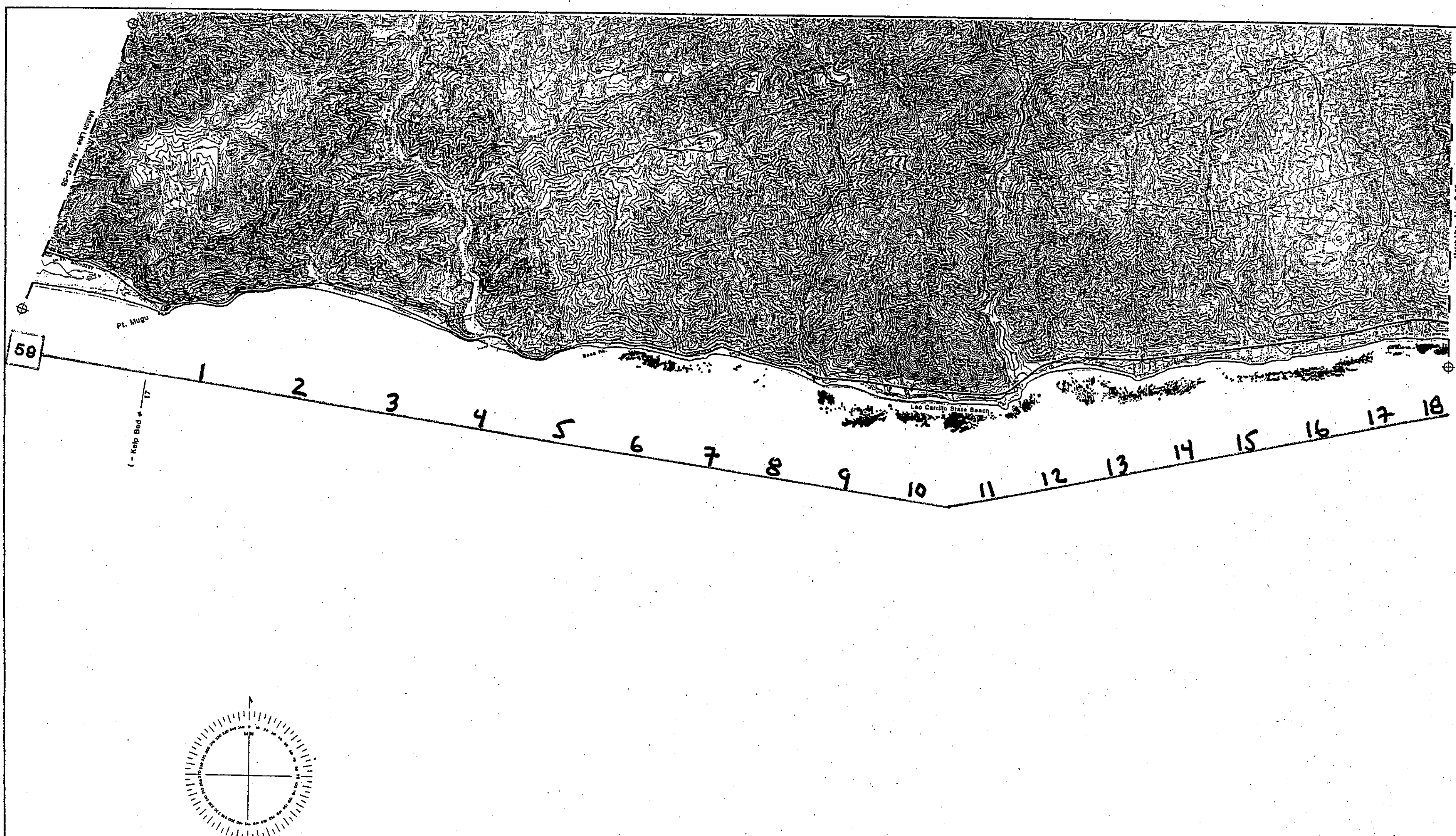
Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Survey Date: DEC 2 1 2011

CALIFORNIA COASTAL KELP RESOURCES		
SCALE: 1:24,000 DATE: 7/89	APPROVED BY:	DRAWN BY REVISED 1.0
Ventura		
© 89 ECOSCAN		DRAWING NUMBER C - 57


Match Line - Map C-57
Match Line - Map C-59
58
1
2
3
4
5
6
7
8
9
10
11
12
13
RESTRICTED AIRSPACE-NO KELP PRESENT
Oxnard Beach
Pt. Hueneme
Laguna Pt.
OXNARD
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 2 1 2011
CALIFORNIA COASTAL KELP RESOURCES
SCALE: 1:24,000
DATE: 7/89
REVISED 1.0
Port Hueneme
ECOSCAN
C - 58

