Status of the Kelp Beds 2010

San Diego and Orange Counties

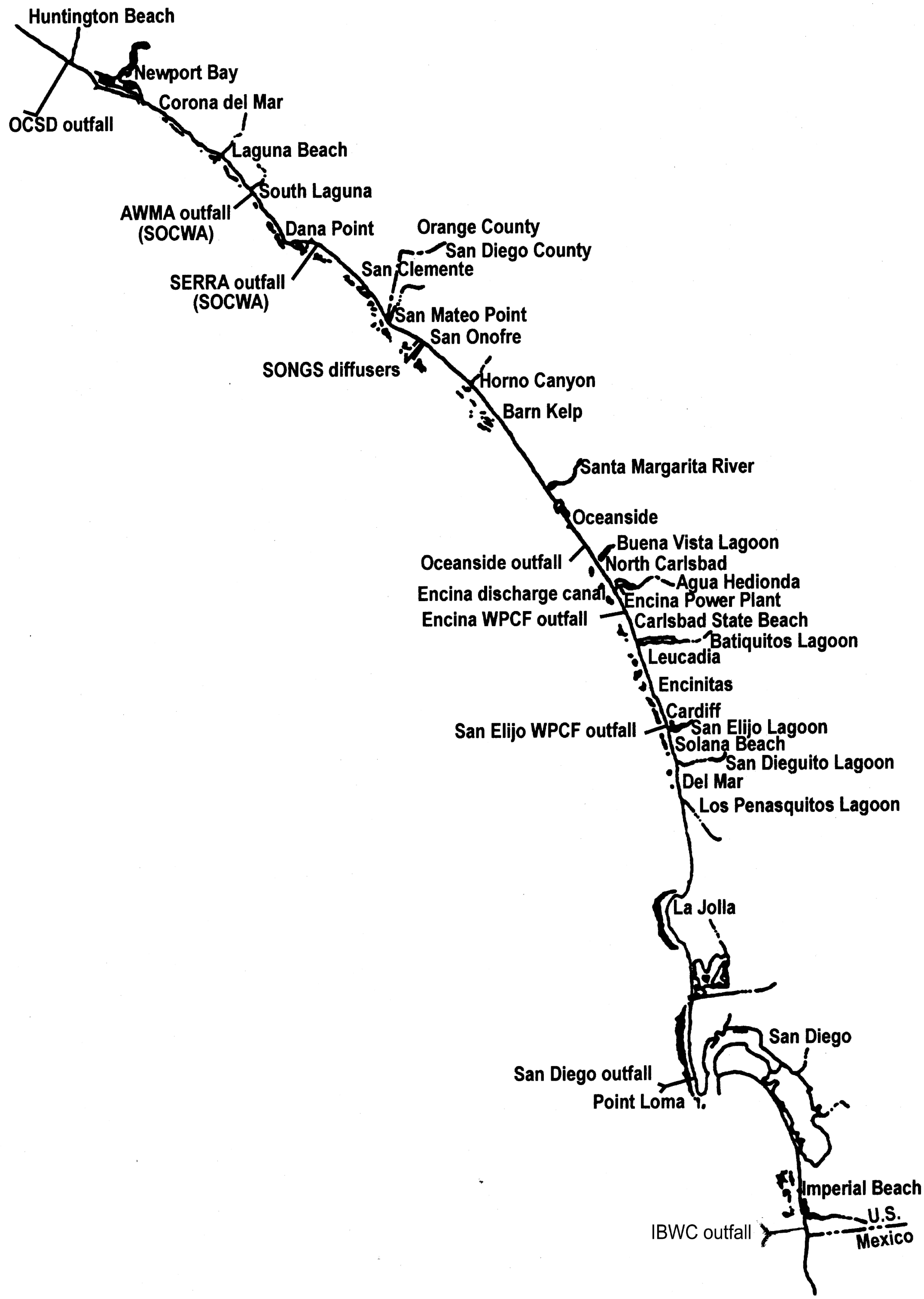
Region Nine Kelp Survey Consortium

June 2011

Prepared by:

MBC
Applied Environmental Sciences
Costa Mesa, California

MBC


Huntington Beach
Newport Bay
Corona del Mar
OCSD outfall
Laguna Beach
South Laguna
AWMA outfall
(SOCWA)
Dana Point
Orange County
San Diego County
SERRA outfall
(SOCWA)
San Clemente
San Mateo Point
San Onofre
SONGS diffusers
Horno Canyon
Barn Kelp
Santa Margarita River
Oceanside
Buena Vista Lagoon
Oceanside outfall
North Carlsbad
Agua Hedionda
Encina discharge canal
Encina Power Plant
Encina WPCF outfall
Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Encinitas
Cardiff
San Elijo WPCF outfall
San Elijo Lagoon
Solana Beach
San Dieguito Lagoon
Del Mar
Los Penasquitos Lagoon
La Jolla
San Diego
San Diego outfall
Point Loma
Imperial Beach
U.S.
IBWC outfall
Mexico

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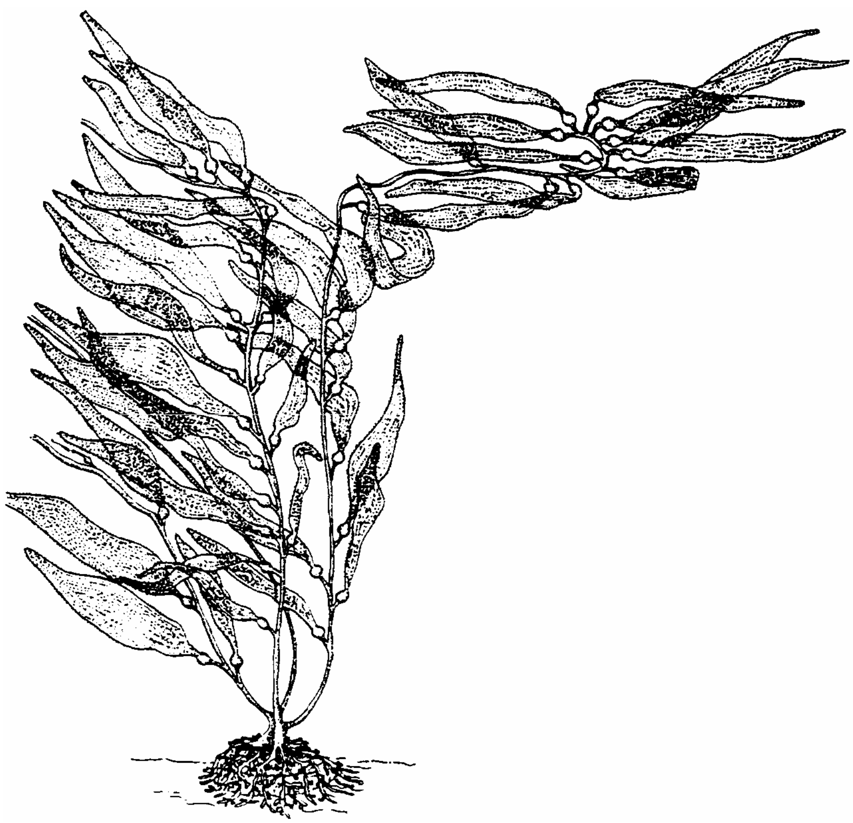

Region Nine Kelp Survey Consortium

June 2011

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JUNE 2011

EXECUTIVE SUMMARY

Foreword. The 2010 giant kelp study of Region Nine continued to demonstrate that relatively short-term environmental factors, including El Niño and La Niña, and very long-term multi-decadal regime shifts with their combined effects on the availability of nutrients controlled the fate of the regions kelp beds in 2010. There was no evidence to suggest any perceptible influence of the various dischargers on the persistence of the region's giant kelp beds.

Region Nine Kelp Consortium. Giant kelp beds have been mapped annually in Orange and San Diego Counties for the Region Nine Kelp Survey Consortium since 1983, when it was formed as a result of regulations from the San Diego Regional Water Quality Control Board (SDRWQCB). A series of meetings with several ocean dischargers from the region and the SDRWQCB were held in 1983 to discuss the design and implementation of a regional kelp bed monitoring program. Representatives of Orange and San Diego County dischargers, including publically owned treatment works (POTWs), power generators, storm water agencies, and non-governmental organizations participated. The monitoring program methodology was based upon similar aerial kelp surveys conducted by the late Dr. Wheeler J. North dating back to 1967. The Region Nine Kelp Survey Consortium has been conducting aerial surveys about four times yearly of the giant kelp canopy extent at 25 kelp beds along the San Diego and southern Orange County coast from Newport Beach to the Mexican Border since 1983. When combined with a similar organization (Central Region Kelp Survey Consortium) formed as a result of requirements of the Los Angeles Regional Water Quality Control Board (LARWQCB), the continuous and synoptic coverage of coastal kelp beds is provided for approximately 220 of the 270 miles of the southern California mainland coast from the Ventura-Santa Barbara County line to the Mexican Border.

Aerial Flights 2010. Aerial surveys of the giant kelp beds from Newport Harbor in Orange County to the Mexican Border in San Diego County were conducted in 2010 by MBC *Applied Environmental Sciences* (MBC). The aerial surveys for 2010 were conducted on 28 March, 22 August, 4 November, and 31 December 2010. Reasonable attempts were made to conduct one aerial overflight within each of the four quarters in the year; however, 2010 was the year without a summer. A persistent marine layer with low-lying clouds prevented surveys from late June until mid-August, causing a 1.5-month gap in the record. Due to the delay, the next two surveys were scheduled to split the remaining time, with the third survey scheduled for late October (weather delayed that survey to 4 November), and the last for late December. Based on the results of the surveys, maximum canopy coverage throughout most of the region was generally observed during the flight of 31 December (or the 22 August flight for the La Jolla-Point Loma kelp beds). About one half of the kelp beds had decreased by the late-March 2010 survey from that reported in December 2009, but about 50% of the beds increased from that low by the August 2010 survey (and all maintained canopies which is unusual for summer surveys). By the November 2010 survey, the northern one half generally increased, while the southern half decreased, and almost all increased to their maximums by the December 2010 survey (a significant fraction of what was observed during 2009 surveys).

Oceanographic Environment 2010. The National Oceanic and Atmospheric Administration (NOAA) indicates that the 2010 year was a La Niña year following a mild El Niño in 2009. The year started with warmer-than-average sea surface temperatures prevailing throughout the region in 2010, followed by a transition into a La Niña period of cooler-than-average seawater temperatures which continued through mid-September, becoming slightly warmer than average in October, and then cooling considerably below average in November and December 2010.

Historic sea surface temperatures (SST) from the Newport Pier, San Clemente Pier, Scripps Institution of Oceanography Pier, and Point Loma South buoy were used to determine the availability of nutrients in the region. In the Southern California Bight temperature and nutrients have been shown to be inversely related; high temperatures equal low nitrates and low temperatures equal high nitrate availability. All four SST stations were more or less in synchrony (with rare exceptions); however, the degree to which each upwelling event was recorded was very different. The Newport Pier Station recorded much cooler temperatures, closely followed by San Clemente Pier; however, the Scripps pier and Point Loma data indicated that while upwelling pulses were recorded in the same time frame, the magnitude was much less in the southern portion. From January through February, temperatures were warmer than average (and until mid-April at Scripps and at Point Loma), but gave way to cooler waters through May at the northern stations, and about average at Scripps and Point Loma. All stations were much cooler than average through the summer until October, when most were slightly warmer than average. In November waters again became cooler than average through the first two weeks of December promoting a mild resurgence of the kelp canopy in the region's beds by year's end. As a result, increases in bed sizes from August and November 2010 were relatively uniform across most of the Region Nine kelp beds with most expanding to a significant fraction of what they were in early-to-mid 2009. The relationship between temperature and nutrients appeared favorable in early 2010 in the south and very favorable in the north based on the monthly Nutrient Quotient Index (NQ). However, the lack of nutrients from May to November 2010 in the south, resulted in a very low NQ value of 11 for the calendar year in the south at Scripps, NQ=14 at San Clemente Pier, and NQ=26 at Newport Pier in the north. Comparing the NQ for the 2010-2011 season indicated that conditions were much better in the north with a projected value of NQ=35 at Newport Pier, bu the beds in the south did not fare as well with an NQ of only 17 at Scripps Pier, and only NQ=20 at Point Loma South (Table 1). These values should have resulted in relatively mediocre kelp canopy increases in the south in 2010, but above-average kelp canopy coverage in the north.

Water clarity was relatively favorable for kelp growth in 2010; rainfall totals were at average levels in the region, but the contrast from drought made it appear higher and there were relatively short periods when the rivers and streams emptied into the ocean making the nearshore waters turbid. Algal blooms occurred but did not persist long enough to seriously affect photosynthetic opportunities and did not appear to contribute to any stress on the kelp beds. In general, turbidity from storms, rainfall, and phytoplankton blooms did not appear to be a factor in the growth of kelp canopy in 2010.

Typical swell sizes and directions were observed through most of 2010, with swells generally approaching the region from the south and west. Swells over 4 m high can potentially cause damage to the kelp beds if occurring during periods when the kelp beds are under stress from a lack of nutrients. High swell conditions (>4 m) briefly existed during late January at San Pedro CDIP Buoy (4.4 m) and swells over 3 m also occurred at Dana Point (3.65 m) and Oceanside (3.7 m) during the same period; the same swell only reached about 2.75 m at Camp Pendleton and 1.90 m at Scripps (CDIP 2011), but at Point Loma South there were very large swells for a week in late January. In early March swells were again large, and there were several periods from mid-April to late May with high waves, but seas were relatively calm after that as swells were either low energy or had a more southern approach until late November into December. Wave energy, height, and density data at the San Pedro, Dana Point, Oceanside, and Point Loma South CDIP Buoys indicated there were high-amplitude waves near or over 3 m (with one over 4 m and several approaching or over 3.5 m). Therefore wave and swell intensity probably contributed to stresses upon the giant kelp resources, but in spite of the fairly large swells recorded during 2010, they were not persistent and there was no evidence of any substantial impacts on the kelp beds in Region Nine, with the possible exception of the loss of the Imperial Beach kelp bed.

Giant Kelp Survey Results 2010. Results of the 2010 Region Nine aerial surveys indicated that the maximum measured kelp canopy was 11.706 km^2, decreasing from the 13.571 km^2 recorded in 2009. Based on the 2010 aerial surveys, 24 of the 25 beds monitored were present: 13 kelp beds decreased, 11 kelp beds increased, and one was missing (as in 2009). Boat surveys were conducted during most of the year from Newport Beach to Barn Kelp and in early November 2010 in the northern portion and early December 2010 in the southern portion to document the kelp canopies and verify anomalies suggested by the earlier data. By the 28 March 2010 survey, most of the central to northern portion of the region lost kelp canopies, while those from Dana Point north appeared to have maintained their size from that seen in late 2009, with a couple of beds increasing. By the August 2010 survey, most of the kelp beds showed increasing canopies (helped by the cooler water temperatures over summer) with La Jolla and Point Loma reaching maximum canopy size during this survey. A dichotomy again existed by the 4 November 2010 overflight; beds in the north increased and those in the south decreased. However, by the late December survey almost all beds had increased or maintained earlier maximum sizes (again with the exception of La Jolla and Point Loma kelp beds, which decreased greatly). Overall, kelp in 2010 had mixed responses to nutrient pulses, with some capitalizing on the relatively good conditions of early 2010 and most increasing in the south from Newport Coast to just past San Onofre at Horno Canyon, while the beds from Barn Kelp to Imperial Beach all (with the exception of La Jolla kelp bed) decreased. While gains were relatively small (with the exception of San Clemente kelp), many of the very large beds lost considerable canopy coverage ranging from a loss of 99% at the Imperial Beach kelp bed to only 6% lost at the Salt Creek/Dana Point kelp bed. However, because of good gains in some of the beds, the overall loss for the year was only about 14% of the existing kelp canopies. Therefore, the total area of kelp coverage by the December 2010 survey was very good, but it was below that documented in 2009 (which was the best since 1941 according to published records).