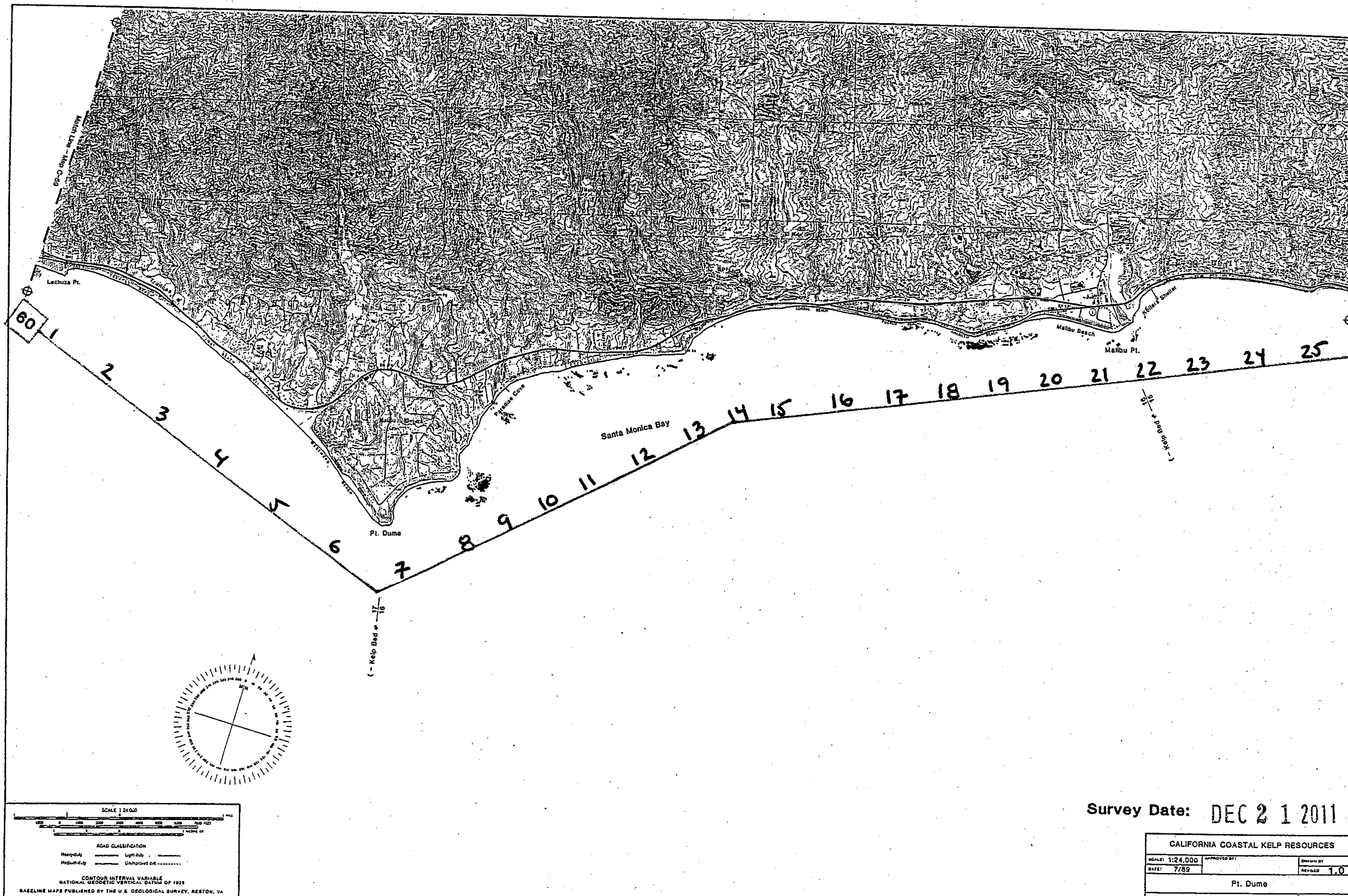


LEGEND

- OFFSHORE KELP CANOPIES
- ROCKY INTERTIDAL ZONE
- OFFSHORE ROCKS/ISLANDS
- SAND BEACH

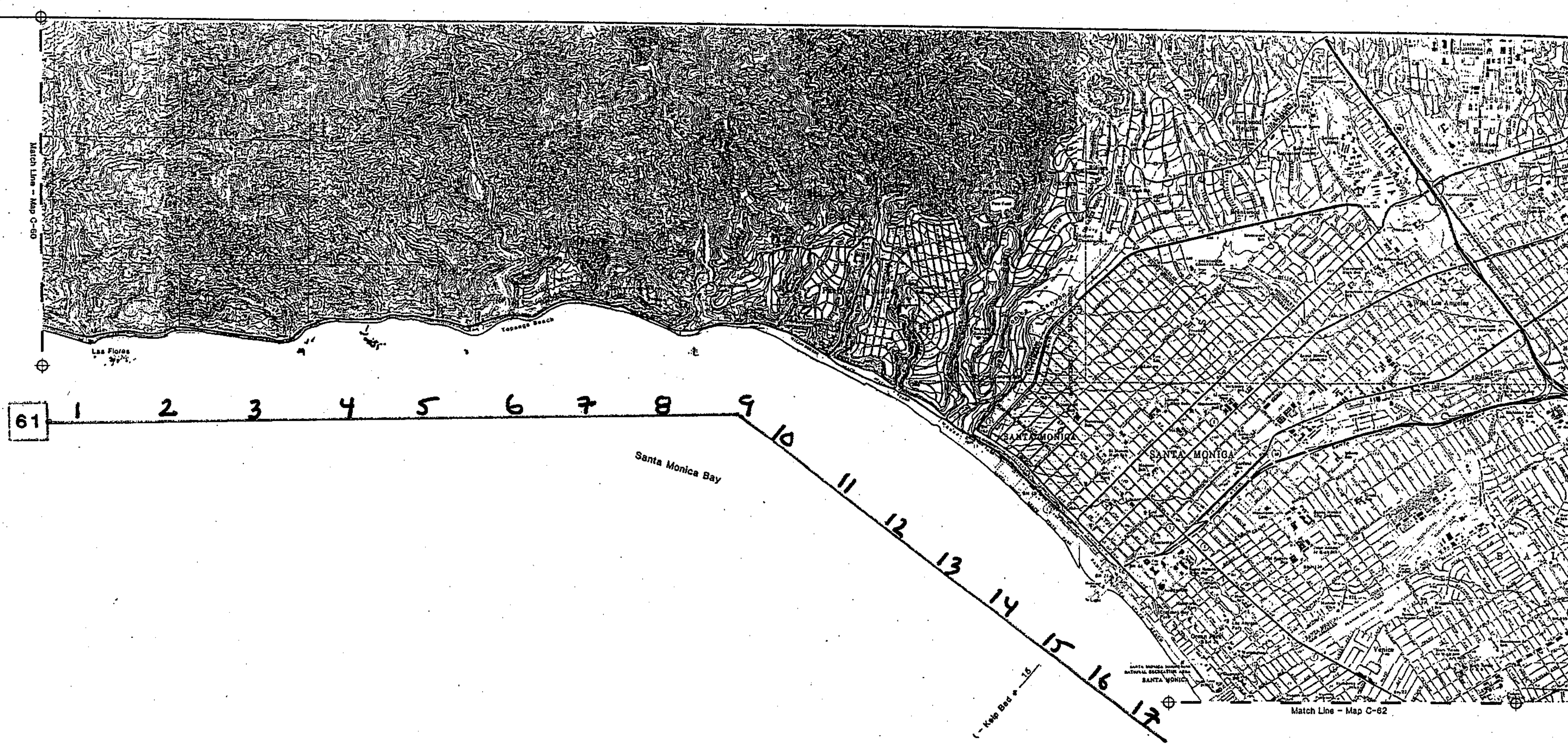
Survey Date: DEC 2 1 2011

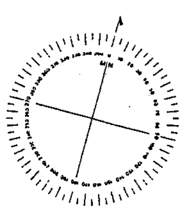
CALIFORNIA COASTAL KELP RESOURCES		
SCALE: 1:24,000	APPROVED BY:	DRAWN BY
DATE: 7/89		REVISED 1.0
Pt. Mugu		
© 89 ECOSCAN		DRAWING NUMBER C - 59



Survey Date: DEC 2 1 2011

CALIFORNIA COASTAL KELP RESOURCES		
SCALE: 1:24,000	APPROVED BY:	DRAWN BY
DATE: 7/89		REVISED 1.0
Pt. Dume		
ECOSCAN		DRAWING NUMBER C – 60





Survey Date: DEC 2 1 2011

LEGEND
- OFFSHORE KELP CANOPIES
- ROCKY INTERTIDAL ZONE
- OFFSHORE ROCKS/ISLANDS
- SAND BEACH

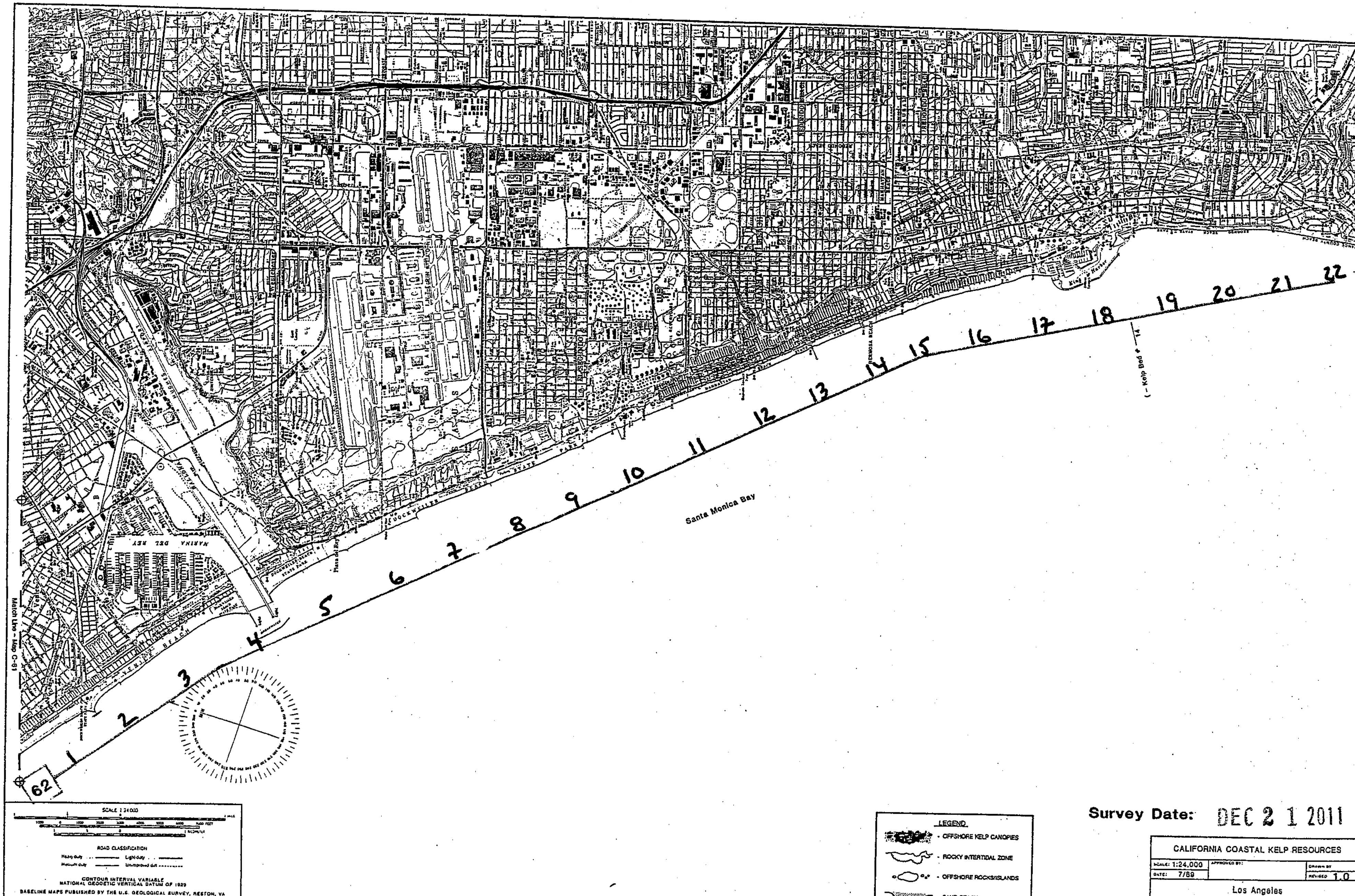
SCALE 1:24000

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty ———
Medium-duty ——— Unimproved dirt - - - - -

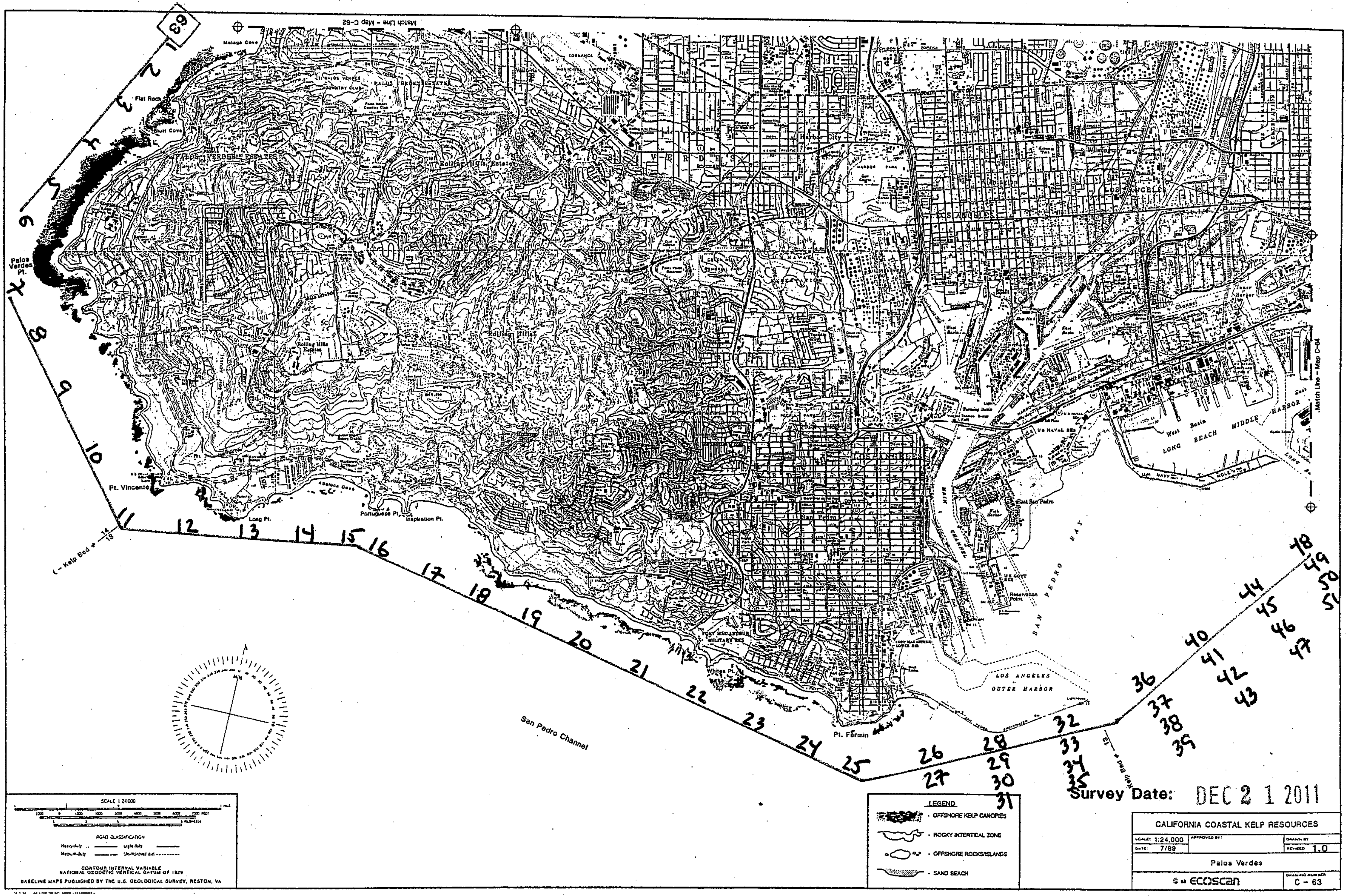
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA

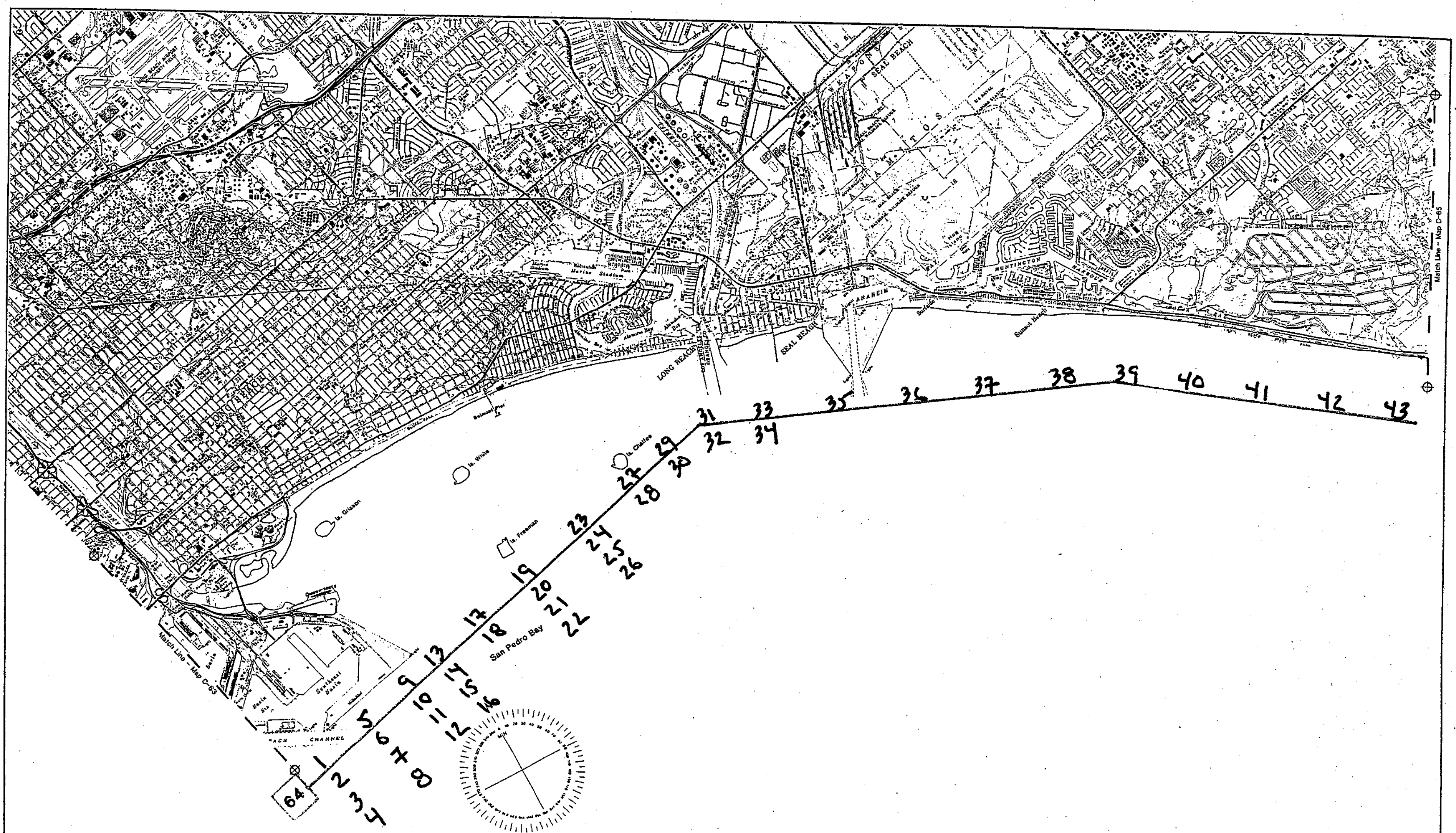
CALIFORNIA COASTAL KELP RESOURCES		
SCALE: 1:24,000	APPROVED BY:	DRAWN BY
DATE: 7/89		REVISED 1.0
Santa Monica		
© 89 ECOSCAN		DRAWING NUMBER C - 61



Survey Date: DEC 2 1 2011

CALIFORNIA COASTAL KELP RESOURCES		
SCALE: 1:24,000	APPROVED BY:	DRAWN BY
DATE: 7/89		REVISED 1.0
Los Angeles		
ECOSCAN		DRAWING NUMBER C - 62