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 within the region that we cannot yet accurately predict with our current knowledge. In spite of this uncertainty in our predictive ability, the kelp bed canopies of Region Nine remained fairly robust as has been observed during the past seven years.

Conclusion 2010. The giant kelp surveys of 2010 continued to demonstrate that kelp bed dynamics in Region Nine are controlled by large scale oceanographic factors. 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 was sustained in 2010 as nutrients appeared to be replete in the region with the advent of a La Niña for most of 2010. As of early-June 2011, water temperatures in the Southern California Bight continue to remain unseasonably cool portending possible increases in 2011, but the prognosis is for El Niño neutral conditions which could stall any further increases in the canopy size.

2011. Based on the results of the first aerial survey of 2011 and supplemented by direct biologist-diver observations, a trend of decreasing total canopy coverage was recorded indicating that conditions were relatively unfavorable for kelp in early 2011 in Region Nine. NOAA indicates that average SST anomalies will transition from La Niña to ENSO-neutral conditions later in 2011. As temperatures recorded at Newport were cool and those at Scripps were warmer by May, the outlook in mid 2011 is mixed, but it is likely that the overall impact is that there will be a reduction in canopy for the kelp beds of Region Nine in 2011.

STATUS OF THE KELP BEDS 2010
SAN DIEGO AND ORANGE COUNTIES

REGION NINE KELP CONSORTIUM
June 2011

INTRODUCTION

The giant kelp beds (*Macrocystis pyrifera*) from Newport Harbor to the Mexican border were surveyed by aerial infrared photography in 2010 by MBC *Applied Environmental Sciences* (MBC). The surveys were conducted as close to quarterly as possible and were flown by Ecoscan Incorporated on 28 March, 22 August, 4 November, and 31 December 2010. One aerial survey (on 16 April 2011) has been completed for the 2011 survey year. Digital color infrared and color photos were taken of the entire coastline during each survey. These slides were then processed and the kelp depicted on each slide was transferred to base maps to facilitate intra-annual comparisons and for ease of analysis (Appendix A).

Giant kelp beds have been mapped annually since 1983 in Orange and San Diego counties for the Region Nine Kelp Survey Consortium formed as a result of regulations from the San Diego Regional Water Quality Control Board (SDRWQCB). In 1983, the 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. The Region Nine Kelp Survey Consortium has been conducting aerial surveys (usually quarterly) of kelp canopy extent at 25 kelp beds along the San Diego County and southern Orange County coast from Newport Beach to the Mexican Border since 1983 (Appendix A and Figure 1). This program was reviewed by the Los Angeles Regional Water Quality Control Board (LARWQCB) and in late 2002 they formulated similar kelp monitoring regulations. From these regulations, dischargers in the Ventura, Los Angeles, and part of Orange counties formed the Central Region Kelp Survey Consortium. The Central Region and Region Nine 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.

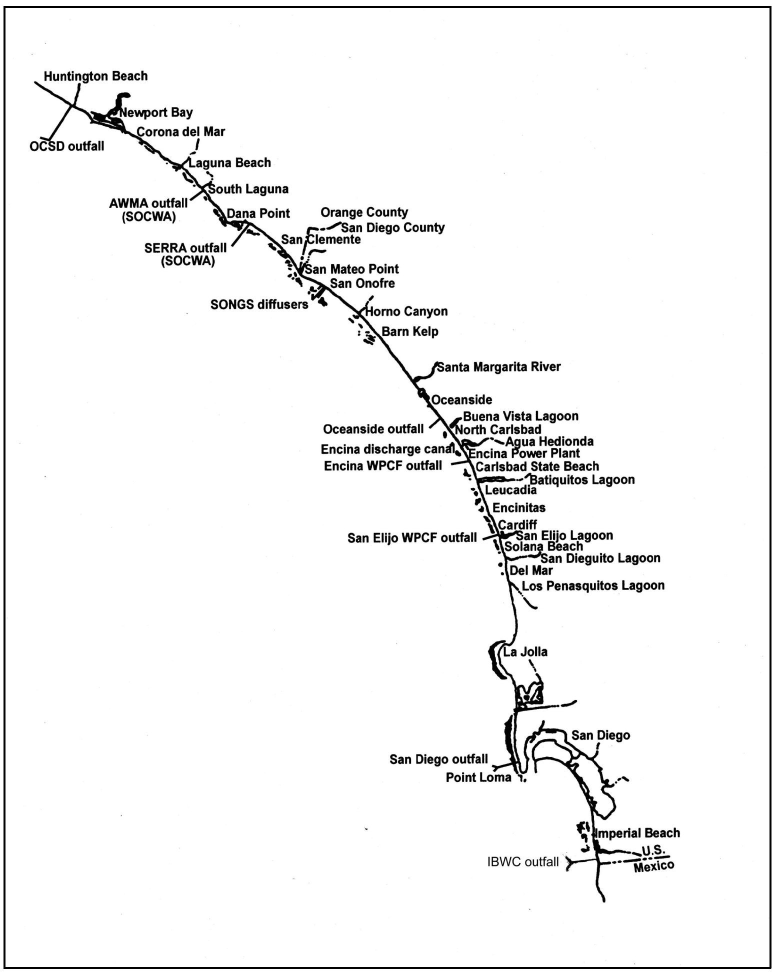

Figure 1. Ocean dischargers located within the Region Nine kelp survey area.

KELP LIFE HISTORY

Kelp consists of a number of species of brown algae of which 10 are typically found from the Mexican Border to Point Conception (Southern California Bight [SCB]). Compared to most other algae, kelp species can attain remarkable size and long life span (Kain 1979, Dayton 1985, Reed et al. 2006). Along the 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). 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). Darwin (1860) noted the resemblance of the three-dimensional structure of kelp stands to that of terrestrial forests. 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 (such as found at the Channel Islands), giant kelp may even thrive to depths of 150 ft. Along the mainland coast, high productivity, terrestrial inputs, and continental shelf mixing result in greater turbidity attenuating light levels and precluding giant kelp from deeper depths. Consequently, kelp generally does not grow deeper than 60 ft along the coastal shelf. Although exceptional conditions in San Diego have produced impressively large beds that grow vigorously in 110 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 also form in sandy bottom habitats (if sufficient attachment points such as large worm tubes are present) in regions protected from direct swells as seen along portions of the Santa Barbara coastline. A brown alga, giant kelp, like plants, requires light energy for photosynthesis and, therefore, light availability at depth is an important factor to kelp growth.

Giant kelp beds are susceptible to a host of challenges to survive and long-term studies have shown that the kelp beds tend to be cyclical in nature (Hodder and Mel 1978, Neushul 1981, North 1983, North and Jones 1991, Jahn et al. 1998, Dayton et al. 1999, and North and MBC 2001). Giant kelp has a complex reproductive life cycle which requires favorable growth factors to be optimal for a span of months during the process. In order to reproduce giant kelp undergoes a heteromorphic alternation of generations, meaning the second generation offspring spores are microscopic and do not resemble the parent, whereas their progeny (the third generation offspring) resemble the grandparents (adult giant kelp). The stage of giant kelp that is most familiar is the adult canopy-forming 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 very short distance from the parent sporophyte. Within three weeks, the zoospores mature into microscopic male and female gametophytes. These gametophytes release sperm and eggs into the water column where fertilization occurs. The life cycle is completed when a fertilized egg settles on suitable substrate and develops into a new sporophyte or juvenile giant kelp (Figure 2). However, as mentioned, successful completion of the life cycle relies on the persistence of favorable conditions throughout the process.

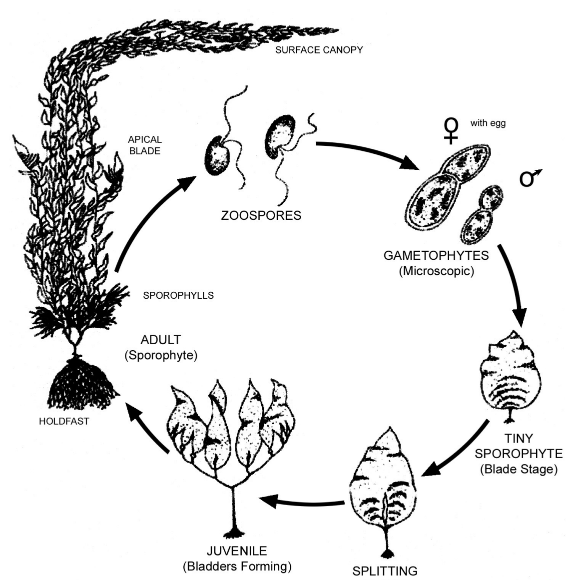

Figure 2. Kelp life cycle.

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.

ENVIRONMENTAL DETERMINANTS OF KELP GROWTH

Giant kelp bed size and health is known to be highly variable but there was a downward trend from the inception of surveying in 1911 to 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 10,360 ha (103.6 km^2) (Tarpley and Glantz 1992), a 25% reduction from that reported by Crandall (138 km^2) in 1911 (from Neushul 1981). Measurements that Crandall took of the Region Nine kelp beds in 1911 indicated that total coverage was about 44 km^2; this total decreased to about 20 km^2 by 1934, to 16 km^2 in 1941, increased to almost 17 km^2 in 1955, but was down to 4.5 km^2 by 1967. The kelp beds did not again attain the coverage recorded in 1955 until more than 40 years later in 1989. 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 (referring 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. Primarily kelp needs adequate light conditions to photosynthesize, and the amount of light available can be affected by physical and biological factors. Prolonged conditions of turbidity resulting from terrestrial run-off, especially during lengthy rainstorms, can reduce kelp growth. Phytoplankton blooms are typical in the spring and fall due to upwelling of nutrients into the inshore waters, but blooms of phytoplankton can also sufficiently occlude 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; fortunately phytoplankton blooms since have had no lasting effect on the kelp beds through 2010.

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). 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 (from the rain of dying organisms in surface 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. 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). 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. 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℃ (64℉) generally indicate waters with very low nutrient content. With roughly each one degree centigrade temperature drop (1.9℉), the availability of nitrates essentially doubles. Therefore, at a temperature of 12℃ (54℉), 14 times more nutrients are theoretically available than at 16-17℃ (62-64℉).

Storms. Many other physical factors can sometimes impart greater regional influence. For example, 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 to the kelp; large swells increase the severity of this motion increasing the drag force on the kelp and can break fronds or even dislodge an entire giant kelp. As these accumulate, there is an increasing drag force on each neighbor causing them to be ripped free of their attachment to the bottom. The resultant mass of entangled, loose giant kelp can drift through a kelp bed ripping out 100s or 1,000s of giant kelp that wash ashore or become a floating kelp paddy offshore. Large storms with catastrophic wave energies, noted in 1983 and 1988, and at the beginning of winter 2005-2006, devastated the kelp beds. There is an apparent increasing frequency of El Niños (Boersma 1998) or of a general thermal regime shift (Fiedler 2002). The ramifications of more intense and more frequent El Niño conditions include a potential increase in the frequency of damaging storms that can take out whole kelp beds. Conversely, storms may clear reefs of competing species, sweep sediments from underlying bedrock, and can be a factor in the expansion of a bed by opening habitat not previously available for colonization by giant kelp. 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 causing sediment-laced surge to abrade the multi-layered invertebrate coverage and expose bed rock for spore colonization (Appendix B).

Of primary concern are storms that produce swell heights that exceed 4 m. In the shallow nearshore zone where waves are influenced by the sea bottom, the resulting motion becomes increasingly more horizontal as waves approach the shore. Large swells increase the severity of this motion with greater drag force on the kelp, which results in breakage of fronds or even dislodging an entire adult giant kelp (Dayton and Tegner 1984, Ebeling et al. 1985, Seymour et al. 1989). Wave heights were recorded at four wave sensing buoys (Scripps Coastal Data Information Program - CDIP) situated from San Pedro to Point Loma South (offshore Imperial Beach), in the Region Nine study area. Wave heights of over 4 m were recorded at San Pedro (CDIP Station 092) on two separate occasions, one (4.35-m height) in late January and another in late December at slightly over 4 m (Figure 3). On five other occasions at the San Pedro buoy in 2010, wave heights were at or exceeded 3 m (four of them at 3.5, 3.8, 3.75, and 3.7-m heights) from late January to mid-May. Wave heights at Dana Point (CDIP Station 096) were between 3 and 4 m on five separate occasions in 2010: late January (3.5 and 3.7 m), late February (3.2 m), and late December 2010 (3.0 and 3.1 m) (Figure 4). At the Oceanside buoy (CDIP Station 045) waves over 3 m in height were recorded in the same time period as found at Dana Point. Wave heights did not exceed 4 m at Oceanside, but were at or exceeded 3 m on four separate occasions in 2010: the first two in late January (3.7 m and 3.45 m), in late February (3.4 m), and then once in late December at 3.6 m (Figure 5). The Point Loma South station (CDIP Station 191), recorded two events over 4 m: 4.2-m high in late January, and 4.2-m high in late December 2010 (Figure 6). On eight other occasions, swell heights met or exceeded 3.0 m: once in late January (3.5 m), twice in late February (3.75 and 3.8 m), twice in mid-to-late

April (3.2 and 3.7 m), late May at 3.3-m high, and 3.0-m high in late December (Figure 6). Several of the wave events could have caused considerable damage to the kelp beds as several events approached or surpassed the 4 m in height, especially early in the year at Imperial Beach kelp bed, which is on cobble bottom that is especially prone to damage from large swell events. The almost total loss of the Imperial Beach kelp bed may have been the result of these very strong wave regimes recorded from the Point Loma South Buoy (offshore of Imperial Beach kelp bed).

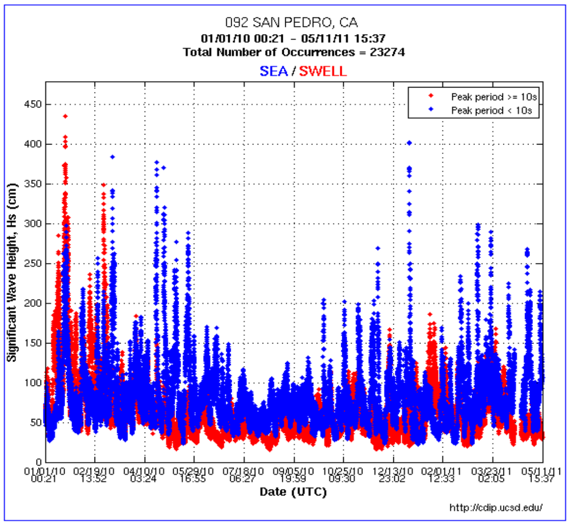

Figure 3. Significant wave heights offshore San Pedro, CA. 1 January 2010 through 11 May 2011.