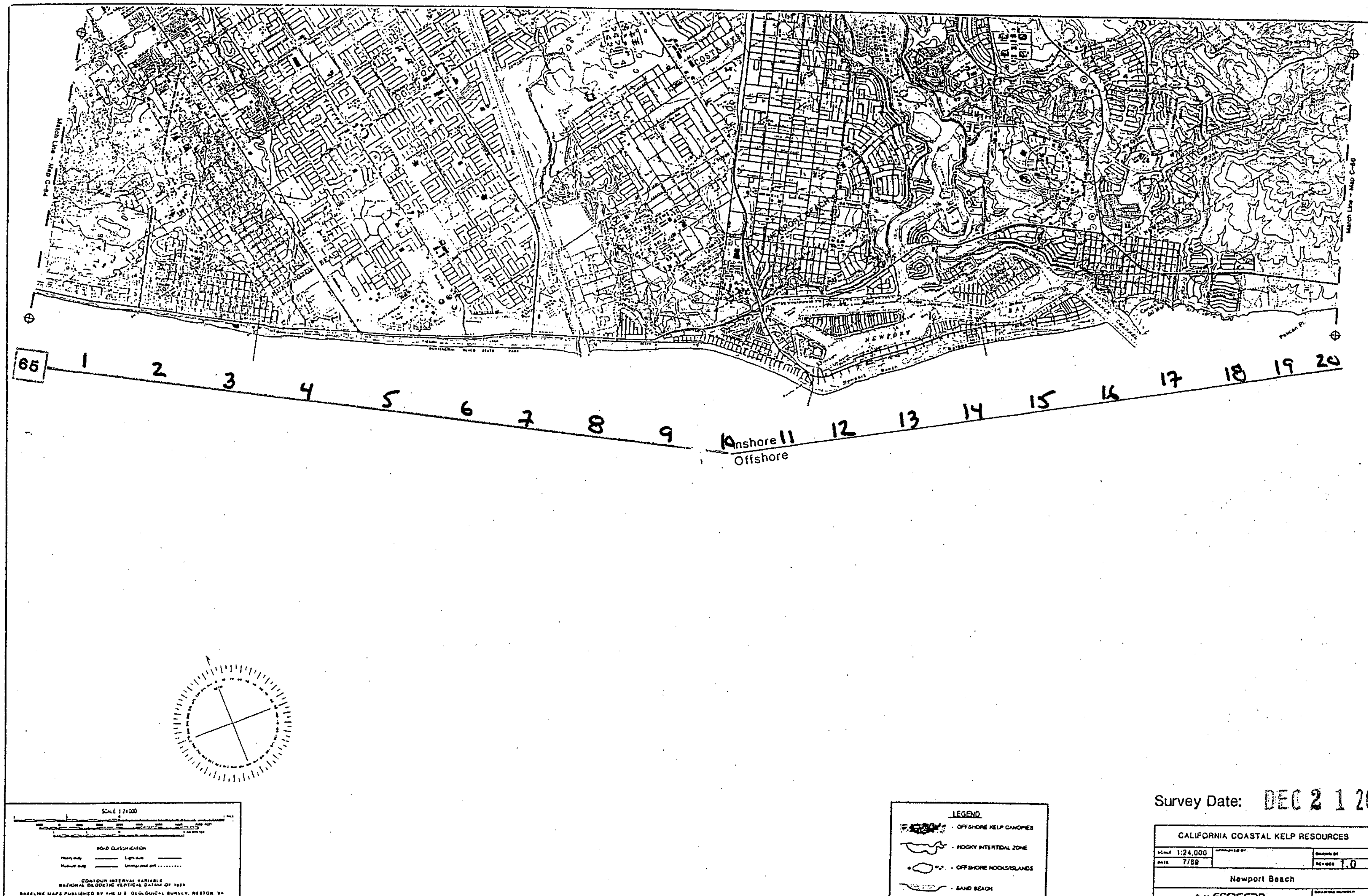

Survey Date: DEC 21 2011
CALIFORNIA COASTAL KELP RESOURCES
SCALE: 1:24,000
DATE: 7/89
REVISED 1.0
Palos Verdes
ECOSCAN
C - 63
LEGEND
- OFFSHORE KELP CANOPIES
- ROCKY INTERTIDAL ZONE
- OFFSHORE ROCKS/ISLANDS
- SAND BEACH
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
Match Line - Map C-62
Match Line - Map C-64
San Pedro Channel
Palos Verdes Pt.
Pt. Vincente
Long Pt.
Portuguese Pt.
Inspiration Pt.
Pt. Fermin
Flat Rock
Malaga Cove
LOS ANGELES OUTER HARBOR
SAN PEDRO BAY
MAIN CHANNEL
LONG BEACH MIDDLE HARBOR
63



Survey Date: DEC 2 1 2011

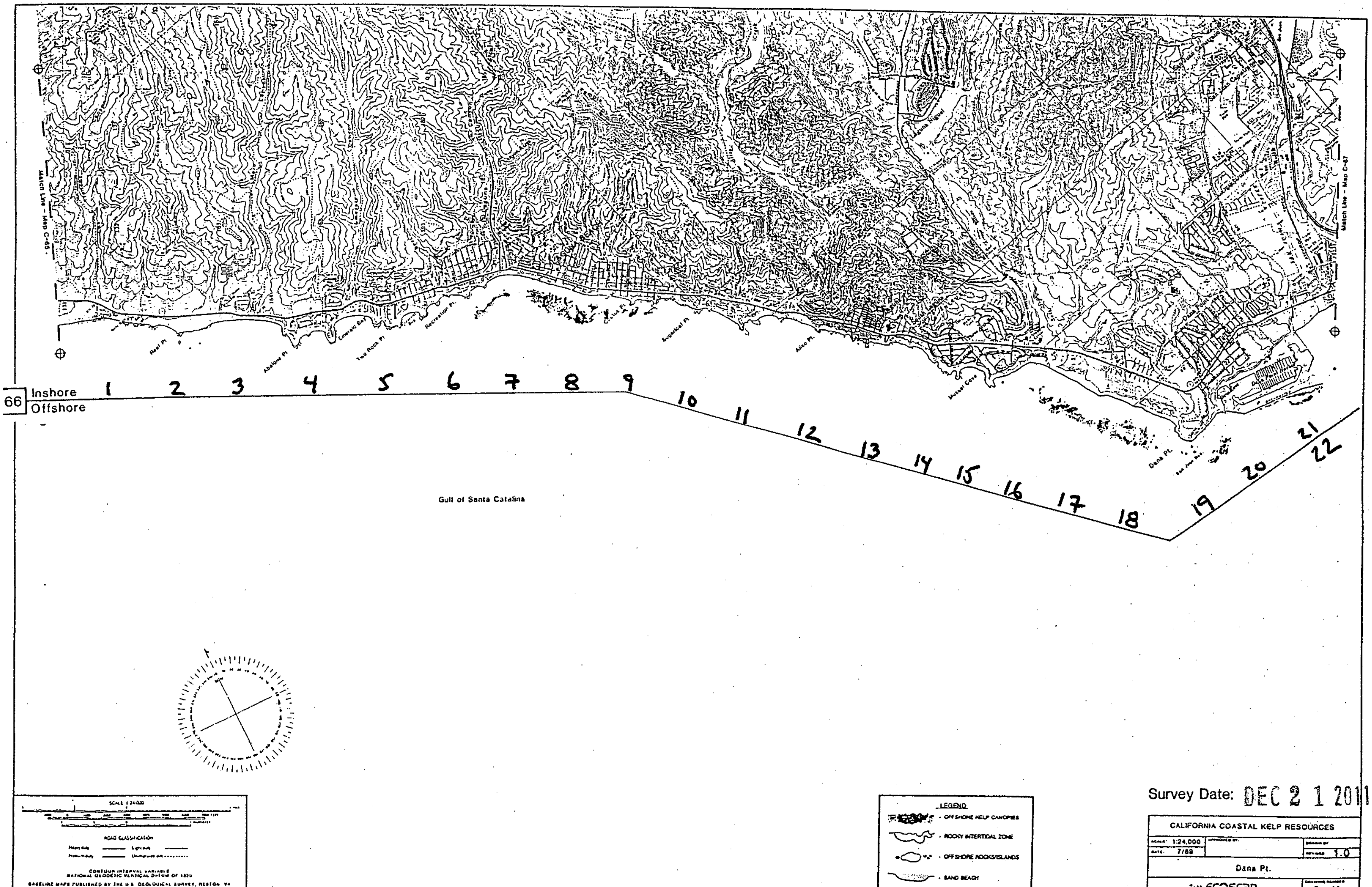
CALIFORNIA COASTAL KELP RESOURCES

SCALE: 1:24,000	APPROVED BY:	DRAWN BY:
DATE: 7/89		REVISED: 1.0
Long Beach		
© 89 ECOSCAN		DRAWING NUMBER C - 64



Survey Date: DEC 2 1 2011

CALIFORNIA COASTAL KELP RESOURCES		
SCALE 1:24,000 DATE 7/89		REVISED 1.0
Newport Beach		
© 89 ECOSCAN		C - 65



LEGEND

- OFFSHORE KELP CANOPIES
- ROCKY INTERTIDAL ZONE
- OFFSHORE ROCKS/ISLANDS
- SAND BEACH

Survey Date: DEC 2 1 2011

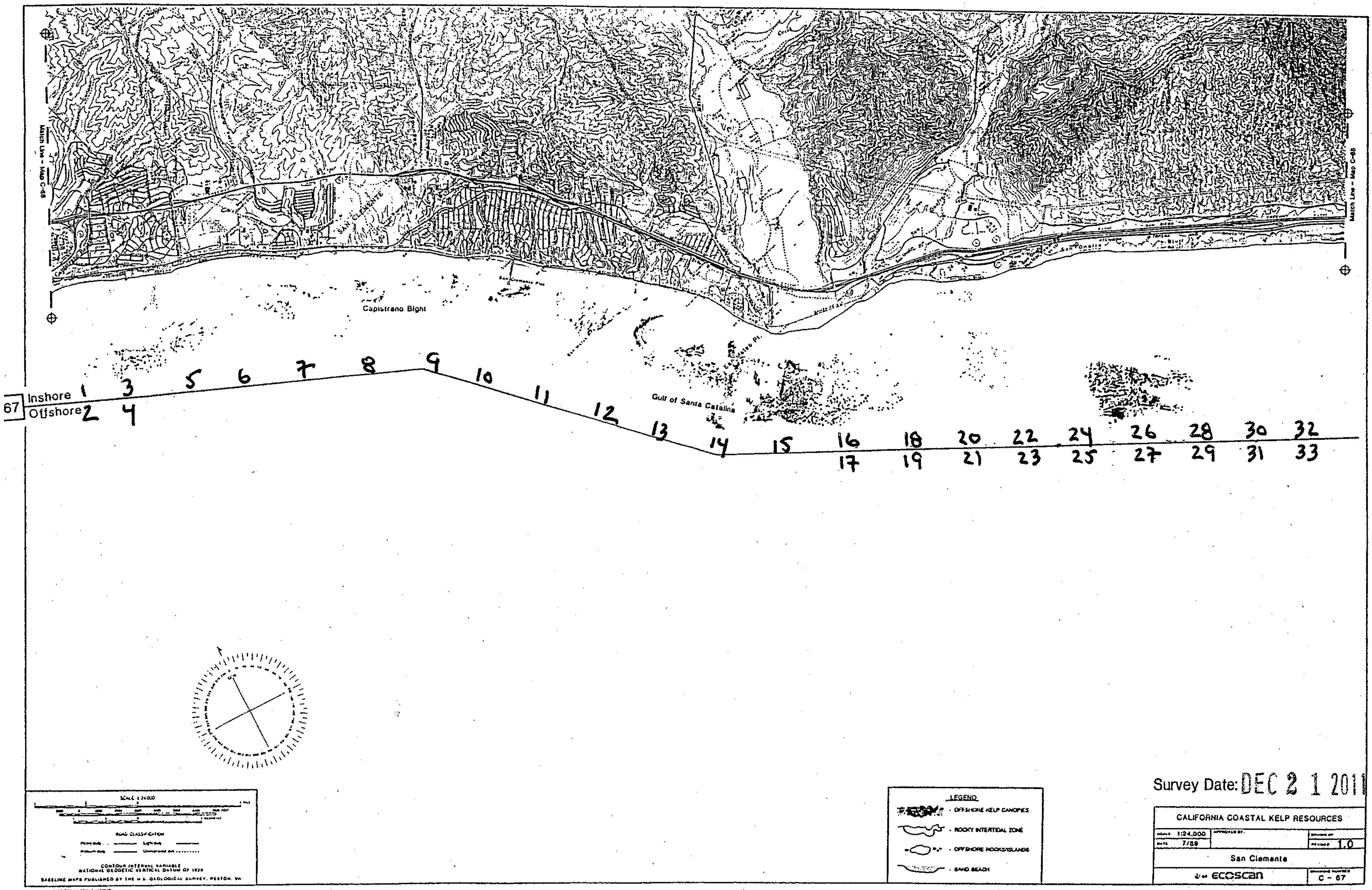
CALIFORNIA COASTAL KELP RESOURCES

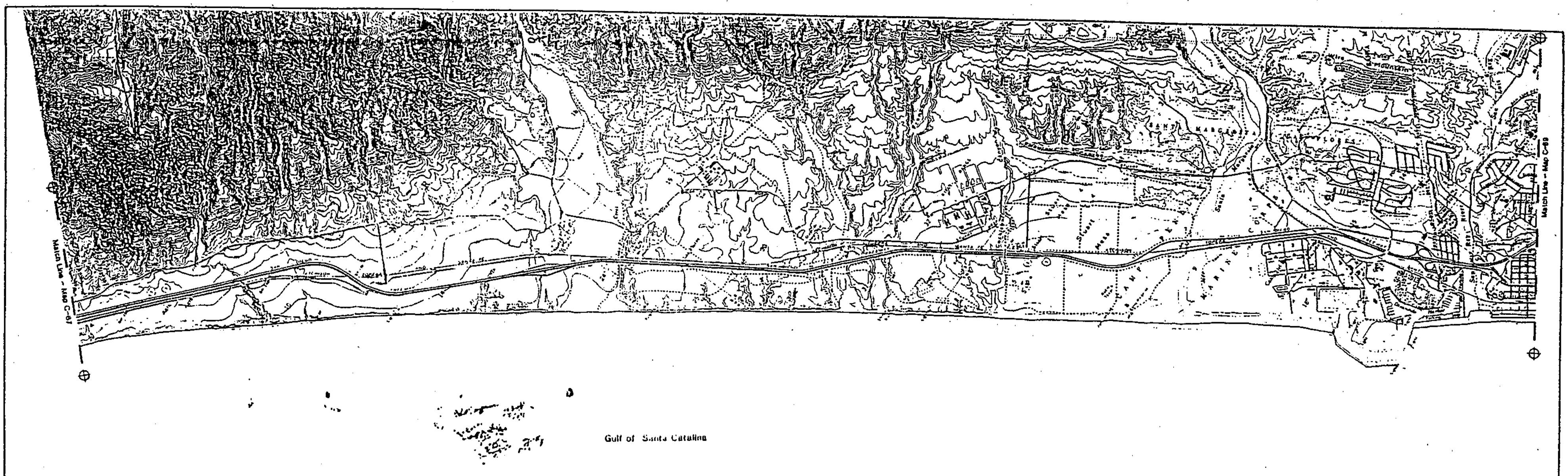
Scale: 1:24,000
Date: 7/89
Revised: 1.0

Dana Pt.

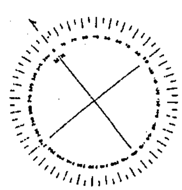
ECOSCAN

C - 66


Match Line - Map C-66
Match Line - Map C-68
Capistrano Bight
Gulf of Santa Catalina
67
Inshore 1 3 5 6 7 8 9 10 11 12 13 14 15 16 18 20 22 24 26 28 30 32
Offshore 2 4 17 19 21 23 25 27 29 31 33
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 2 1 2011
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
San Clemente
ECOSCAN
C - 67



68																			
Inshore	1	3	5	7	9	11	13	15	17	19	21	23	25	26	27	28	29	30	31
Offshore	2	4	6	8	10	12	14	16	18	20	22	24							



SCALE 1:24000

ROAD CLASSIFICATION

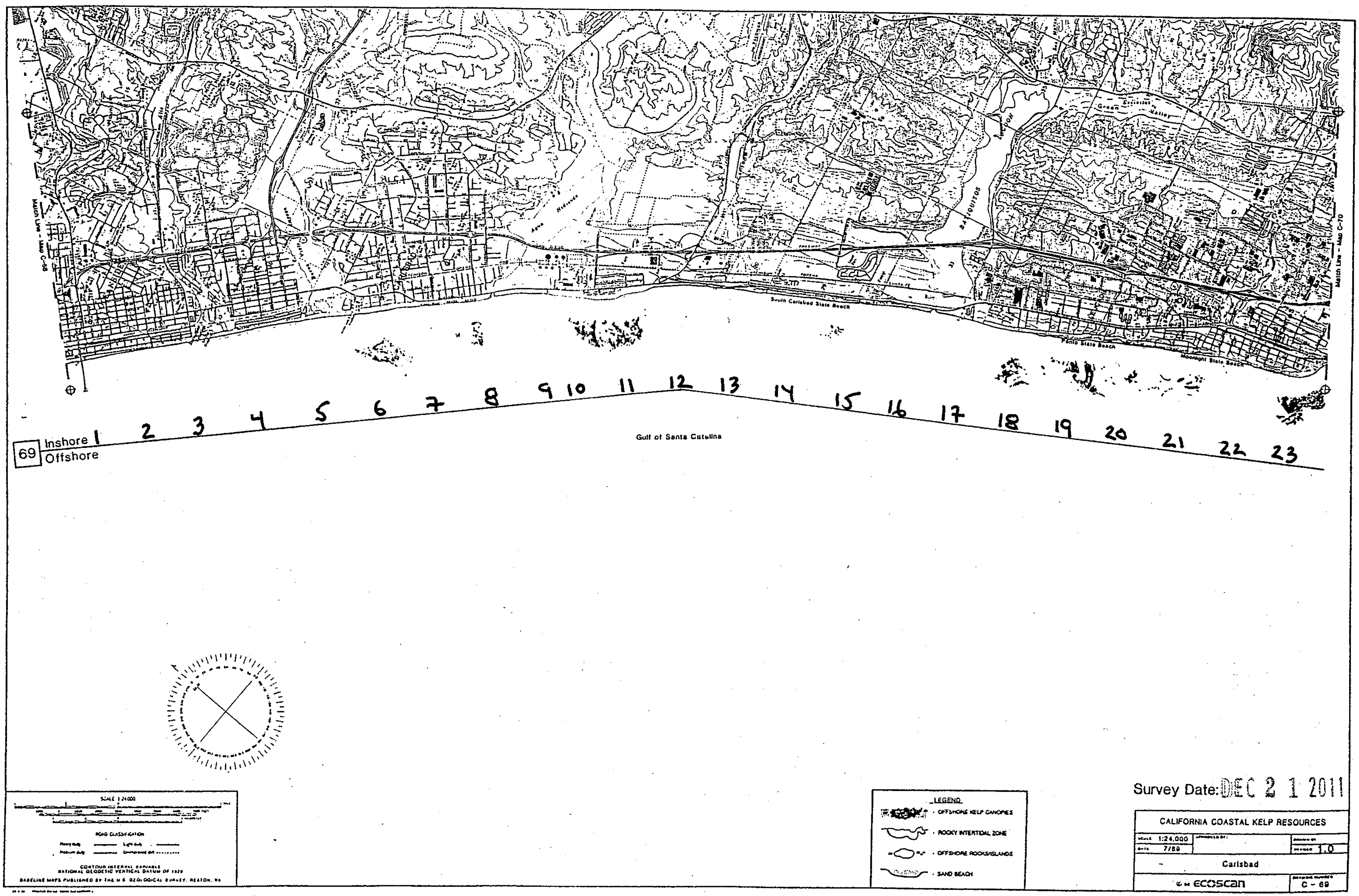
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY RESTON VA