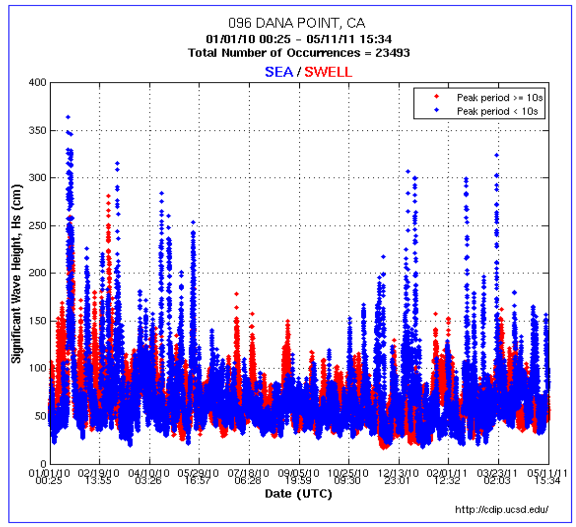

Figure 4. Significant wave heights offshore Dana Point, CA. 1 January 2010 through 11 May 2011.

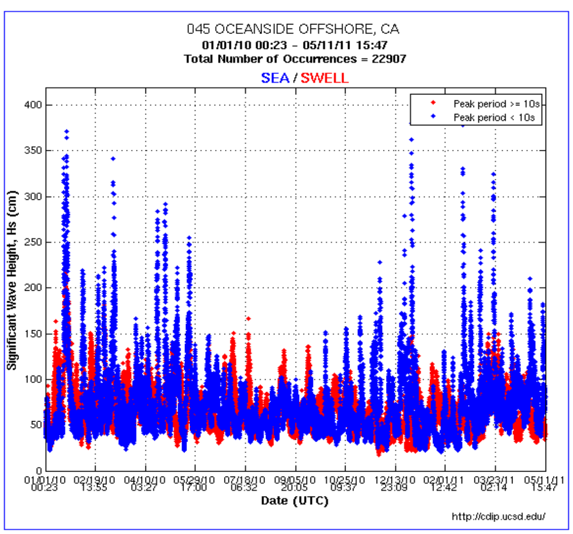

Figure 5. Significant wave heights offshore Oceanside, CA. 1 January 2010 through 11 May 2011.

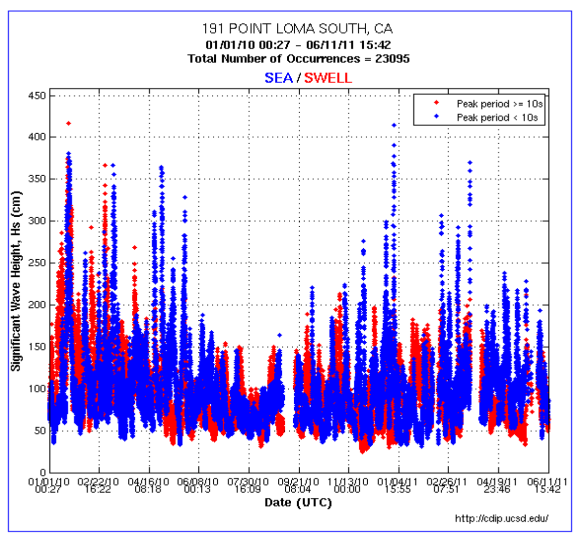

Figure 6. Significant wave heights offshore Point Loma South, CA. 1 January 2010 through 11 June 2011.

Grazing. Kelp herbivores can affect kelp beds; therefore monitoring their status or the status of their predators can be important in determining checks on kelp growth. 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 wholesale loss of kelp beds at San Mateo Point, Palos Verdes, Imperial Beach, and large effects on many other kelp beds (North and Jones 1991). Grazing effects were apparent in late December 2010 at the Imperial Beach kelp bed where numerous old holdfasts infested with purple urchins were observed during a dive survey to ascertain the condition of the kelp bed.

Anthropogenic Effects. Large-scale oceanographic cycles such as the El Niño Southern Oscillation (ENSO) events are monitored closely, and 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 coverage 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 Point Loma (in the mid-1990s) and Palos Verdes (SWQCB 1964, North 1968, Meistrell and Montagne 1983). It appears the cause of the loss of kelp at the Point Loma outfall was not the sewage, but probably the accompanying turbidity (North 2001). Other anthropogenic effects have included unchecked runoff from a coastal construction project of Interstate 5 at Barn Kelp in the late-1960s, which resulted in the loss of that bed for several years (North and MBC 2001); unfamiliarity with the ecological consequences of fisheries within kelp forests also contributed to predator-prey inequalities (Tegner and Dayton 2000). Another example includes the loss of beds offshore of Salt Creek in the late-1970s from construction activities. Historically, these anthropogenic losses would also include the loss of the Horseshoe Kelp bed offshore of San Pedro Harbor in the late-1930s. This loss 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 Huntington Flats kelp bed disappeared in the early-1930s probably as a result of the construction of the Anaheim Bay, Alamitos Bay, and the Long Beach breakwaters.

Sediment Regime. Changes in oceanographic sediment regimes contributed to the disappearance of several kelp beds since the 1911 Crandall surveys. Large kelp beds existed offshore of 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 sand inundation or possibly because the kelp beds were attached to sandy bottoms, and once eliminated, had difficulties recovering. Biologist subtidal observations on the seafloor of the historically established kelp beds at Sunset Beach, Crystal Cove, San Onofre, Santa Margarita, and the Mexican Border indicate that no suitable hard substrate is found on bottom for the re-establishment of these kelp beds (Curtis 2010, pers. obs.). Sub-bottom profiling at several of these locations has revealed that hard substrate is buried by as much as one meter of sand at Crystal Cove, San Onofre, and in the Barn Kelp area (Elwani 2007, pers. comm.).

ENSOs. Dramatic shifts in kelp abundance and density can occur over seasons, years, and between locations (Hodder and Mel 1978, Neushul 1981, North 1983, Jahn et al. 1998, Dayton et al. 1999). Some aspects of these shifts are readily apparent, such as the loss of kelp during El Niño conditions, when warmer-than-average temperatures accompany a reduction in available nutrients in the upper water column, 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. 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 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). While ENSO events can elicit global effects, a given event may not necessarily produce local effects (Tsonis et al. 2005). 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. As ENSOs have been recurring events presumably for thousand 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. 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 1950 (Figure 7). A glance at 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 in the entire time period, whereas the previous 27 years were characterized by mostly cold water events (Figure 7). A close look at the model makes it obvious that warm periods (and presumably a lack of nutrients) have predominated since the early 1970s, whereas cold water periods appeared to be much more prevalent before about 1977. To further exacerbate the normal cyclical nature of the kelp beds off southern California, recovery time from the various El Niños increased during this last warm water period. No definitive explanation yet exists for this, though more frequent storm damage or unusually persistent, low-nutrient conditions may be possible causes. Prior to 1980, a few years appeared to suffice to initiate a recovery of kelp affected by a major event. Since 1980, recoveries have been short-lived, probably due to the pace of the recurring El Niños, low nutrients, and storm damage. As depicted, it is clear that most of 2009 was a warm water period (an El Niño); however, as Tsonis et al. (2005) 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 2010 than in 2009.

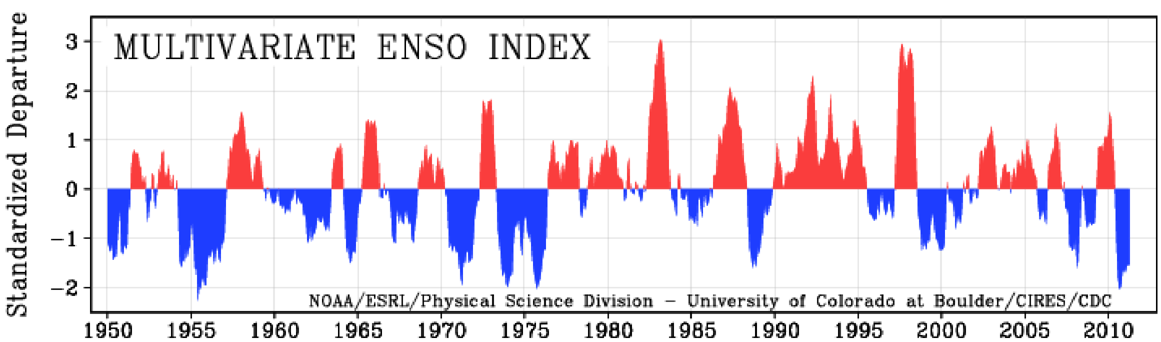

Figure 7. Multivariate ENSO Index from 1950 to 2010.

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. However, there are also more wide-ranging, longer period cycles than ENSOs that are little understood, but which may have profound impacts on the kelp beds of southern California such as the Pacific Decadal Oscillation (PDO) and the Inter Decadal Oscillation (IDO), which 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). As these effects dissipate, it was assumed (previously) that conditions become more or less normal; however, more detailed analysis (with the advantage of hindsight) reveals that the marine ecosystem has been fundamentally changed in a way that could portend serious consequences for the sustainability of the kelp bed resources. These far-reaching changes are usually decades in length and can have profound effects on the local marine communities, including large changes in abundance and biodiversity (Bakun 2004, Noakes and Beamish 2009).

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 indicates 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. Prior to this period of replete conditions, El Niño and La Niña events had much less of a profound effect on kelp beds compared to those in the following period of depleted nutrients that detrimentally affected the kelp beds in the latter part of the 20th century (Parnell et al. 2010). This has resulted in a nutrient deficient regime with pulses of nutrients to sustain the beds only available during the rebound effects from ENSO events and generally weak spring and fall upwelling events. These regime shifts can come in the form of a gradual drift, smooth oscillations, or steplike changes as noted in the 1976-1977 climate-regime shift and the later 1988-1989 shift (Miller and Schneider 2000). As noted previously these shifts are not necessarily reversals of earlier shifts, but can instead be orthogonal (sideways or disconnected with previous) shifts affecting various species differently, meaning species that may have disappeared during a previous shift, may not reappear, or species that appear during a new shift may be different that those lost during the previous shift.

Since it appears that El Niño and La Niña periods currently continue to be the prime force controlling kelp bed canopy size (at least until a regime shift to a more nutrient replete environment which may take years for us to realize it has occurred) our dependence on the temperature/nutrient relationship will probably continue to provide a basis for predicting or at least understanding controlling influences on kelp beds. In that vein, from Figure 7 it can be determined that a warm-water period occurred in 2009. Prior to this, a cooler water period (a La Niña) beginning in about 2007 resulted in very good kelp productivity by 2008 which extended into early 2009. In 2007, a brief warm period did not have the same deleterious effect noted in 2005-2006 as upwelling and nutrients appeared to return in the fall and winter of 2008 resulting in positive gains for the year overall. The El Niño and La Niña periods are large scale events, however, and a given event may not necessarily produce local effects. Therefore, in certain years that are designated El Niño years, there may not necessarily be locally poor kelp growth for the year. Many other physical factors can sometimes impart greater regional influence. All of these variables influence kelp beds and therefore are important factors to monitor in estimating the relative health of the beds.

PREDICTING POTENTIAL GROWTH

As previously discussed, sea surface temperature (SST) is a useful surrogate for nutrient availability; while there appears to be convincing evidence that seawater density can also be used as a surrogate, and to predict nutrient availability (possibly better than temperature), long-term measurements on smaller scales than the SCB are not readily available. Temperature measurements in the marine environment, however, have been ongoing for decades in many areas along the coast at temperature sensing stations resulting in a readily available resource that can be an indicator of nutrient availability. At the sampling locations, automated samplers measure conductivity, temperature, and fluorometry every one to four minutes. These data are made available in real time via the Southern California Coastal Ocean Observation System (SCCOOS) website (www.sccoos.org). The average early morning SST for each 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, Gerard 1982). The value for each month is summed (12 monthly values) for the indexed year (July 1 to June 30) (Table 1). For example, a month with an average temperature of 14.5°C has a nutrient quotient (NQ) value of 4 while a temperature of 12.5°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 when nutrients were replete or when depleted to establish possible temporal trends.

Table 1. The kelp nutritional index of each month is based on weighting values given to Sea Surface Temperature (SST) data compiled monthly and derived from data from: Scripps Institution of Oceanography (SIO) Pier, Newport Pier (NP), San Clemente Pier (SCP), Point Loma South (PLS), and historic data from Kerckhoff Marine Laboratory (KML). These data are shown in part to better define the temperature regime of the region. 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 30 June. Years in Red denote warm-water years, Blue cold-water years, based on NOAA Multivariate ENSO Index (MEI), June 2011.

	Number of months falling into indicated temperature range					SIO	NP	PLS	KML	SCP
Weighting Factor	*14*	*8*	*4*	*2*	*1*	Season	Season	Season	Season	Season
Season	12.01-13.0℃	13.01-14.0℃	14.01-15.0℃	15.01-16.0℃	16.01-17.0℃	NQ	NQ	NQ	NQ	NQ
	NP (SIO)	NP (SIO)	NP (SIO)	NP (SIO)	NP (SIO)					
2010-2011	-(-)	2(-)	3(4)	3(-)	1(1)	17	35	20	NA	19
2009-2010	-(-)	-(-)	3(-)	3(4)	1(1)	9	19	11	NA	11
2008-2009	-(-)	-(-)	4(2)	2(2)	3(1)	11	23	15	NA	NA
2007-2008	-(-)	2(1)	3(2)	-(1)	1(3)	21	29	NA	NA	NA
2006-2007	-(-)	-(-)	5(2)	1(2)	1(-)	12	18	NA	23	NA
2005-2006	-(-)	1(-)	3(1)	1(4)	2(-)	12	22	NA	24	NA
2004-2005	-(-)	-(-)	2(-)	2(3)	1(2)	8	11	NA	13	NA
2003-2004	-(-)	-(-)	2(2)	2(2)	2(-)	12	14	NA	14	NA
2002-2003	-(-)	1(-)	2(-)	3(4)	1(3)	11	24	NA	23	NA
2001-2002	-(-)	-(1)	4(3)	1(1)	1(2)	24	27	NA	19	NA
2000-2001	-(-)	1(1)	1(4)	3(-)	1(1)	25	70	NA	19	NA
1999-2000	-(-)	-(-)	2(3)	3(2)	2(4)	20	51	NA	16	NA
1998-1999	-(-)	1(3)	4(2)	-(1)	3(2)	36	64	NA	27	NA
1997-1998	-(-)	-(-)	-(-)	-(-)	3(2)	4	11	NA	3	NA
1996-1997	-(-)	1(-)	-(2)	-(2)	1(1)	13	34	NA	9	NA
1995-1996	-(-)	-(-)	2(3)	1(1)	1(-)	15	32	NA	11	NA
1994-1995	-(-)	-(-)	2(2)	1(4)	3(-)	16	38	NA	13	NA
1993-1994	-(-)	-(-)	1(1)	2(3)	2(2)	12	10	NA	10	NA
1992-1993	-(-)	-(-)	-(-)	3(3)	1(2)	8	9	NA	7	NA
1991-1992	-(-)	-(-)	2(2)	1(1)	3(2)	12	16	NA	13	NA
1990-1991	-(-)	-(-)	2(2)	3(2)	1(-)	16	23	NA	13	NA
1989-1990	-(-)	1(1)	2(1)	1(3)	1(-)	15	21	NA	19	NA
1988-1989	1(-)	2(2)	1(2)	1(1)	-(1)	27	39	NA	36	NA
1987-1988	-(-)	1(-)	2(2)	1(1)	1(1)	11	21	NA	19	NA
1986-1987	-(-)	(-)	2(-)	1(3)	1(2)	8	11	NA	11	NA
1985-1986	-(-)	-(-)	2(-)	2(2)	2(3)	7	20	NA	14	NA
1984-1985	-(-)	3(-)	1(2)	1(3)	1(-)	14	35	NA	31	NA
1983-1984	-	-	1	3	2	ND	10	NA	12	NA
1982-1983	-	-	-	4	2	ND	12	NA	10	NA
1981-1982	-	1	3	1	1	ND	40	NA	23	NA
1980-1981	-	-	3	2	2	ND	23	NA	18	NA
1979-1980	-	-	2	3	1	ND	24	NA	15	NA
1978-1979	-	2	2	1	1	ND	40	NA	27	NA
1977-1978	-	-	-	2	3	ND	7	NA	7	NA
1976-1977	-	1	-	2	1	ND	17	NA	14	NA
1975-1976	-	2	4	-	-	ND	50	NA	32	NA
1974-1975	-	5	1	1	1	ND	41	NA	45	NA
1973-1974	-	3	1	1	1	ND	52	NA	31	NA
1972-1973	-	-	2	4	2	ND	19	NA	18	NA
1971-1972	2	1	3	-	-	ND	49	NA	48	NA
1970-1971	2	1	2	1	1	ND	52	NA	47	NA
1969-1970	-	2	-	3	2	ND	23	NA	24	NA
1968-1969	-	1	4	-	2	ND	29	NA	26	NA
1967-1968	-	-	3	2	2	ND	24	NA	18	NA
ND = no data				Average Since 1967		15.2	29.5	15.3	20.1	15.0
- = 0					Since 1977	14.7	26.0	15.3	16.6	15.0
					1967-1976	NA	35.6	NA	30.3	NA