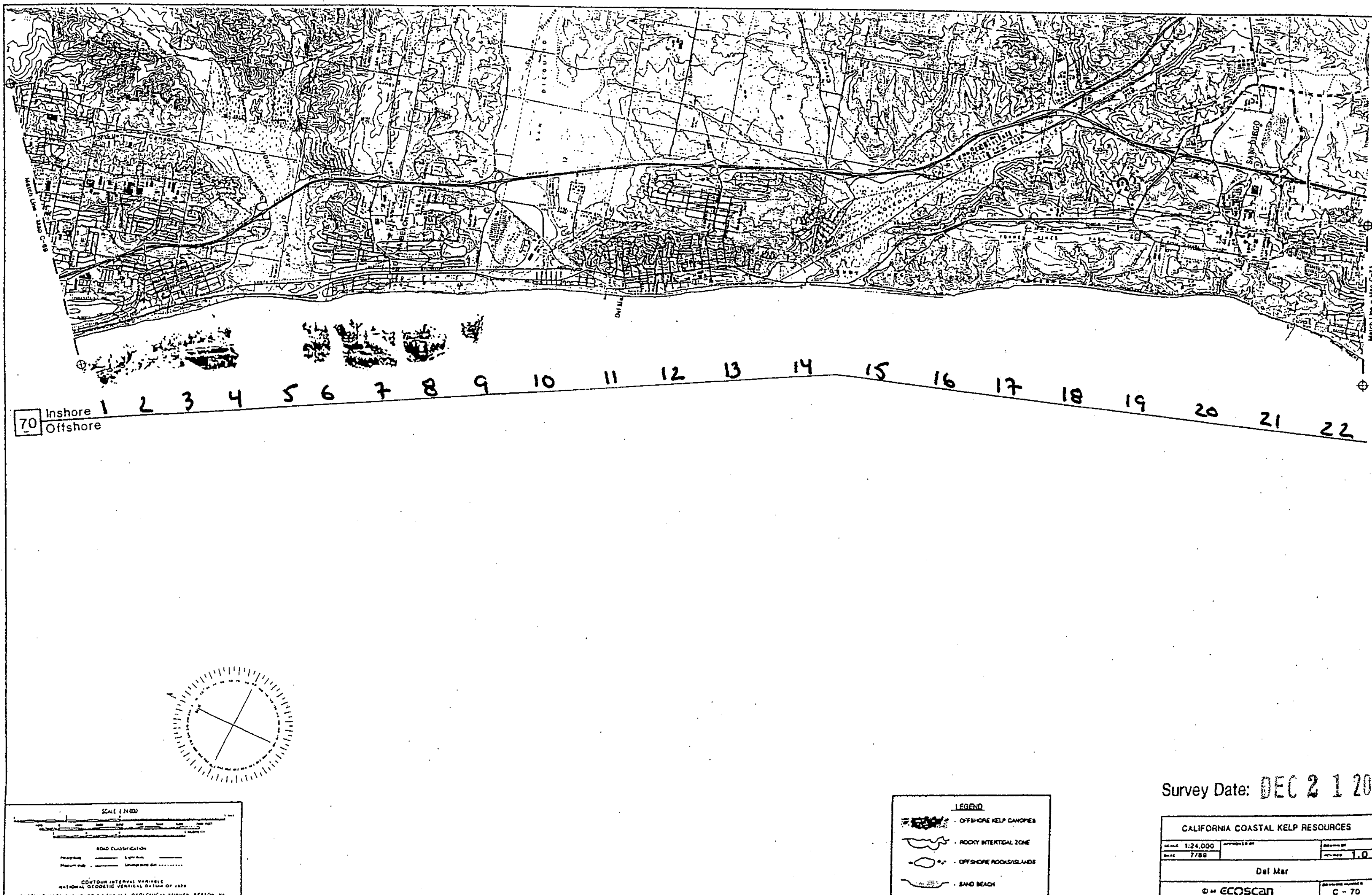
LEGEND
- OFFSHORE KELP CANOPIES
- ROCKY INTERTIDAL ZONE
- OFFSHORE ROCKS/ISLANDS
- SAND BEACH