At times a rather large disparity is seen between nutrient quotients across the region. This is, in part, due to variability in local oceanographic regimes between the beds at the northern end of Region Nine offshore of Newport Beach and those at the southern end to the Mexican Border. This variability is driven by prevailing flow characteristics and bathymetric features which probably result in periodic upwelling from submarine canyons offshore of Newport, La Jolla, and along the rocky shores of the coastline, particularly where Dana Point, San Mateo, and Point Loma all jut offshore (which may result in upwelling in the local region and allows large kelp beds to form and flourish during good years and allows kelp to grow to depths of 100 ft at Point Loma). Superimposition of the four temperature stations indicate that the same oceanographic impulses were present at each, but the degree of their effects were muted or exaggerated at the individual stations indicating the variability in nutrient availability over a relatively small portion of the coastline (Figure 8). To capture these nutrient pulses, the four temperature stations are situated (in the northern end of the region) at the end of the Newport Pier (Figure 9) and at San Clemente Pier (Figure 10), while the southern portion of the range is represented by SST stations at the end of the Scripps Pier (Figure 11) and offshore of Imperial Beach. The San Clemente Pier location was added in 2008 to determine potential influences of upwelling at San Mateo Point and because SSTs have been collected there for the past 54 years; the Point Loma South station (Figure 12) was added in 2010 to capture nutrient conditions at Point Loma to Imperial Beach. To illustrate the variability observed regionally, SST sampling stations, situated at opposite ends of the region, had nutrient quotients of 27 at Newport Pier and 11 at Scripps Pier for the 2010 calendar year, while temperatures for the nutrient year (which began in July 2010 and continues through June 2011) suggested slightly better nutrient conditions with an NQ of 35 at Newport Pier and 17 at SIO (through April and May of 2011). Both of these measures indicate that nutrients were potentially greater in the northern beds during this period. Annual values were

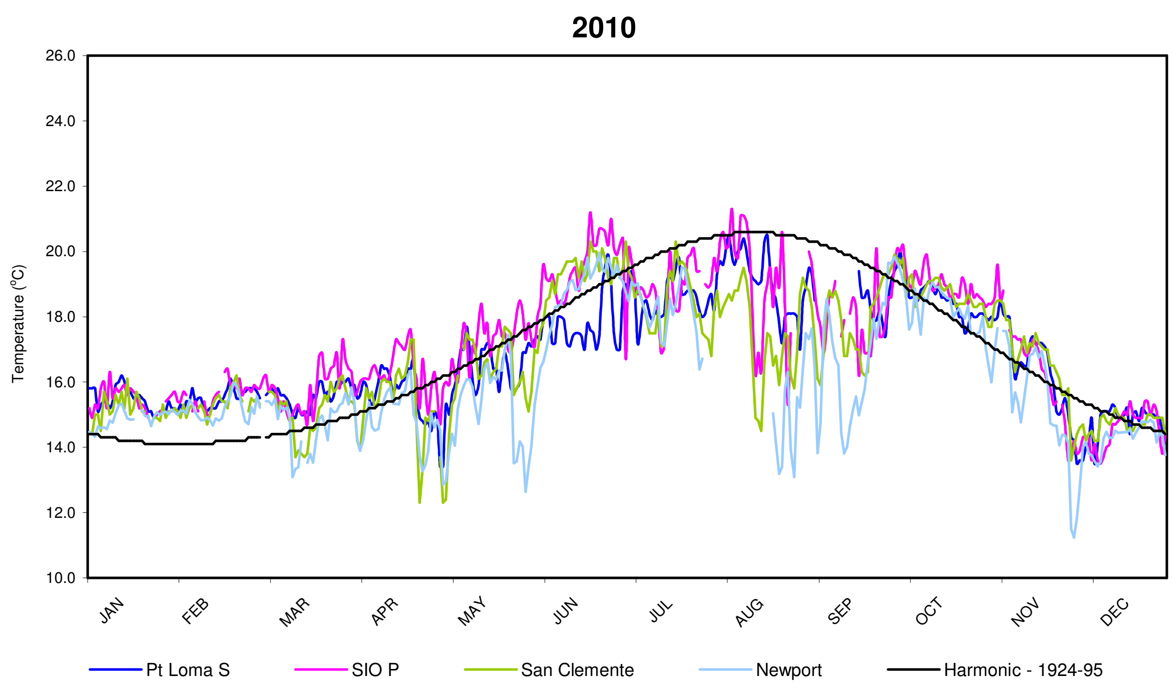

Figure 8. Daily sea surface temperatures (SST) from four Region Nine monitoring locations superimposed on the SIO harmonic equation.

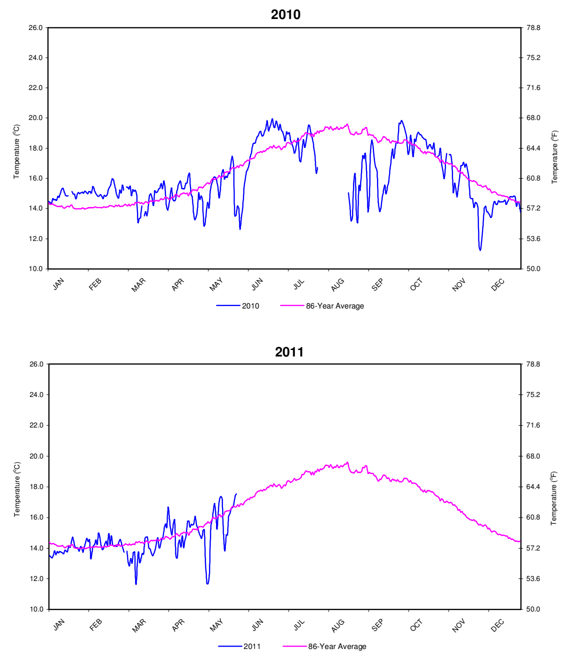

Figure 9. Daily sea surface temperatures (SST) from Newport Pier for 2010 and through 15 May 2011.

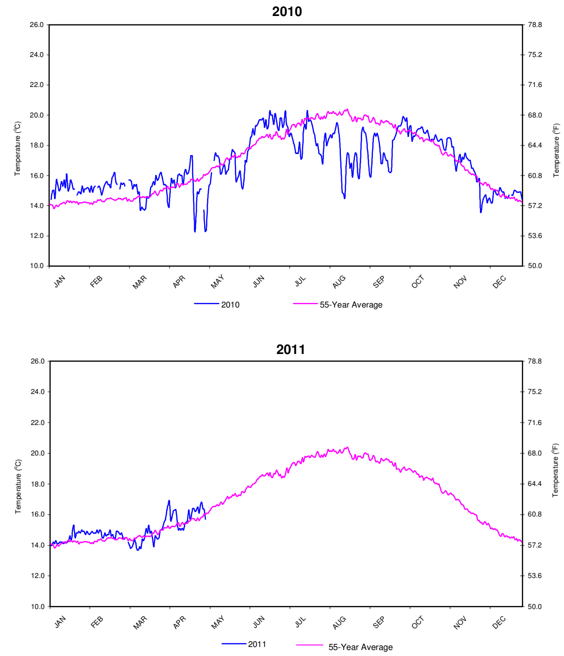

Figure 10. Daily sea surface temperatures (SST) from San Clemente Pier for 2010 and through April 2011.

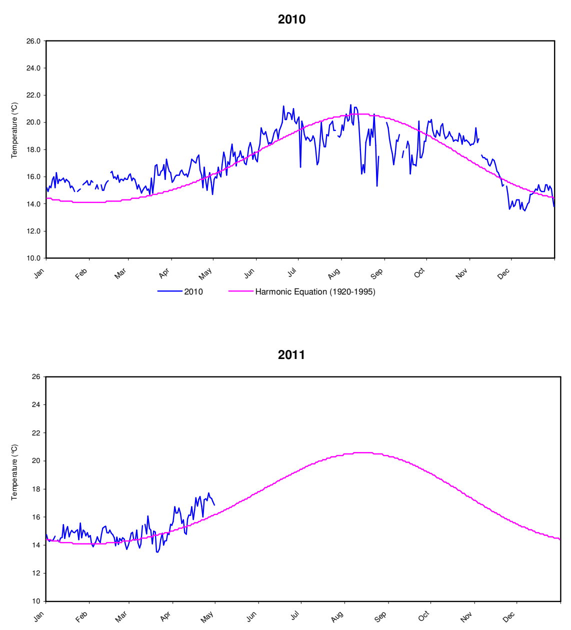

Figure 11. Daily sea surface temperatures (SST) from Scripps Institution of Oceanography Pier for 2010 and through May 2011.

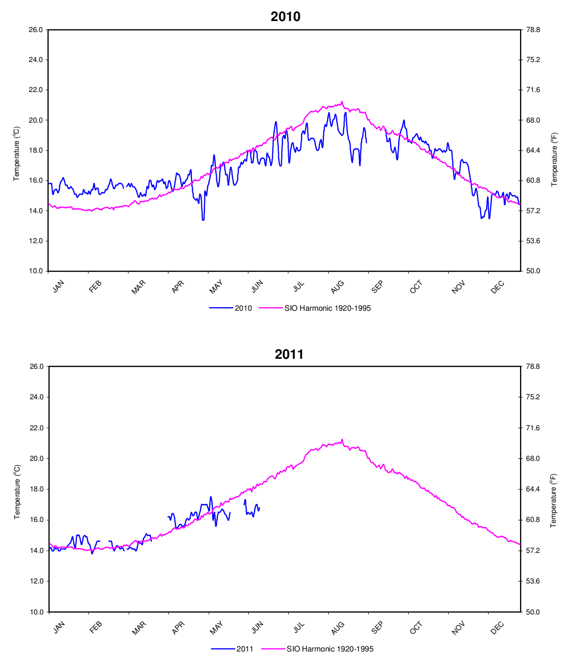

Figure 12. Daily sea surface temperatures (SST) from Point Loma South for 2010 and through 11 June 2011.

well above 25 until about 1977, averaging 30.3 at Kerckhoff Marine Laboratory in Newport Harbor from 1967 to 1977, but only about 16.8 after (Table 1). At Newport Pier, annual NQ values were 35.6 pre-1977 and 26.0 after. At Scripps Pier, the NQ value (starting in 1984) has averaged 15.2, indicating that the beds have had below average nutrient availability during the period. Values above 25 indicate average or above average nutrients available to sustain growth. The lower-than-25 average NQ values over the past 34 years at Newport (27 years at Scripps and 30 years at Kerckhoff) support the observation (from the data) that much of the time nutrients are depleted in southern California and the kelp beds are stressed and must rely on above-average years to propagate effectively.

The nutrient quotient index, whether large or small, represents fairly closely the relationship of temperature to kelp canopy. A good example is the 1997-1998 year when NQs indicated a particularly bad year for giant kelp beds and a total canopy coverage of only 0.547 km^2 was recorded in Region Nine. In this example, seasonal NQ value was 4 at Scripps Pier, 3 at Kerckhoff, and 11 off Newport Beach. In contrast, is the 1988-1989 (a year in which many kelp beds reached their maximum extent in several decades totaling 16.868 km^2) the same beds had nutrient quotient values of 27, 36, and 39, respectively (Table 1). Kelp growth during 2001 was also good following a strong La Niña from 1999 to 2001, however the particularly high index values seen off the Newport Pier from 1999-2001 may reflect strong, localized upwelling events that did not occur on a region-wide scale. Offshore of the Newport Pier in the 2004-2005 season, the nutrient quotient was 11, while at Kerckhoff Marine Laboratory it was 13, and at Scripps Pier it was 8, suggesting very poor availability of nutrients in the entire Region Nine; kelp canopies became much reduced in 2005 and were in full retreat by 2006. By the 2007-2008 season, nutrient availability was higher than average in both areas: 29 in the Newport Beach area and 21 in the vicinity of Scripps Pier. Nutrients fueled a strong recovery in kelp canopy by the end of 2007 and, although nutrients did not appear to be especially abundant in 2008, by December 2008 kelp canopies were larger than they had been in decades, surpassing the kelp canopy coverage of 1989-1990.

As can be seen in the overlay (Figure 8) and the individual SST graphs, none of the beds had particularly good nutrient availability in the first three months of 2010 and by the late March 2010 aerial survey, 15 of the beds from Capistrano Beach to Imperial Beach had decreased considerably from that observed in March and June of 2009 when Region Nine kelp beds were greatest in extent for the year. By August 2010, canopies had mostly increased (responding to cooler waters through May and a mild summer), but the increases and some decreases were not large during that survey, with the exception of the La Jolla and Point Loma kelp beds which recorded their greatest canopy coverage at that time. The November 2010 survey showed most of the beds in the southern portion increasing while most in the northern half decreased, again responding to cool temperatures in the north, while temperatures in the south were cool for the summer but considerably warmer than those in the north. By the end of the year (December 31), most beds reached their greatest extent for the year, with the La Jolla and Point Loma kelp beds decreasing considerably from the highs in August (this was consistent with a drop in temperature during the last two months giving some of the beds an impetus). The 2010-2011 season suggests that through most of the year nutrients were only adequate for growth in the north with an NQ of 35 recorded at Newport Pier, decreasing quickly to an NQ of 19 at San Clemente Pier, while the SIO and Point Loma stations in the south had NQs of 17 and 20, respectively. The effects of the low and high NQs were reflected in the kelp canopies, with most of the canopies in the north increasing while those in the south typically decreased. A look at the nutrient quotients for the previous year indicated that nutrients were very poor from May through December of 2009 which resulted in large decreases in canopy size as nutrients became limiting after the peaks of either the March or June 2009 survey. The large reductions of canopies by the December 2009 survey masks a very healthy rebound throughout 2010 (which did not quite match the run up to the large canopies noted in early 2009).

Although the fall and winter are typically treated as a unit (hence 2010-2011 NQ values), when examining the SSTs for the 2010 year only (NQ=27 at Newport Pier), we can see that nutrients at Newport were available most of the year with the exception of June, July, and October. Superimposing these temperature patterns (Figure 8), it can be seen that near Scripps nutrients were probably only available in the early (through mid-April) and late (November into December) portions of the year (Figure 11), while at San Clemente Pier the water was cooler indicating nutrients were probably greater through April, but did not reappear in any significant amount again until mid-November (Figure 9). At Newport Beach the SST pattern mirrored that of San Clemente with temperatures very similar, but numerous upwelling periods were noted during August and September, with nutrients again becoming widely available in mid-November (Figure 10). This pattern resulted in the largest canopies generally being recorded in the December 2010 aerial surveys.

KELP BED SUMMARY 1911 - 1982

In 1911, a mapping expedition of most of the Pacific coast canopy-forming kelps was conducted to determine the amount of potash (an essential ingredient in explosives at the time) potentially available from the kelp. Crandall's kelp mapping cruise was conducted in 1911 using row boats, compass, and sextants to triangulate positions. Using this methodology, most of the kelp beds in the Region Nine Consortium's area were mapped (Appendix B). There have been some marked changes in the size of the beds since Crandall's measurements. These changes for some beds were so large (and typically downward), that some later researchers assumed that Crandall's measurements of canopy size were widely inaccurate. North in 1964 (SWQCB 1964) re-measured Crandall's Palos Verdes charts and found the 2.53 nautical miles square (1.0 naut. mi^2 = 3.43 km^2) Crandall reported, to be very similar to his measurement of 2.42 naut. mi^2 (which did not include most of Malaga Cove). Neushul (1981) also assumed there was a scaling error and re-measured the maps producing a total about 10% less than what Crandall measured. Although there are probably gaps and holes in the kelp beds that Crandall could not measure (that we readily see in aerial photos), the actual dimensions of the beds (but not area) that Crandall reported were probably relatively accurate as the areal survey extent and configuration reported have been confirmed on earlier charts (Neushul 1981). Some of these beds have since grown to the sizes noted in Crandall's time confirming that the physical dimensions of the beds he reported were probable, suggesting that the ability to accurately measure the beds on the charts was similar to that available to North and Neushul. Another factor that favors using the areal extent that Crandall measured is that fishing boat captains he interviewed reported that the beds were in fairly poor condition at the time of his survey from that noted in previous years. To add further credibility to this premise, Imperial Beach kelp bed measured 0.984 km^2 in 1911, and up until the end of the Twentieth Century was never larger than about 0.727 km^2 (occurring in 1987), seemingly confirming suspicions that Crandall's measurements were not accurate. However, in 2007 and 2008, Imperial Beach kelp bed grew much larger than what Crandall measured, lending credence to Crandall's statement that beds were in poor condition compared to earlier years. It therefore follows that the Point Loma and La Jolla beds of the early-1900s were probably much larger than they are today. Crandall's original maps were re-measured electronically to a much greater accuracy available to Crandall or Neushul (1981) or Hodder and Mel (1978) and found to agree in many areas, but disagree strongly in some. These measurements appear to indicate that most of the beds were much larger in the past than has been seen during the past half century. Point Loma Kelp was three times larger in 1911 than it has been during the last three decades. Our measurements of Crandall's maps have been incorporated in the historical table presented herein as a baseline for all subsequent surveys from 1911 to 1982 (Table 2).

KELP BED SUMMARY 1983 - 2010

The Consortium's monitoring began in the midst of the El Niño of 1982-1984 with only 11 of the 25 monitored sites displaying canopy in 1983. A high was reached in 1991 with all 25 beds (two in Laguna Beach and the three beds for Leucadia) displaying canopy (due to its ephemeral existence, Torrey Pines is not one of the regularly monitored beds) and a low in 1998 during the 1997-1998 El Niño with only eight kelp beds displaying canopy at some point during the year. Total kelp canopy coverage for the region was at its lowest in 1984 with less than 0.5 km^2 and at its highest in 2008 when kelp canopy coverage was almost 19 km^2; the average canopy coverage across the region was about 6.6 km^2 during this period (North and Jones 1991, North and MBC 2001, and MBC 2002-2010a).

Table 2. Historical canopy coverages in km² of San Diego and Orange County kelp beds from 1911 to 1989 surveys. Values represent approximately the maximum coverages for each year. Areal estimates from 1967 on were derived from charts based on infrared aerial photographs. Known cold-water periods are depicted in Blue and warm-water periods in Red.

	Canopy Area (km²)																
Kelp Bed	1911	1934	1941	1955*	1959*	1963*	1967	1970	1975	1980	1983	1984	1985	1986	1987	1988	1989
Corona del Mar	0.580	ND	ND	ND	ND	ND	0.086	0.180	0.160	0.150	0.031	0.006	-	-	-	0.007	0.010
North Laguna Beach	Tr	ND	ND	0.680	0.160	ND	0.001	0.011	0.003	0.036	0.035	0.025	0.028	0.022	0.028	0.042	0.055
South Laguna Beach	Tr	ND	ND	ND	ND	ND	0.001	0.011	0.003	0.036	0.040	0.028	0.077	0.041	0.087	0.145	0.264
South Laguna	Tr	ND	ND	2.020	0.180	0.020	-	0.014	0.008	-	0.004	-	-	-	-	0.023	0.041
Dana Point-Salt Creek	1.871	ND	ND	p	p	p	0.240	0.077	0.096	0.008	0.013	0.007	0.036	0.031	0.174	0.568	0.878
Capistrano Beach	1.153	ND	ND	p	p	p	0.080	0.050	0.070	0.020	-	-	-	-	-	0.032	0.233
San Clemente	1.390	ND	ND	6.310	3.710	0.010	0.080	0.050	0.070	0.020	-	-	-	-	0.017	0.124	0.444
San Mateo Point	1.272	ND	ND	p	p	p	-	0.057	0.140	0.360	0.163	0.045	0.152	0.077	0.200	0.432	0.870
San Onofre	1.946	ND	ND	p	p	p	-	-	0.300	0.160	0.102	0.031	0.042	0.053	0.045	0.348	0.638
Horno Canyon	0.352	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	0.006	0.033
Barn Kelp	3.171	ND	ND	1.370	ND	0.130	0.017	0.019	0.160	0.056	-	-	-	-	-	0.008	0.116
Santa Margarita	0.710	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	-	-
North Carlsbad	0.767	ND	ND	2.620	2.520	1.180	0.009	0.060	0.100	0.120	-	-	-	-	0.031	0.049	0.096
Agua Hedionda	0.161	ND	ND	p	p	p	-	0.006	0.036	0.019	-	0.001	0.011	0.018	0.021	0.032	0.047
Encina Power Plant	0.642	ND	ND	p	p	p	-	0.025	0.144	0.074	-	0.002	0.024	0.045	0.120	0.161	0.251
Carlsbad State Beach	0.278	ND	ND	p	p	p	0.032	0.120	0.200	0.078	-	-	0.027	0.018	0.077	0.032	0.049
Leucadia	1.224	ND	ND	p	p	p	0.240	0.440	0.500	0.670	0.001	0.002	0.104	0.074	0.426	0.197	0.291
Encinitas	0.367	ND	ND	p	p	p	0.065	0.173	0.153	0.228	-	0.016	0.083	0.032	0.177	0.153	0.209
Cardiff	0.713	ND	ND	0.340	0.400	0.160	0.125	0.337	0.297	0.442	0.018	0.021	0.176	0.120	0.340	0.229	0.575
Solana Beach	1.097	ND	ND	p	p	p	0.290	0.490	0.560	0.690	-	0.001	0.115	0.120	0.367	0.427	0.488
Del Mar	0.540	ND	ND	p	p	p	0.190	0.260	0.190	0.210	-	-	0.008	0.021	0.081	0.063	0.104
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Tr	Tr
La Jolla	6.060	8.161	7.847	1.660	6.490	0.640	0.330	0.290	0.840	1.900	0.032	0.034	0.720	0.930	2.369	2.200	4.755
Point Loma	18.675	11.465	8.286	1.990	0.610	0.240	2.700	4.900	3.000	4.200	0.200	0.160	1.570	2.100	3.682	2.322	5.842
Imperial Beach	0.984	ND	ND	ND	ND	ND	-	-	-	0.350	-	-	0.058	0.150	0.727	0.067	0.579
TOTAL	43.948*	19.626*	16.133*	16.990*	14.070*	2.380*	4.486	7.570	7.030	9.827	0.639	0.379	3.231	3.852	8.969	7.667	16.868

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

Sources: 1934, 1941 from North (1964); 1955, 1959, 1963 from Neushul (1981);
1859 Point Loma 18.675 from SWRCB (1964)

These ENSO oceanographic events and regime shifts result in changes that appear to be magnitudes greater in impact to the regional kelp bed resources can be determined from all but the most egregious cases of anthropogenic effects. The southern California kelp beds have been adversely affected by warm water events and powerful storms during the last two decades. Storms have been very severe with several causing widespread damage to the region's kelp beds. Some of these storms during El Niños produced wave heights exceeding 4 m; these wave events occurred on more than 40 occasions between 1980 and 1998 (NOAA 1999).

However, there have been several cases where turbidity from either sanitation discharges or construction activities have been implicated in the disappearance of kelp beds. A few examples include the loss of kelp beds near the White Point outfall in the 1960s, the loss of beds offshore of Salt Creek in the late-1970s from construction activities (North and Jones 1991), and more recently (in the mid-1990s), the loss of kelp at the Point Loma outfall (possibly related to a broken pipe discharging sewage) (North 2000). During the Point Loma pipe break period, it appears that the cause of the kelp bed decline was not the sewage, but probably the accompanying turbidity (North 2001).

Large scale oceanographic events, however, are likely responsible for the loss of kelp from Newport Beach to South Laguna during most of the decade of the 1990s with warm water prevalent during these years. The shallower beds of the Newport-Irvine coast failed to reappear after the El Niño of 1982-1984 and the deeper beds offshore of Laguna disappeared after the 1992 El Niño. The beds of San Diego County typically extend into deeper waters and, although seriously depleted, were able to survive the El Niño of 1982-1984. Typically, the basal portions of kelp will survive beneath the thermocline and be able to regenerate canopy fairly quickly following the return of nutrient-rich waters, as evidenced by the remarkable recovery of Point Loma and La Jolla kelp beds in 1985.

The decade of the 1990s followed a very large La Niña. The favorable conditions of that La Niña, combined with the impetus provided by the great storm of 1988, resulted in increasing kelp canopy coverage to levels not seen since the 1970s. Most of the following decade was characterized by a string of almost continuous El Niños. These culminated in the 1997-1998 El Niño that was as great (or greater depending on the parameters measured) in its negative impact on the kelp beds as that of the large 1982-1984 El Niño. The adverse effects of this El Niño seriously damaged the remaining kelp beds, resulting in only eight of the Region's 25 kelp beds having canopies by 1998 (Table 3). Of these eight, only Point Loma displayed any canopy by the end of 1998.

The positive effect on the kelp canopies of the La Niña of 1999-2000 was encouraging and it had an appreciable positive impact on the kelp beds in southern California (Veisze et al. 2004). The effect, however, did not proceed at the rapid pace noted during the 1989 La Niña (following the 1988 Great Storm), probably because of other serendipitous factors mentioned earlier. The difference between these two apparently similar events was that the La Niña of 1989 started with 23 canopies totaling 7.7 km^2 of kelp along the coast, whereas at the beginning of the 1999-2000 La Niña (April 16, 1998 survey) only three canopies (Dana Point, La Jolla, and Point Loma), together with less than 0.5 km^2 of kelp canopy, were present (Table 3).

With the advent and impetus provided by the large La Niña of 1999-2000, favorable conditions returned and generally remained through 2002. The La Niña had a very positive effect on the kelp bed resources and nutrients remained high in 2002. Despite the formation of a small El Niño on the equator, at the end of 2003 about one-half of the kelp beds increased and the remainder decreased, resulting in a small net loss of kelp in the region overall from that noted in 2002. The 2003 year was similar to 2002, and its effects on the kelp beds was similar in the amount of kelp present in the range with all but two of the historical beds displaying canopy and the total canopy coverage was about 10.6 km^2. As 2004 began, temperatures were near average in both the north and south when compared to their respective long-term means. Sea surface temperatures (SSTs) became abruptly warmer than average in mid-February in both

Table 3. Canopy coverages in km² of San Diego and Orange County kelp beds from 1989 to 2010 surveys. Values represent approximately the maximum coverages for each year. Areal estimates derived from charts based on infrared aerial photographs. Known cold-water periods are depicted in Blue, warm-water periods in Red, and neutral periods in Green.