Survey Date: DEC 2 1 2011

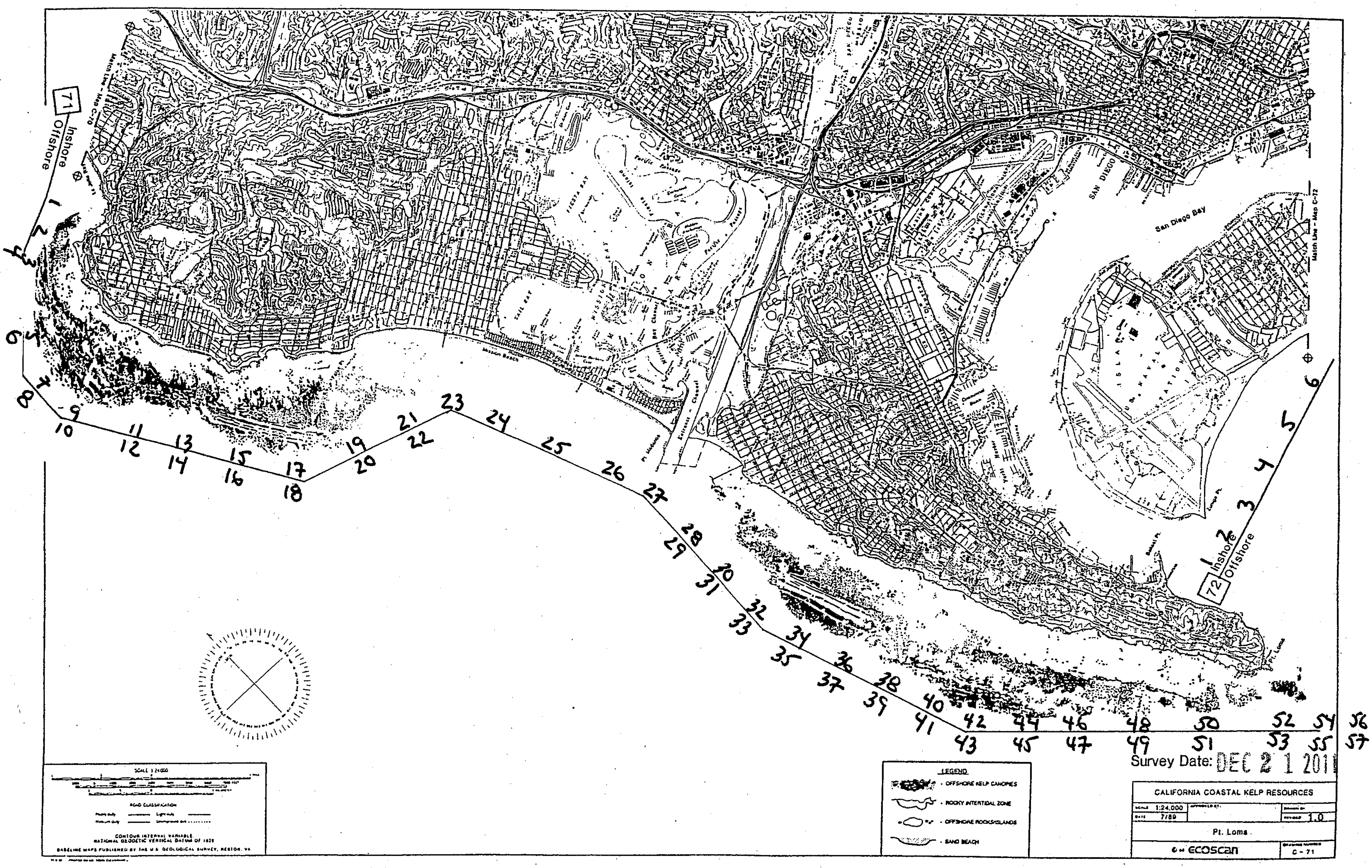
CALIFORNIA COASTAL KELP RESOURCES

SCALE 1:24,000		
DATE 7/89		1.0
Camp Pendelton		
ECOSCAN		C - 88

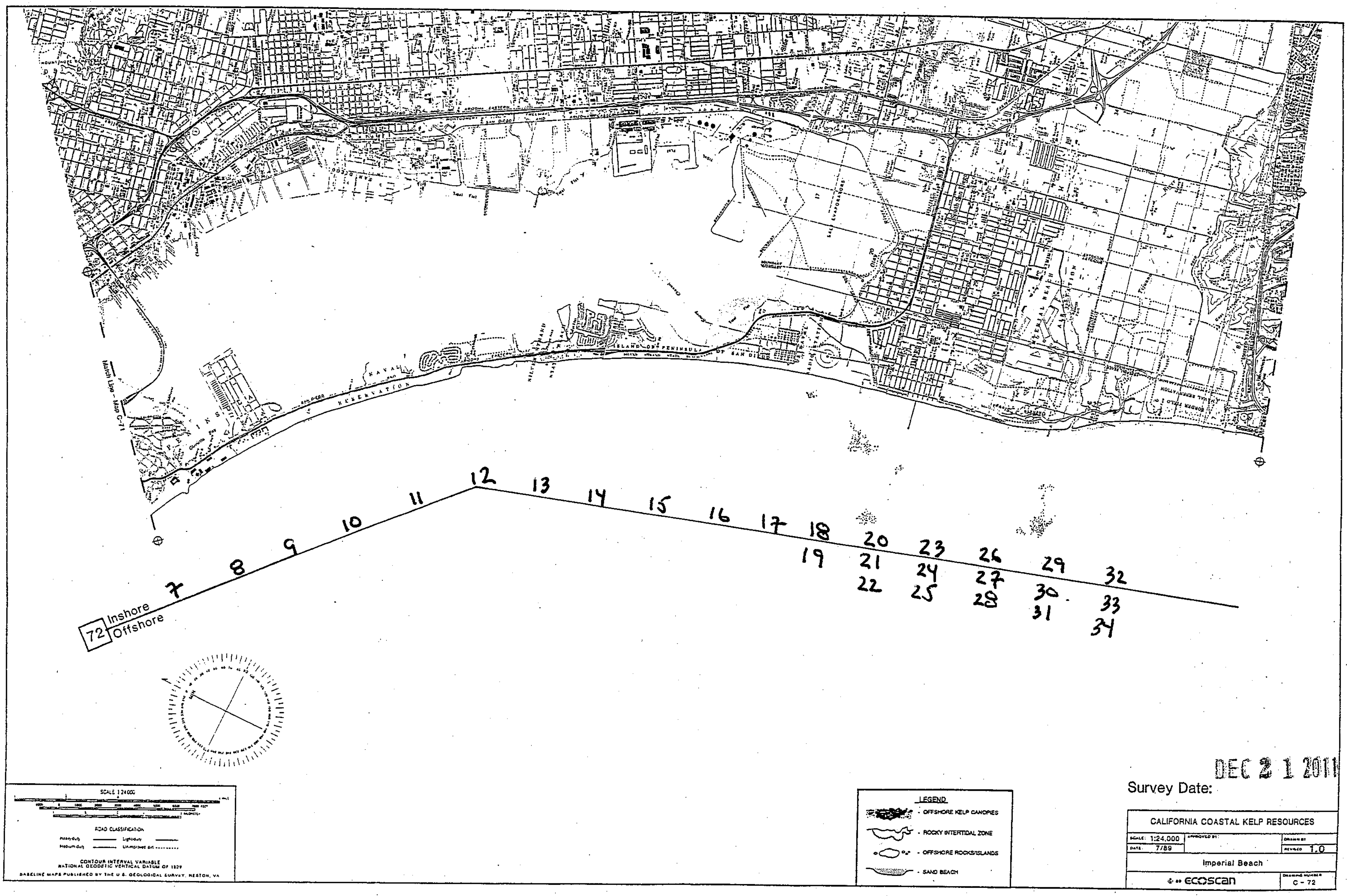

Match Line - Map C-68
Match Line - Map C-70
South Carlsbad State Beach
Ponto State Beach
Moonlight State Beach
Green Valley
Gulf of Santa Catalina
69
Inshore
Offshore
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
Survey Date: DEC 2 1 2011
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Carlsbad
ECOSCAN
C - 69



Match Line - Map C-69
Match Line - Map C-71
SAN DIEGO
Del Mar
70 Inshore
Offshore
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
LEGEND
· OFFSHORE KELP CANOPIES
· ROCKY INTERTIDAL ZONE
· OFFSHORE ROCKS/ISLANDS
· SAND BEACH
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
Survey Date: DEC 2 1 201
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Del Mar
ECOSCAN
C - 70



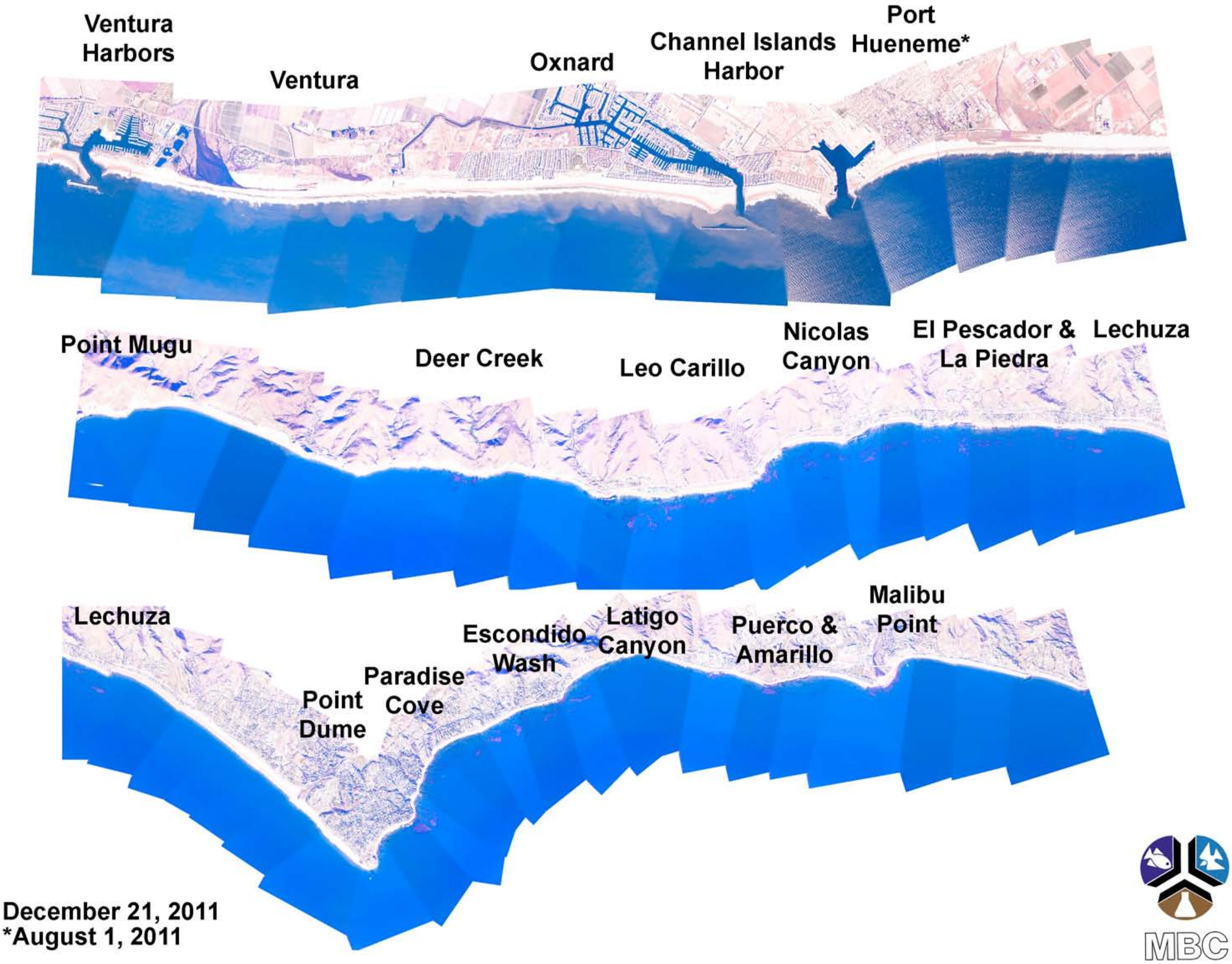
71 Inshore Offshore
72 Inshore Offshore
San Diego Bay
SAN DIEGO
Mission Beach
Pt. Loma
Survey Date: DEC 2 1 2011
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Pt. Loma
ECOSCAN
C - 71
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA



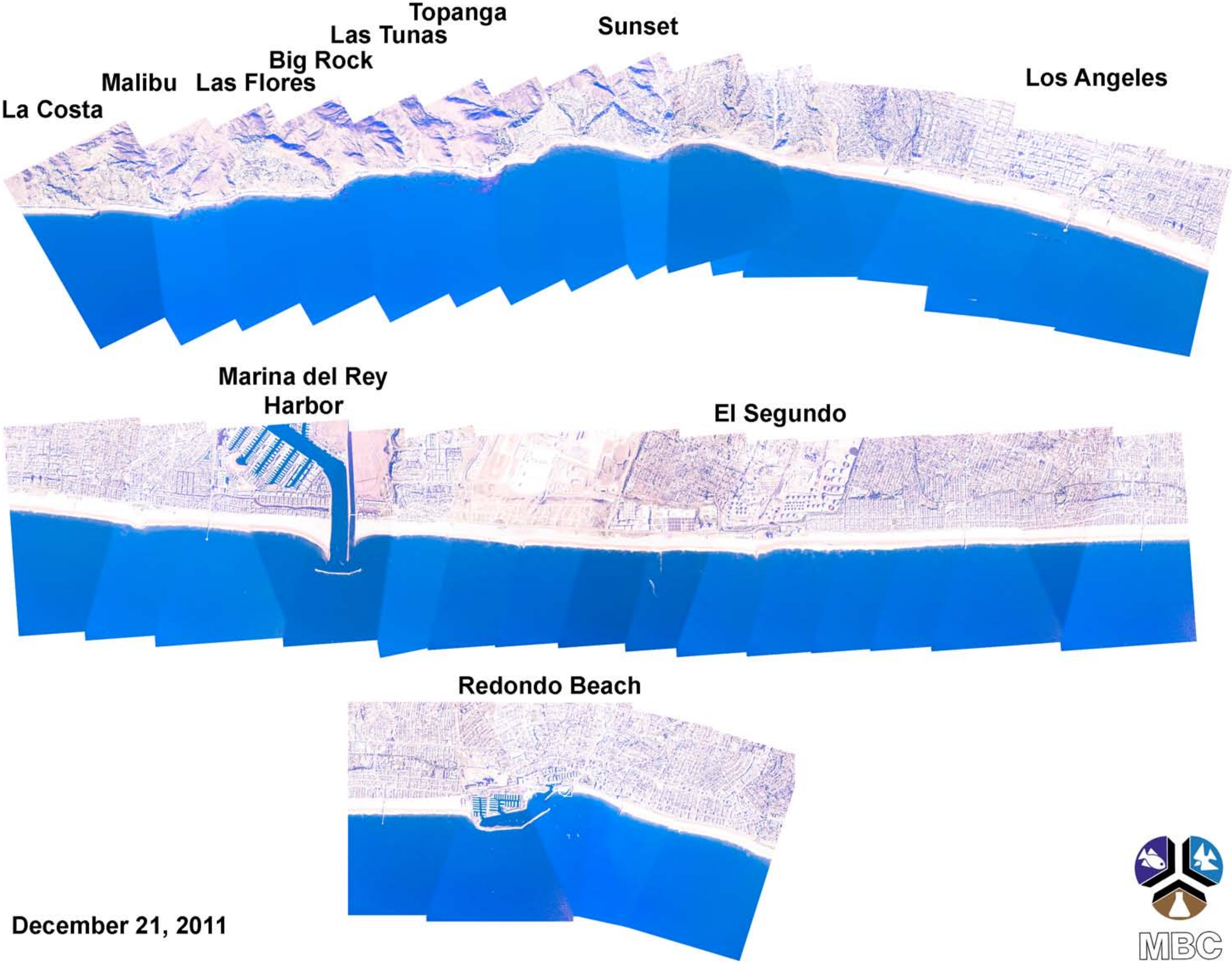
Match Line - Map C-71
72
Inshore
Offshore
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
SCALE 1:24000
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BASELINE MAPS PUBLISHED BY THE U.S. GEOLOGICAL SURVEY, RESTON, VA
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
DEC 21 2011
Survey Date:
CALIFORNIA COASTAL KELP RESOURCES
SCALE: 1:24,000
DATE: 7/89
APPROVED BY:
DRAWN BY
REVISED 1.0
Imperial Beach
ECOSCAN
DRAWING NUMBER C - 72