	Canopy Area (km^2)																					
Kelp Bed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Newport Coast CDM	0.010	0.001	0.0003	-	-	-	-	-	-	-	-	-	-	<0.001	0.002	0.002	0.0004	0.023	0.054	0.089	0.095	0.161
North Laguna Beach	0.055	0.034	0.029	-	-	-	-	0.001	-	-	-	-	-	-	0.0004	-	-	-	-	0.002	0.005	0.093
South Laguna Beach	0.264	0.243	0.093	0.056	0.028	-	-	-	-	-	-	-	-	0.005	0.0002	0.008	-	-	0.001	0.025	0.058	0.098
South Laguna	0.041	0.023	0.030	0.009	0.006	0.005	-	-	-	-	-	0.003	0.002	<0.001	0.004	0.009	0.003	-	0.004	0.023	0.017	0.023
Dana Point-Salt Creek	0.878	0.329	0.480	0.184	0.234	0.116	0.076	0.061	0.034	0.005	0.080	0.170	0.314	0.432	0.303	0.278	0.123	-	0.302	1.068	0.892	0.839
Capistrano Beach	0.233	0.110	0.134	0.148	0.022	-	-	-	-	-	<0.001	<0.001	0.044	0.118	0.069	0.008	-	0.011	0.002	0.071	0.071	0.124
San Clemente	0.444	0.304	0.243	0.044	0.051	0.010	0.010	0.047	-	-	0.006	0.005	0.124	0.316	0.352	0.182	0.178	0.014	0.016	0.203	0.210	0.710
San Mateo Point	0.870	0.472	0.120	0.103	0.220	0.080	0.010	0.073	0.098	-	0.051	0.050	0.090	0.155	0.242	0.123	0.258	0.016	0.201	0.487	0.545	0.583
San Onofre	0.638	0.763	0.170	0.053	0.163	0.201	0.096	0.196	0.108	<0.001	0.005	0.020	0.041	0.030	0.162	0.109	0.065	-	0.320	0.476	0.419	0.458
Horno Canyon	0.033	0.010	0.018	0.040	-	-	-	-	-	-	-	0.002	0.034	-	0.001	-	-	-	0.015	0.083	0.018	0.081
Barn Kelp	0.116	0.382	0.262	0.124	0.002	0.010	0.172	0.204	0.178	-	0.310	0.375	0.547	0.667	0.492	0.075	0.064	-	0.466	0.858	0.926	0.500
Santa Margarita	-	-	0.049	0.009	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
North Carlsbad	0.096	0.119	0.044	0.004	0.018	0.020	0.008	-	-	0.003	-	-	0.017	0.053	0.017	0.003	0.013	-	0.026	0.108	0.135	0.078
Agua Hedionda	0.047	0.046	0.016	0.004	0.012	0.004	0.008	0.009	-	-	-	-	-	<0.001	0.002	0.001	0.008	-	0.016	0.080	0.092	0.031
Encina Power Plant	0.251	0.179	0.083	0.025	0.022	0.011	0.058	0.032	0.013	-	-	0.002	0.029	0.097	0.178	0.067	0.001	-	0.081	0.306	0.215	0.176
Carlsbad State Beach	0.049	0.081	0.035	0.008	0.002	0.011	0.025	0.013	-	-	-	0.003	0.023	0.047	0.002	0.0001	-	-	0.064	0.121	0.127	0.069
Leucadia	0.291	0.341	0.163	0.084	0.035	0.010	0.189	0.087	0.062	-	0.015	0.090	0.209	0.334	0.185	0.048	0.001	0.016	0.233	0.421	0.429	0.215
Encinitas	0.209	0.241	0.080	0.036	0.037	0.016	0.061	0.023	0.048	-	0.029	0.040	0.131	0.153	0.050	0.016	-	0.002	0.205	0.346	0.205	0.128
Cardiff	0.575	0.468	0.072	0.054	0.034	0.080	0.092	0.026	0.031	0.016	0.063	0.150	0.309	0.405	0.202	0.045	-	0.004	0.286	0.484	0.520	0.213
Solana Beach	0.488	0.466	0.257	0.053	0.023	0.108	0.134	0.003	0.073	0.009	0.091	0.200	0.407	0.488	0.245	0.022	0.093	0.0003	0.457	0.823	0.505	0.328
Del Mar	0.104	0.082	0.097	0.006	0.003	0.029	0.082	-	*Tr	0.004	-	0.006	0.015	0.035	0.030	-	-	-	0.037	0.057	0.044	0.038
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.001	0.0004	0.003
La Jolla	4.755	3.632	3.230	1.301	0.681	1.119	0.824	0.371	0.478	0.215	1.146	1.250	2.555	3.366	3.444	1.029	0.873	0.117	2.750	4.145	2.274	2.776
Point Loma	5.842	5.943	4.310	1.153	1.917	3.589	1.134	1.187	2.235	0.295	1.725	3.290	6.574	3.799	4.509	1.924	2.152	1.767	3.616	6.623	4.909	3.977
Imperial Beach	0.579	0.651	0.370	0.111	0.025	0.108	0.053	0.008	0.027	-	0.019	0.020	0.078	0.210	0.083	0.191	0.400	0.400	1.493	1.895	0.861	0.004
TOTAL	16.868	14.920	10.385	3.609	3.535	5.527	3.032	2.341	3.385	0.547	3.540	5.676	11.542	10.710	10.573	4.137	4.233	2.371	10.644	18.795	13.571	11.706

NOTE: "-" = 0; Trace = <100 m^2

the north and south and warm water persisted through much of the year, as evidenced by SSTs taken from Scripps at La Jolla and Cal-Tech's Kerckhoff Marine Laboratory in Corona del Mar. Data from these two locations suggested that nutrients were lacking in much of the region for most of 2004 resulting in about a 60% loss of canopy (to about 4.1 km^2) from the more than 10 km^2 recorded in 2002 and 2003.

Although conditions did not improve greatly in 2005 (15 beds), the canopy coverage noted in 2004 was maintained through the end of the year with some losses recorded probably as a result of persistent phytoplankton blooms and severe storm surge. By the 20 April 2006 survey, deterioration in all of the kelp canopies was observed, especially in the area from Salt Creek-Dana Point to La Jolla. Water temperatures were warmer than average from March through December indicating a severe lack of nutrients in the entire region (Table 1). By the June and September overflights, most of the canopies were missing or just a trace of kelp was noted. Overall, conditions in 2006 were poor for kelp with total area of kelp coverage declining by more than 40% from 2005 to about 2.4 km^2 (Table 3). Condition of the kelp beds was much poorer at the end of 2006 with only 11 of the 25 beds displaying canopy at some time during the 2006 survey year. The maximum measured kelp canopy in Region Nine in 2007 increased greatly from the 2.391 km^2 recorded in 2006 to 10.644 km^2. Average temperatures were observed in early 2007, followed by a long, warm summer, and finally a decrease in temperatures in November and December as recorded by the NOAA Climate Diagnostic Center (www.cdc.noaa.gov). The observed increase in kelp growth during 2007 suggests that nutrients were probably available below the thermocline as the canopy recovery from a very poor October aerial survey was significant. Another factor in the increases noted were probably the absence of unusually high turbidity caused by runoff or phytoplankton blooms, and the absence of effects from large swells and breaking waves, which have contributed to losses in the past (especially in 2006). In 2008, aerial surveys suggested the increases in kelp canopies noted in December 2007 appeared to have been maintained, and by June 2008 a few beds from Leucadia to Imperial Beach were slightly larger than noted during the past December survey. However, by the 24 September 2008 overflight, many of the canopies in the southern portion were missing (only 4 of 12 beds between Newport Harbor and North Carlsbad showed canopy, whereas 12 of the 13 beds from Agua Hedionda to Imperial Beach were present). Data from numerous boat trips and diver surveys confirmed that in spite of the loss of most of the surface canopy, kelp was surviving below the thermocline. The seemingly poorer nutrient conditions in the middle-to-late part of the year in both the north and south resulted in serious deterioration of many of the kelp canopies, but temperatures became cooler by year's end and resulted in a marked recovery (Table 1). Good nutrient conditions in 2007 promoted favorable kelp growth in 2008, with total area of kelp coverage increasing to more (18.795 km^2) recorded in the 70 years since 1941. From the highs of 2008, kelp retreated during a warm 2009 with the maximum canopies observed in March or June (totaling a very large 13.571 km^2), but becoming much less thereafter. Canopies in 2010 were revitalized by a La Niña which became evident by April and resulted in canopy increases in August and December 2010 to large fractions of what was observed in 2009 with 11.706 km^2 of kelp canopies remaining by the end of 2010.

REGION NINE KELP BEDS

GENERAL OVERVIEW

MBC has identified 25 persistent kelp beds In the Region Nine kelp survey area extending from Newport Harbor (Orange County) to the north and the Mexican Border to the south. In this same region, California Department of Fish and Game recognizes just 10 kelp beds; Fish and Game (F&G) Kelp Beds 1-10 (Appendix A).

Fish and Game Kelp Bed Number 10 includes the kelp beds beginning at Newport Harbor and moving south past Crystal Cove State Park to Abalone Point, collectively known as the Newport Coast kelp bed. The Newport Coast kelp bed was the only kelp bed in northern Orange County to survive the 1957-1959 El Niño. In contrast, this section of the coastline was also the most severely affected by the El Niño of 1982-1984, resulting in the total loss of kelp in 1985. The area was the subject of a kelp restoration project by MBC Applied Environmental Sciences which resulted in a small, semi-stable kelp population at Reef Point at Scotchman's Cove (now Crystal Cove State Park) (MBC 1990). A series of El Niños in the early 1990s eliminated kelp again from the area and the 1997-1998 El Niño resulted in the complete extirpation of giant kelp at that site. In past El Niños, typically some giant kelp survived below the thermocline until conditions become more favorable. In most of the north Orange County kelp beds (with the exception of Dana Point), available rocky substrate only extends out to depths of about 40 ft and historically, the beds have never been large. With the exception of one bed outside of Newport Harbor, Crandall did not report any other beds along this section of the coastline in his 1911 survey. The thermocline during the 1982-1984 and the 1997-1998 El Niños was depressed below the depth critical to the survival of the giant kelp, resulting in the total extirpation of kelp from the southern part of the region. There was no surviving giant kelp below the thermocline to repopulate the coastline when conditions returned to a more favorable regime. The prevailing longshore currents in the area are to the south; therefore, a source of kelp spores would most likely be to the north. Any potential donor beds were too distant to provide enough spores to colonize rocky substrate at locations more than about 100 m from the primary bed. Based on numerous dive surveys, there were urchin barrens on many of the rocky reefs, or there was little available substrate that was not already occupied by multi-storied, encrusting invertebrate and algal coverage. The urchins and this coverage would have precluded settlement by spores on appropriate substrate. Because of these factors, and undoubtedly other unknown factors, giant kelp was absent from this area. No natural kelp beds were close enough to supply kelp spores to initiate a recovery of the giant kelp in this region. Subsequently, no kelp was noted in any aerial surveys of the north Orange County coast nor was any kelp found during numerous dive surveys. Further restoration attempts in the region by a North Orange County Regional Occupation Program group (managed by Gordon Lehman and Dave Meyers) began at Corona Del Mar in 2000 and with the Coast Keepers (Crystal Cove) beginning in about 2004 and continued until there were ultimately measurable kelp bed canopies by 2007 (appearing in the aerial photos) which have continued to increase through 2010.

Fish and Game Kelp Bed Number 9 is located from Abalone Point through Laguna Beach. Available hard-bottom subtidal habitat is intermittent with sandy substrate predominating in much of the area. The hard substrate, where found, does not extend much beyond depths of 40 ft throughout this region. This area too was devoid of kelp from about 1993 until restoration efforts began in 2002 by MBC Applied Environmental Sciences and later by the Coast Keepers. Several sites were selected for kelp restoration in both north (three sites) and south (27 sites) Laguna Beach, with varying degrees of success through 2007, before environmental conditions ultimately favored the efforts resulting in several small canopies that appeared in 2008. They expanded in size and area during 2009, and continued to produce even larger canopies in 2010. Beginning at South Laguna and at the Salt Creek-Dana Point kelp beds, rocky bottom extends further offshore reaching depths of 60 ft and supports a good growth of kelp during favorable years. South of Dana Point, rocky bottom is restricted to depths of 50 ft and less, and intermittent rock, cobble, and sand substrate is found in the nearshore environment to San Clemente which can result in turbid waters and sparse canopies during some years and large canopies during years with good nutrient availability.

Fish and Game Kelp Bed Number 8, covering San Clemente, San Mateo, and San Onofre, is comprised of several kelp beds located on a cobble bottom with intermittent sand patches to depths of 50 ft. Although historically several large beds existed in this region (Crandall 1912), most of the substrate turns from cobble to predominantly sand about one mile past San Onofre with little or no hard substrate available for several miles until reaching Barn Kelp. Crandall's observation o0f kelp in this region previously would suggest that kelp either grew on reefs that presumably existed here and have been buried by sand inundation, or kelp was growing on the sand as it does in the Santa Barbara region.

Fish and Game Kelp Bed Number 7 includes Horno Canyon and Barn Kelp to just north of Oceanside. Horno Canyon was a very large, elliptical shaped kelp bed well offshore of Horno Canyon that completely disappeared during the 1957-1959 El Niño (North and Jones 1991). The bed has not reappeared since, but during good years, small patches of kelp are found growing inshore in an area that divers have determined is a cobble bottom. Barn Kelp is a layered shelf reef community extending out to depths of 50 ft and is known to undergo sediment shifts of almost one meter in height causing burial and exposure of boulders which may account for the variability observed in size and shape of the kelp patches. Beyond Barn Kelp, going south, large expanses of sand characterize the bottom with small areas of hard substrate that occasionally support a few kelp off Santa Margarita; although Crandall reported a very large kelp bed offshore of Santa Margarita in 1911, it was not observed during Fish and Games flights from 1955 to 1961 and has not been observed since. Only small areas of hard substrate are found offshore of Oceanside until offshore of Buena Vista Lagoon in Carlsbad about five kilometers past the Oceanside Pier. No kelp beds are recorded in this range, probably because of a predominantly sand bottom in a dynamic environment.

Fish and Game Kelp Bed Number 6 encompasses the beds offshore of Carlsbad, Agua Hedionda, Encina Power Plant, and Carlsbad State Beach. Rocky substrate is found out to depths of 60 ft offshore of most of this area and it supports good canopy coverage with intermittent sand patches between the beds.

Fish and Game Kelp Bed Number 5 is located south of North Carlsbad, and encompasses kelp beds from Leucadia, Encinitas, Cardiff, Solana Beach, and more or less continuously to Del Mar. Another large gap of predominantly sand bottom is found just past the Solana and Del Mar kelp beds to offshore Torrey Pines, where small reefs are found that periodically support some kelp, and then sandy substrate again predominates past Scripps Pier to the beginning of La Jolla Kelp.

Fish and Game Kelp Bed Number 4 is the La Jolla Kelp Bed as rocky substrate becomes prevalent offshore of La Jolla and is more or less continuous to offshore of Pacific Beach, and supports, at times, very large kelp beds out to depths of 90 ft or more. At Pacific Beach to just past the entrance to Mission Bay, sand predominates in the inshore environment and very little hard substrate is found. Past Mission Bay, rocky substrate again begins to dominate and hard substrate and giant kelp is found out to 100 ft and deeper during good years.

Fish and Game Kelp Bed Number 3 is a very extensive bed and is a part of Point Loma kelp bed that runs more than 10 kilometers along the length of the peninsula. At one time, the bed extended from the Mission Bay entrance to about "two nautical miles" due south of the promontory at Point Loma, a distance of almost 14 kilometers (North and Jones 1991). The Mission Bay extension disappeared about 1949 possibly from dredging and shoreline construction in Mission Bay and Pacific Beach (respectively).

Fish and Game Kelp Bed Number 2 is the lower portion of Point Loma Kelp that crosses the mouth of the bay and continues south. Historically, kelp was found well south of the entrance to San Diego Bay "two nautical miles" south (North and Jones 1991); that area is identified as F&G Bed 2. This southerly extension probably no longer existed by the mid-1950s (North and Jones 1991). Sand predominates to just before the pier offshore of Imperial Beach, and there are no large kelp stands proceeding south for at least two kilometers.

Fish and Game Kelp Bed Number 1 is a group of kelp beds found on a low-lying mostly cobble reef area beginning north of the Imperial Beach Pier and extending to the Mexican Border. They are situated in depths ranging from about 20 to 55 ft. This area supported a bed that was over one kilometer square in 1911, but was never again as large during the remainder of the century. But in 2007, the beds in this region surpassed 1911 areas and grew to almost 1.5 km^2 and grew even larger in 2008 reaching a canopy size of almost 1.9 km^2, before declining sharply in 2009, and all but disappearing in 2010. Hard substrate is probably buried periodically and then exposed during large storm events; in any event, the bed changes shape and reappears in different locations as noted during its reappearance following the 1988 "Great Storm" (North and Jones 1991). Although very little kelp is noted beyond Imperial Beach to the Mexican Border due to a predominantly sandy substrate, this area supported a large kelp bed in the early part of the 20th century that started on the United States side of the border and extended beyond the Mexican Border. This kelp bed has not been recorded since the 1911 survey, apparently disappearing sometime between then and 1967 (the next recorded survey of the area). No kelp is currently found offshore of the International Boundary and Water Commission's outfall.

2010 SURVEY YEAR – RESULTS OF THE SURVEYS

Aerial Surveys 2010. The aerial surveys for 2010 were conducted on 28 March, 22 August, 4 November, and 31 December 2010. One aerial survey (on 16 April 2011) has been completed for the 2011 survey year (Appendix C). On each survey, a continuous series of downward-looking photographs were taken with digital infrared and color film. The photographs that illustrated the greatest canopy coverage were then composited and a photomosaic was constructed using Adobe Photoshop CS2 (Appendix D). Each photo was geo-referenced to at least three prominent features on the map and converted to UTM or other acceptable coordinate system and then converted to a geo-referenced TIF file. The kelp beds were then layered onto standard base maps to facilitate interannual comparisons. These images were then digitally superimposed on base maps, and the canopy area was estimated using ArcGIS 9 (Appendix A).