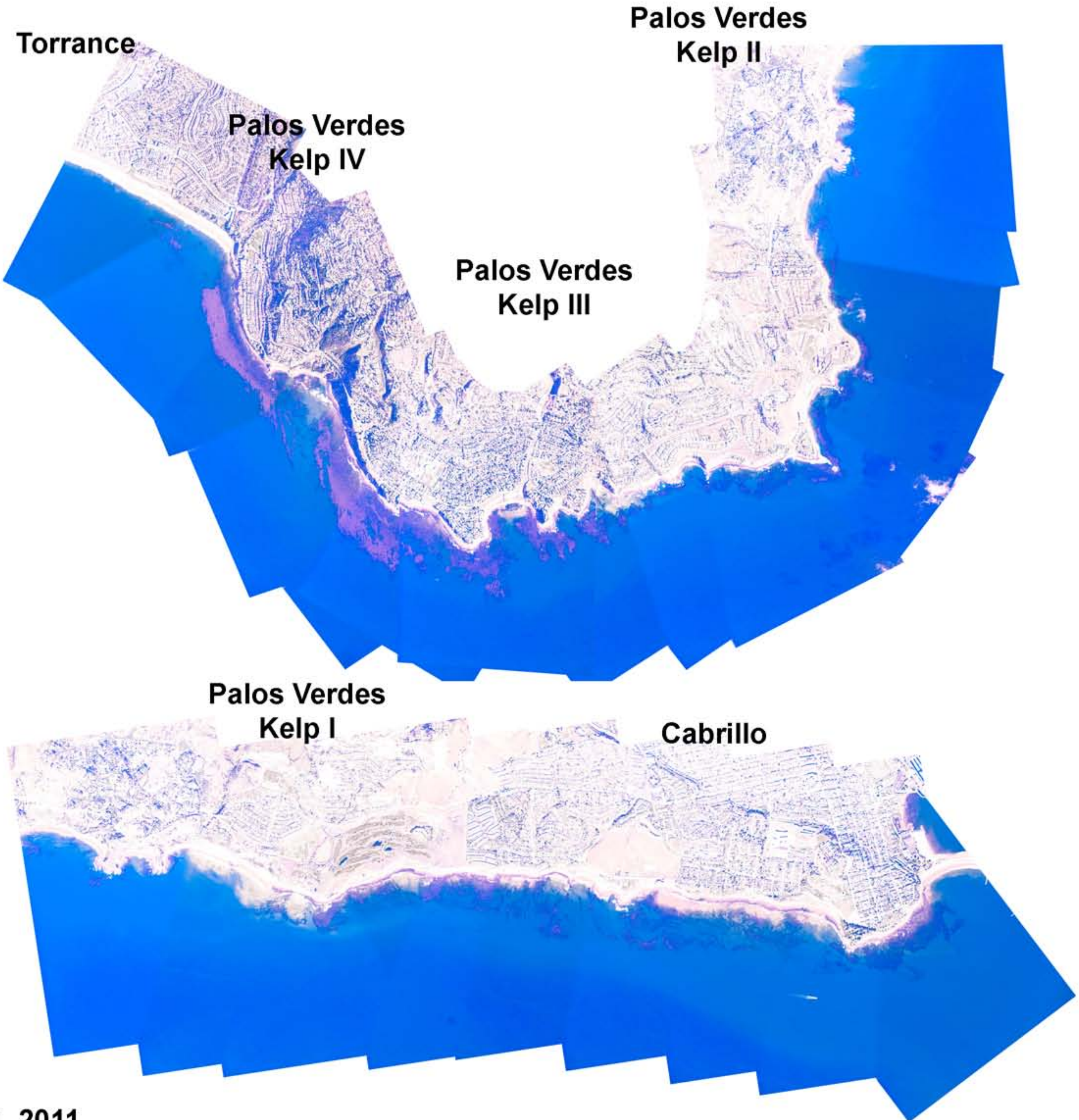
APPENDIX D

Kelp Canopy Aerial Photographs



Ventura Harbors
Ventura
Oxnard
Channel Islands Harbor
Port Hueneme*
Point Mugu
Deer Creek
Leo Carillo
Nicolas Canyon
El Pescador & La Piedra
Lechuza
Lechuza
Point Dume
Paradise Cove
Escondido Wash
Latigo Canyon
Puerco & Amarillo
Malibu Point
December 21, 2011
*August 1, 2011
MBC


La Costa
Malibu
Las Flores
Big Rock
Las Tunas
Topanga
Sunset
Los Angeles
Marina del Rey
Harbor
El Segundo
Redondo Beach
December 21, 2011
MBC

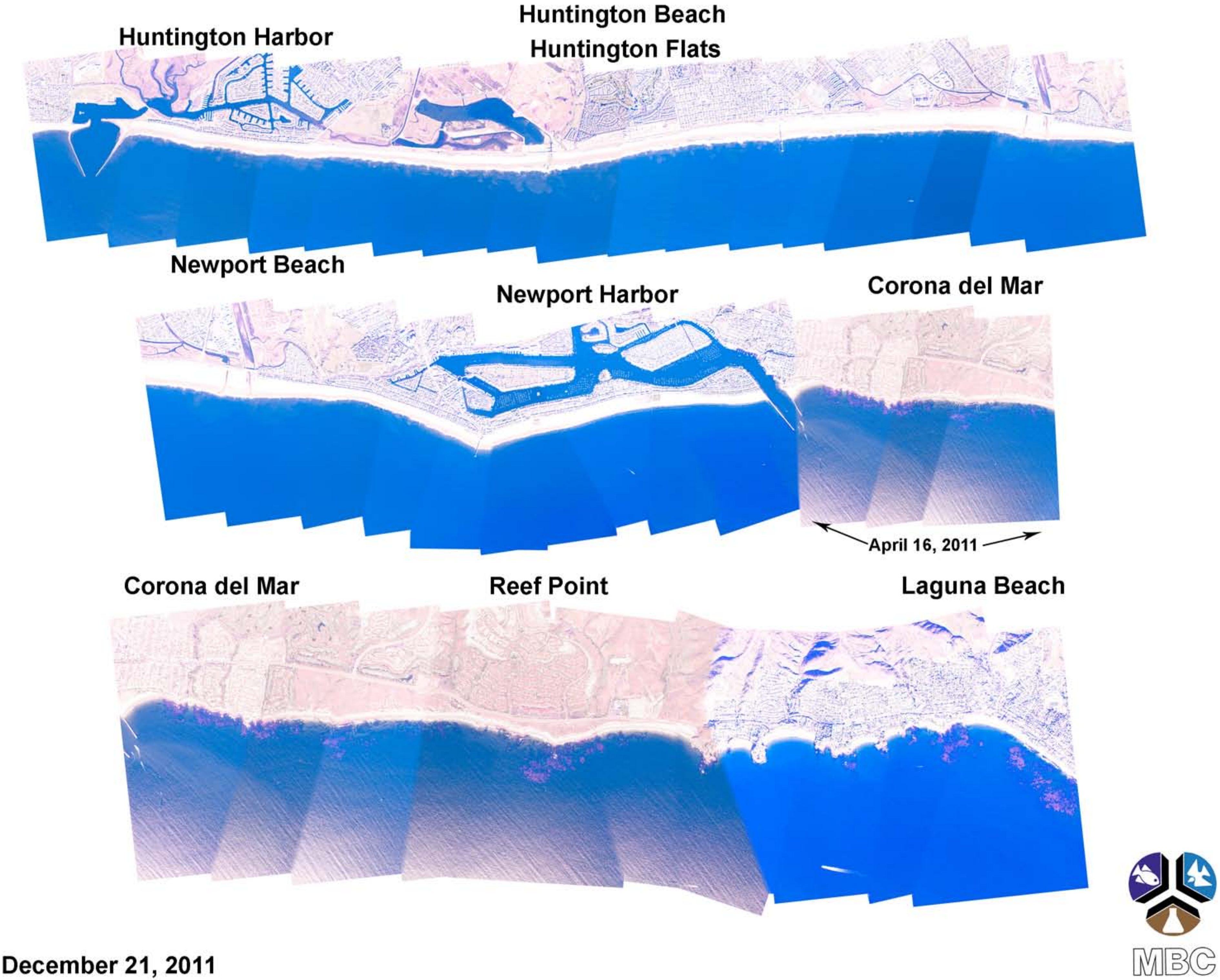


December 21, 2011

POLA/POLB Harbors

December 31, 2010

MBC


Huntington Harbor
Huntington Beach
Huntington Flats
Newport Beach
Newport Harbor
Corona del Mar
April 16, 2011
Corona del Mar
Reef Point
Laguna Beach
December 21, 2011
MBC