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 as scheduled; however, 2010 was a very unusual year with fog persisting over much of the summer. Due to this, the scheduled June survey was not conducted until August 22 during one of the rare sunny weeks of the summer. A quote from the Los Angeles Times on 21 September 2010 (2010) summarized the strange weather that caused flight delays:

> *"Summer played hooky on us. It never really showed up," said Bill Patzert, a climatologist for the Jet Propulsion Laboratory in La Cañada Flintridge. "We leaped from spring to fall." Patzert said a low-pressure trough that stalled along the West Coast from Alaska to southern Baja California kept the summer cooler than usual, with many overcast days. Monthly temperatures in downtown Los Angeles from April to now have averaged between one to three degrees cooler than normal. Patzert said it's one of the coolest summers in decades. Jamie Meier, a meteorologist for the National Weather Service in Oxnard, said that LAX tied the coldest average temperature for August on record, going back to 1944."*

As the June survey was conducted almost two months later than ideal, in consultation with the Consortium the remaining two were earmarked to split the remaining time; therefore, there was no September survey scheduled. Instead it was scheduled for late October, which again because of inclement conditions was conducted a week later on 4 November. The last survey for the year captured most of the kelp beds at their greatest extent with the survey being conducted as scheduled on 31 December 2010. Past surveys have been occasionally missed, especially during the summer, due to persistent fog; however, infrared can see through light fog. Based on the results of the surveys, maximum canopy coverage throughout most of the region was seen during the flight of 31 December, although the kelp beds of La Jolla and Point Loma depicted larger canopies on the 22 August aerial survey. Most kelp beds increased through the 2010 year from losses in mid-to-late 2009 and maintained canopies during summer with the cooler water temperatures due to the La Niña (Table 4).

Table 4. Rankings assigned to the 2010 aerial photograph surveys of the San Diego and Orange County kelp beds, and rankings assigned to an April 2011 aerial survey. The basis for a ranking was 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.

	2010 Survey				2011 Survey
Kelp Bed	March 28	August 22	November 04	December 31	April 16
Newport Harbor*	2.5	2.0	3.0	3.0	3.0
Newport Coast CDM-CC	3.0	2.5	3.0	3.5	3.0
No. Laguna Beach	3.0	3.0	3.5	4.0	3.5
So. Laguna Beach	2.0	3.5	3.5	4.0	3.5
South Laguna	2.0	3.5	3.5	4.0	1.5
Salt Creek-Dana Point	3.0	3.0	3.5	4.0	3.0
Dana Point Marina *	3.0	1.5	2.0	3.0	1.5
Capistrano Beach	3.0	3.0	3.5	3.5	2.5
San Clemente	3.5	3.5	3.5	4.0	3.0
San Mateo Point	2.5	3.5	3.5	4.0	3.0
San Onofre	2.5	3.0	3.0	3.5	2.5
Pendleton Reefs*	-	-	-	-	-
Horno Canyon	1.5	2.0	2.5	3.0	2.0
Barn Kelp	2.0	3.0	3.5	3.5	2.0
Santa Margarita	-	-	-	-	-
Oceanside*	-	0.5	1.0	1.5	1.0
North Carlsbad	2.0	3.0	2.5	3.5	1.5
Agua Hedionda	2.0	3.0	2.5	3.0	2.0
Encina Power Plant	3.0	3.5	3.0	3.5	2.5
Carlsbad State Beach	2.5	2.5	2.0	3.0	2.0
North Leucadia	3.0	3.0	2.5	3.5	1.5
Central Leucadia	2.5	2.5	2.0	3.0	2.0
South Leucadia	1.5	2.0	1.5	2.5	2.0
Encinitas	2.5	2.5	2.0	2.5	0.5
Cardiff	1.5	2.5	1.0	2.5	2.0
Solana Beach	3.0	3.0	2.5	3.0	2.0
Del Mar	3.0	3.0	2.5	3.0	0.5
Torrey Pines Park*	-	-	-	0.5	-
La Jolla Upper	2.5	3.0	2.0	1.5	1.0
La Jolla Lower	2.5	3.0	2.5	2.0	1.0
Point Loma	2.0	3.0	2.5	1.5	1.0
Imperial Beach	-	0.5	0.5	1.0	-

Notes:
Ranking values: 0.5 = very small amt of kelp present, 1 = well below average , 2 = below average, 3 = above average, and 4 = well above average; * = not part of the monitored beds; - = no canopy present;

Boat surveys were conducted during most of the 2010 year from Newport Beach to Barn Kelp, a focused survey was conducted on 2 November 2010 in the northern portion and on 1 December in the southern portion to document the kelp canopies and verify anomalies suggested by the earlier data. By the 28 March 2010 survey, very few kelp canopies appeared to have maintained their size observed in mid-2009 while increased canopy was found in only two kelp beds, Newport Coast (CDM) and North Laguna Beach. The poorer nutrient conditions in the middle-to-late part of the 2009 year in both the north and south resulted in serious deterioration of many of the kelp canopies. By the 22 August 2010 overflight, only a few beds had decreased while 15 beds actually increased from the March 28 survey, and there was no pattern to the increases in respect to northern or southern beds (Table 4). The March survey generally recorded improving kelp canopies. By the 4 November survey, a definitive pattern emerged with the northern beds generally increasing and the southern beds from North Carlsbad to Point Loma decreasing (Table 4). Most beds (excluding La Jolla and Point Loma which decreased drastically) increased to their maximum yearly canopy size by the 31 December survey. Because of the La Niña in 2010, kelp canopies were maintained over the summer allowing a marked recovery by the December survey. Overall, kelp in 2010 generally increased over that observed in the last half of 2009, capitalizing on the relatively good nutrient conditions of 2010. However, some of the very large beds lost considerable canopy coverage, with total area of kelp coverage by the June survey still very good, but below that documented in 2008 (which was the best since 1941 in our records) or in 2009.

Utilizing the 2010 aerial surveys, 24 of the 25 beds monitored were present (Figure 13), and the following changes were documented:

11	Kelp beds increased for the 2010 year
13	Kelp beds decreased for the 2010 year
1	Kelp bed was unchanged (not present in 2010)

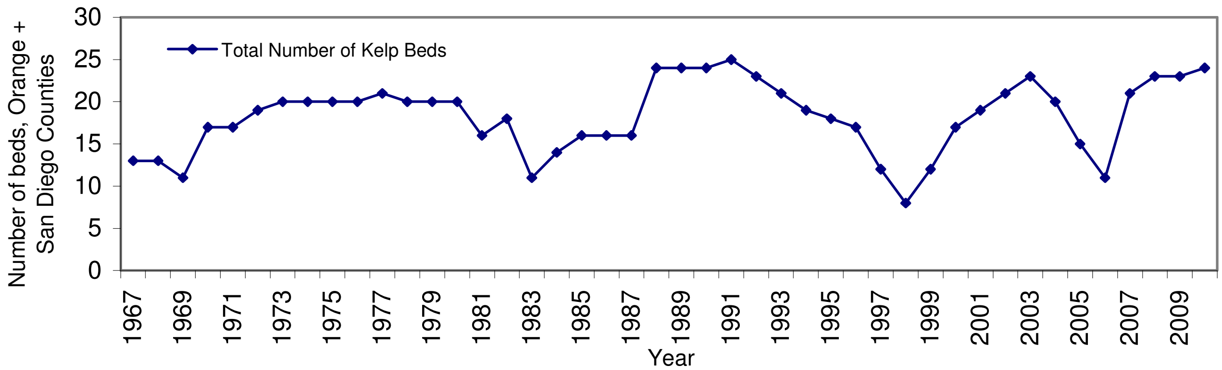

Figure 13. Historical changes in the total number of kelp beds in Orange and San Diego Counties determined by presence or absence of canopies assessed by aerial photography.

Of the two small beds at Torrey Pines and Santa Margarita that appear only occasionally in the region, only Torrey Pines was present in 2010 (although much smaller), whereas Santa Margarita has not been observed since 1992.

Results of the 2010 Region Nine survey indicated that the maximum measured kelp canopy decreased from 13.571 km^2 in 2009 to 11.706 km^2 in 2010 (Figure 14, Table 3). Warmer-than-average temperatures (waning El Niño conditions) were observed in early 2010 (January-April), followed by a cooler-than-average summer and fall as La Niña conditions (July-December) were recorded by the NOAA Climate Diagnostic Center (www.cdc.noaa.gov). Canopies in 2010 were revitalized by a La Niña which became evident by June and resulted in increases in canopies in August and December 2010 to large fractions of what was

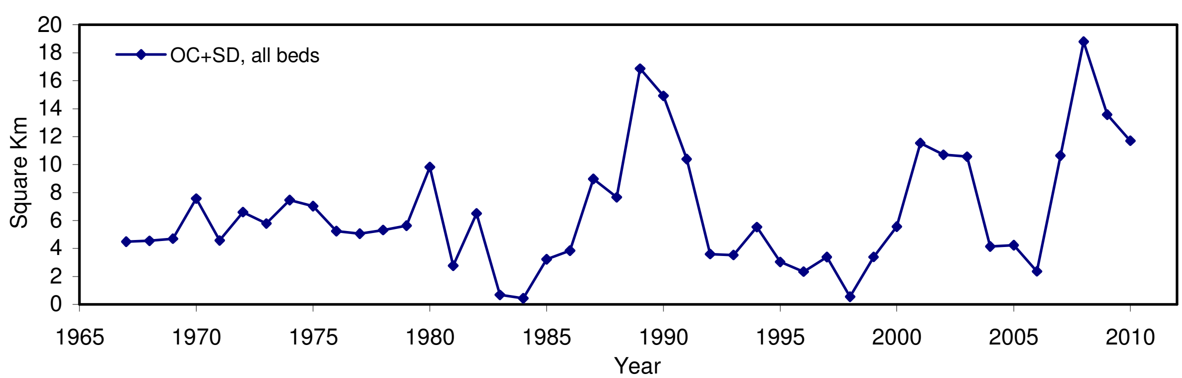

Figure 14. Combined canopy coverages of all kelp beds in Orange and San Diego Counties.

observed in 2009 with 11.706 km^2 of kelp canopies remaining by the end of 2010. With the exception of Imperial Beach kelp bed, there was a marked recovery of all the remaining beds increasing greatly from lows observed in 2009; however, for many beds the previous losses were too large to completely erase by the December 2010 survey.

2010 Sea Surface Temperatures and Nutrients. SSTs from the Point Loma, Scripps, San Clemente, and Newport Pier CDIP stations were used to determine the theoretical availability of nutrients in the region. The variability of SSTs in 2010 tracked fairly closely between the northern, central, and southern portions of Region Nine (Figure 8). However, it was slightly colder (meaning more nutrient availability) in the central and northern portions. This relationship between temperature and nutrients appeared favorable in early 2009 in the south and very favorable in the north based on the monthly Nutrient Quotient Index (NQ) (described in "Status of the Kelp Beds of San Diego and Orange Counties for the Years 1990-2000" [North and MBC 2001]). However, the lack of nutrients (based on warmer SSTs) from May to November 2009, not becoming favorable until December 2009, resulted in a projected very low NQ of 9 in the south and only 11 in the north for the 2009-2010 season (Table 1). The above average kelp canopy coverage in 2008 was the result of a very good impetus in late 2007. It was nurtured early in 2008, followed by a relatively mild summer, and good nutrient availability in the fall in 2008 season. The very low NQs for the 2009-2010 year resulted in fair canopies through June and then much reduced canopies by the end of 2009. To illustrate the variability observed regionally, SST sampling stations, situated at opposite ends of the region, had nutrient quotients of 27 at Newport Pier and 11 at Scripps Pier for the 2010 calendar year. However, temperatures for the nutrient year (which begins in July 2010 and continues through June 2011) suggested slightly better nutrient conditions with an NQ of 35 at Newport Pier and 17 at SIO (through April and May of 2011). Both of these measures indicate that nutrients were potentially greater in the northern beds during this period.

2010 Water Clarity. Water clarity was relatively good in 2010. Typically, periods of sustained high turbidity result from rainfall; during the 2009/2010 rain year, rainfall remained slightly above average with 15.95 inches recorded at Oxnard, 12.43 inches at Los Angeles, and 15.66 inches at Long Beach. However, the contrast after several years of drought made it appear that rainfall was high during that period (NOAA National Climate Data Center [www.ncdc.noaa.gov]). There were periods when the rivers and streams ran strongly and nearshore waters were turbid. There were periods of algal blooms (especially in September long after the rains), but they did not persist for sustained periods in the region during 2010 (SCCOOS 2011). Patches of discolored reddish-brown waters in April and May were observed along beaches from Malibu to Imperial Beach lasting for a few weeks. Monitoring efforts show that these dense blooms were caused primarily by a phytoplankton, the dinoflagellate *Lingulodinium polyedrum* (SCCOOS 2011). 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. A harmless, green foam was also observed on the beaches of southern California in late July. Researchers at Scripps Institution of Oceanography identified *Tetraselmis*, a microscopic green algae, as the causative agent. This green flagellate is about 10 micrometers in size has been found in concentrations as dense as 15 X 10^6 cells per liter of seawater (SCCOOS 2011). Concentrations 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 2010 and thereby decreased photosynthetic opportunities, their duration offshore in 2010 was not sufficient to have adversely affected the health of the Region Nine kelp beds.

2010 Swell Intensity. Typical swell sizes and directions were observed through most of 2010, with swells generally approaching the region from the south and west. High-energy waves that negatively impact the southern California coastline usually are low frequency, high amplitude waves approaching from the west. Such conditions briefly existed during late January and late February and again in late December when wave energy height and density at the San Pedro, Dana Point, Oceanside, and Point Loma South CDIP Buoys indicated high-amplitude waves near or over 3.5 m (with some over 4.0 m). For most of the spring and summer, swells were either low energy or had a more southern approach. Long period, low-frequency waves reached southern California in late January 2010, with swell heights of 4.2 m being recorded at a buoy located off Point Loma and another offshore of San Pedro recorded heights of 4.4 m; wave heights were up to 3.7 m at a similar buoy offshore of Dana Point. These swells become breaking waves as they approach shallow coastal waters and potentially can rip loose kelp holdfasts causing a loss of whole kelp beds. They may have been responsible for the near total loss of kelp at Imperial Beach sometime between late December 2009 and late March 2010. In spite of the fairly large swells recorded during 2010, they were not persistent and there was no other evidence of any substantial impacts on the remaining kelp beds in Region Nine.

2011 UPDATE TO THE PRESENT

One aerial survey for 2011 has been conducted and been critically evaluated. This survey was conducted on 16 April 2011. The daily pattern in temperature change tracked closely between the southern automated sampling stations, but temperatures were much cooler through May 2011 in the north (the latest data available); however, SSTs at Point Loma indicated an NQ of 15 through mid-June 2011, the Scripps Pier indicated an NQ of 13 through March, San Clemente Pier an NQ of 13 through April, and Newport Pier an NQ of 26 through May (Figure 15). Temperatures oscillated above and below the long-term mean (using SIO as the baseline) during the same period in both the southern and northern portions of the range. At this early stage, it is unclear how Region Nine kelp beds will fare in 2011; however, data from the April 16 survey indicate all beds in Region Nine decreased. Most recently, forecasts suggest El Niño neutral conditions to develop during the later portion of the year.

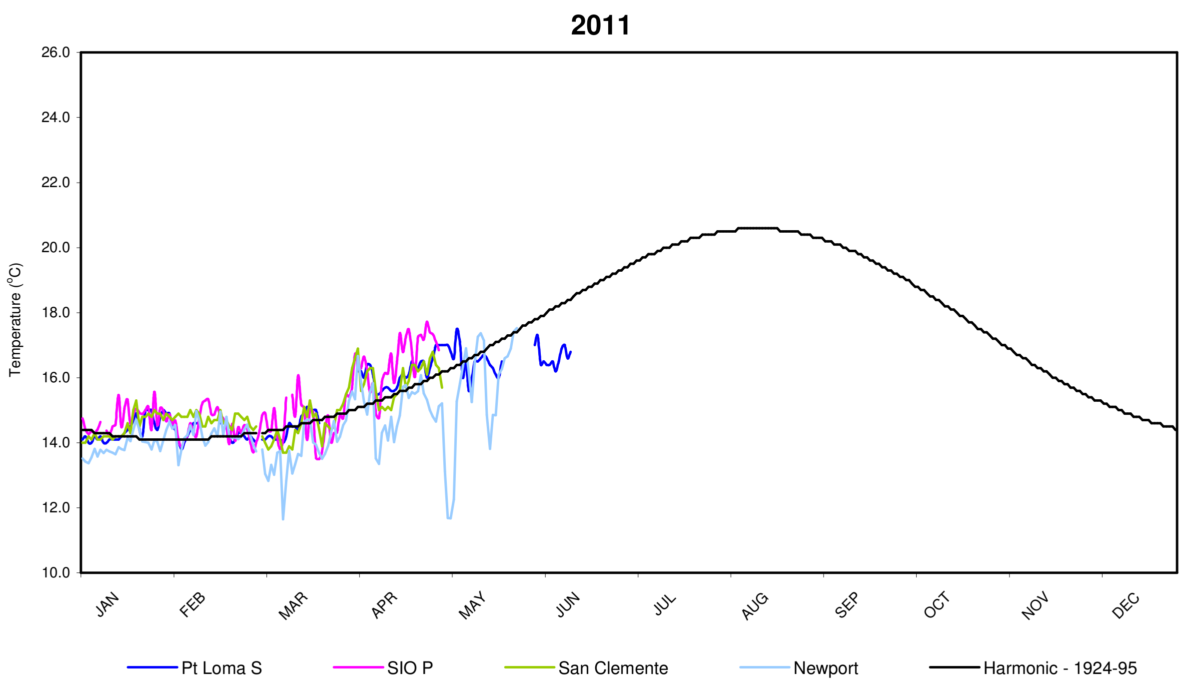

Figure 15. Region Nine combined sea surface temperatures (SST) from Point Loma South to Newport Pier for 1 January 2011 and through 11 June 2011.

STATUS OF THE 25 KELP BEDS IN 2010 AND 2011

The following is a brief synopsis of the status of each individual bed during the survey year of 2010 and an update of their status in 2011, as observed by aerial photography and supplemented by boat cruises and by direct diver observations, where available.

Each kelp bed description below is a portion of what Fish and Game refers to as a kelp bed lease area which can contain more than one giant kelp bed. The Region Nine program identifies these as 25 individual beds (although many are comprised of two or more distinct beds) either using local names or geographical references for the name. Looking at the performance of a single bed can elicit more meaningful information if we compare it to like beds in the region as there can be distinct differences between the beds of Orange and San Diego Counties based on localized upwelling and oceanographic exposure. Therefore, we compare not only the area of each individual bed, but how that bed compares to the average for the beds in both Orange and San Diego County, excluding the very large beds of La Jolla (LJ) and Point Loma (PL) as they tend to skew the data. We also compare total area of the beds in Orange County, the beds in San Diego (with the exception of LJ and PL), and the LJ and PL beds to determine whether any distinct differences are elicited in the overall coverage in a region over time (Figure 16). Comparison of the individual beds to each sub-region further refines the ability to identify underperforming beds and determine possible reasons for the anomalous results. It is important to conduct these comparisons as 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.

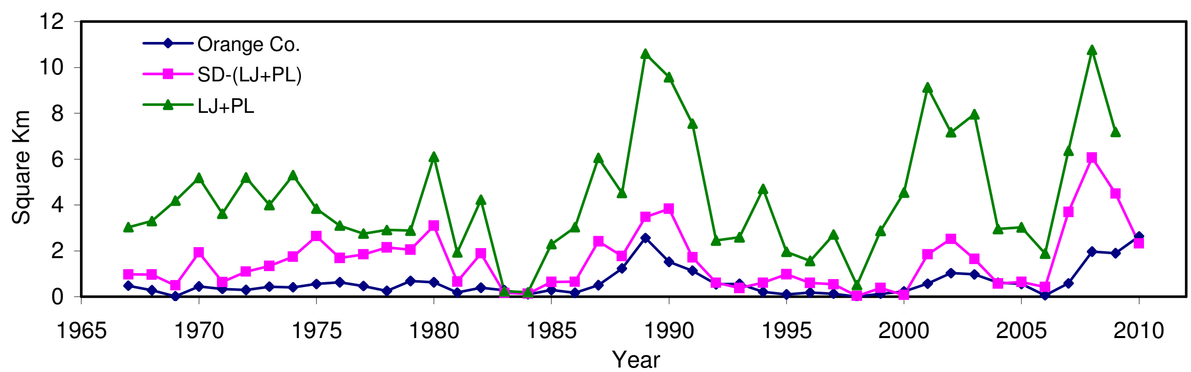

Figure 16. Diagram showing components of the Total Area graph partitioned into the kelp beds of: Orange County; San Diego County less La Jolla and Point Loma ((SD-(LJ+PL)); La Jolla plus Point Loma (LJ+PL).

Huntington Flats to Newport Harbor 2010. 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 sufficiently to increase sedimentation in the area, thereby reducing the likelihood of a kelp bed being sustained. No kelp has been observed historically or in any Region Nine 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 2010 quarterly surveys.

2011. Because the area consists of mostly sandy subtidal zones, and lacks suitable hard substrate, no kelp was noted in this region in 2011 with the exception of a small strip of kelp growing along the west jetty of the Newport Harbor entrance.

Newport Coast - Corona del Mar to Crystal Cove 2010. Giant kelp in this region consisted of a number of small beds (collectively called the Corona del Mar kelp bed) covering 0.580 km^2 of the nearshore coastline during Crandall's survey of 1911, but down to 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, 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 canopy during the early portion of 2003. A dive survey was conducted at the restored Corona del Mar bed in 2003 and purple urchins were prevalent in the area, but kelp recruitment was so successful that drift algae was apparently sufficient to keep the urchins from 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, (approximately 65% of the bed size recorded in 1980) (Table 3). In the March, November, and December aerial surveys of 2010, the various small beds comprising the Corona del Mar kelp bed were very robust. A relatively large kelp bed measuring 200 by 100 m was observed off of Whistler's Reef and a dive survey on 2 November 2010 indicated that the bed was growing on large rocky reefs and tissue colors were indicative of sufficient nutrients. The fronds of the giant kelp appeared to be about 50% mature and about 30% very young suggesting that the bed was healthy and growing. Offshore of Scotchman's Cove, another large canopy was visible having grown from a small bed observed in May 2009 to a bed about 300 m long by 100 m wide and growing in water as deep as 60 ft (Curtis 2010, pers. obs.). The measurement of the Newport Coast kelp bed in December 2010 calculated coverage of 0.161 km^2, which is slightly larger but almost equal to the 1975 and 1977 totals for the region. This indicates that as a result of kelp restoration efforts from 1986 through 2009 (and the added impetus of the 2010 La Niña). 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. Kelp did not return (result of restoration efforts) until a tiny amount was observed in 1989; it was lost again, but returned as the result of further restoration efforts in 2003 (Figure 17).

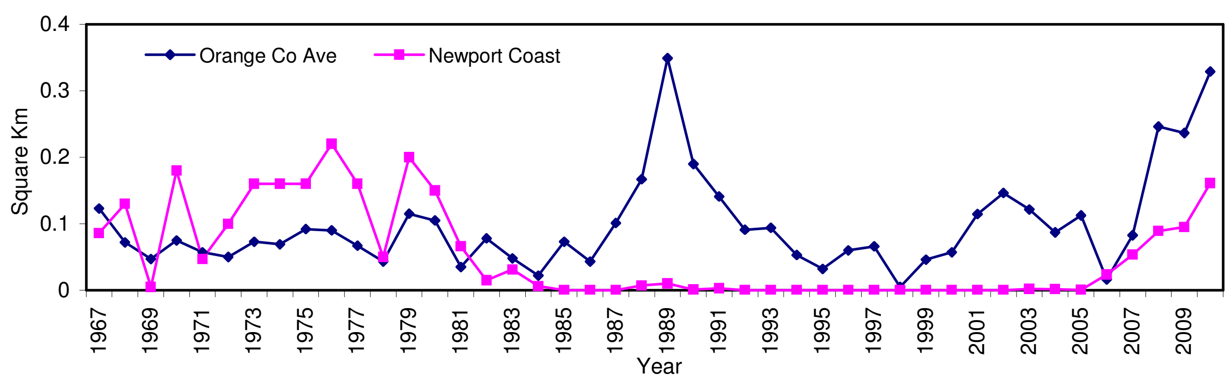

Figure 17. Comparisons between the average Orange County ABAPY and the canopy coverages of the kelp bed off Newport Coast (Corona del Mar/Crystal Cove) for the years shown.

2011. The aerial and boat-based surveys at Newport Coast in 2011 documented that kelp persisted at high coverage throughout the Corona del Mar to Crystal Cove region.

North Laguna Beach/South Laguna Beach 2010. Kelp at this location appears prominently in a map from 1890 produced by T.C. Mendenhall for the U.S. Coast and Geodetic Survey; however, by 1911, apparently there was only a trace of kelp in the area of North and South Laguna Beach, as Crandall did not record any kelp beds at this location. No available records have been found for the intervening years, but in 1955, kelp beds were recorded at 0.680 km^2. Thereafter they stayed relatively small and by 1967, they were listed as very small beds totaling only 0.005 km^2 for both. By 1976 the beds again began to increase in size and stayed substantial until peaking in 1989 at 0.319 km^2 (Table 2). The beds persisted for a few years, becoming smaller with North Laguna Beach disappearing 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 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 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 grew to a canopy of about 0.002 km^2 at North Laguna Beach and 0.025 km^2 at South Laguna Beach by the late December survey of 2008. The kelp beds continued to expand in 2009 and, during the June 2009 survey, kelp recorded in north Laguna Beach totaled 0.005 km^2 and in south Laguna Beach 0.058 km^2, more than 14 acres (Table 3). As these beds disappeared after the 1989 maximum (0.187 km^2) was reached, the calculation of 0.093 km^2 in the north and 0.098 km^2 in the south and a combined coverage of 0.191 km^2 in December 2010 indicates that these beds have also fully recovered due to restoration efforts over an eight-year period (MBC 2010b). 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 18).

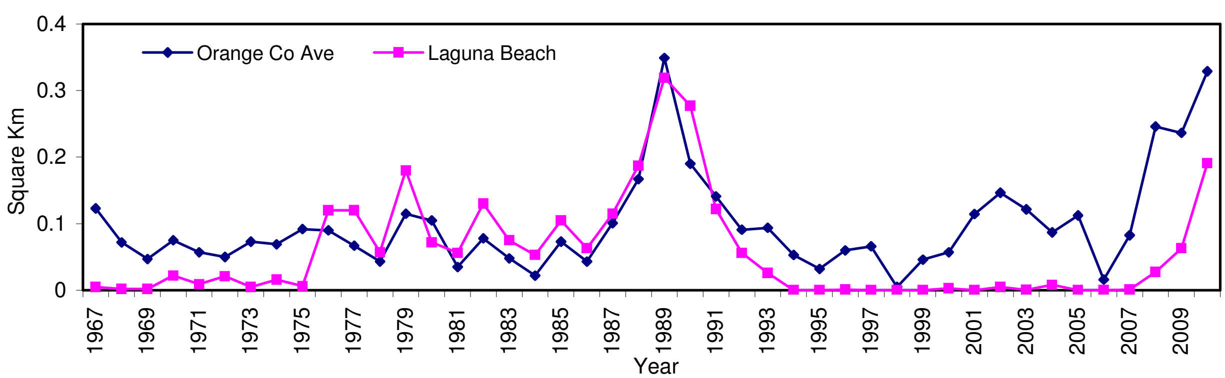

Figure 18. Comparisons between the average Orange County ABAPY with the history of Laguna Beach kelp (i.e., the sums of canopy coverages for North Laguna Beach plus South Laguna Beach kelp) for the years shown.

2011. Conditions in this region remained very good in early 2011, resulting in more substantial canopies in both north and south Laguna Beach. There were several areas of kelp on the southern edge of Main Beach (the dividing line for north and south Laguna Beach) covering about 25 acres and another on the north side of Main Beach covering about 22 acres. Several other small beds were recorded in north Laguna Beach at Divers Cove, and Shaw's Cove, while the beds at Heisler Park increased greatly in size by the April 2011 survey.

South Laguna 2010. Giant kelp was not recorded at this location in Crandall's 1911 survey. A record from 1955 suggests that as much as 2.02 km^2 of kelp coverage was present in the Salt Creek-Dana Point and spilling into the South Laguna region (twice what has been recorded in the region since). Based on that assessment, it was likely the bed was near 0.10 km^2 (twice what has been recorded for this bed). By 1959, the two beds were recorded as being only 0.18 km^2, indicating South Laguna was either not present or very small. No kelp was seen here in Dr. North's survey of the individual beds from 1967 to 1969, but kelp reappeared in 1970 and reached a total of 0.016 km^2 in 1976. The bed disappeared again in 1978 until a brief reappearance in 1983, and was again missing until 1988. By 1989, the bed was about 0.041 km^2, persisted in the area until 1994 and then was gone until 2000. It persisted for the next several years and the various kelp beds were visible in the region in early 2005, but density of kelp decreased sharply and only scattered and tattered giant kelp were noted during the boat surveys through September 2005. A small amount of giant kelp was noted in early January 2006, but was not seen during subsequent aerial surveys and no kelp was seen anywhere in the region in spite of numerous fathometer searches throughout the 2006 survey year. Small kelp beds were seen at the south end of South Laguna in early 2007 that became much larger by the end of 2007. Several boat surveys in early 2008 documented a continuous strip of adult giant kelp in 40 to 50 ft depths extending from Salt Creek north about 0.5 kilometers, stopping well before Aliso Creek. By the end of 2008, the bed canopy measured 0.023 km^2 (Table 3). However, by March 2009, the bed canopy decreased to 0.017 km^2 and decreased thereafter until December when it again began to increase. A dive survey in this region on 6 January 2010 indicated that the kelp bed appeared to have very healthy basal holdfasts and the bed was again increasing in size (Curtis 2010, pers. obs.). By December 2010, the bed increased again to a similar coverage observed in 2008 of 0.023 km^2. The ABAPY for this bed indicated that the bed responded to relatively large stimuli such as the 1989-1990 La Niña and has continued to respond to the increase in the Orange County average noted since 2007 (Figure 19).

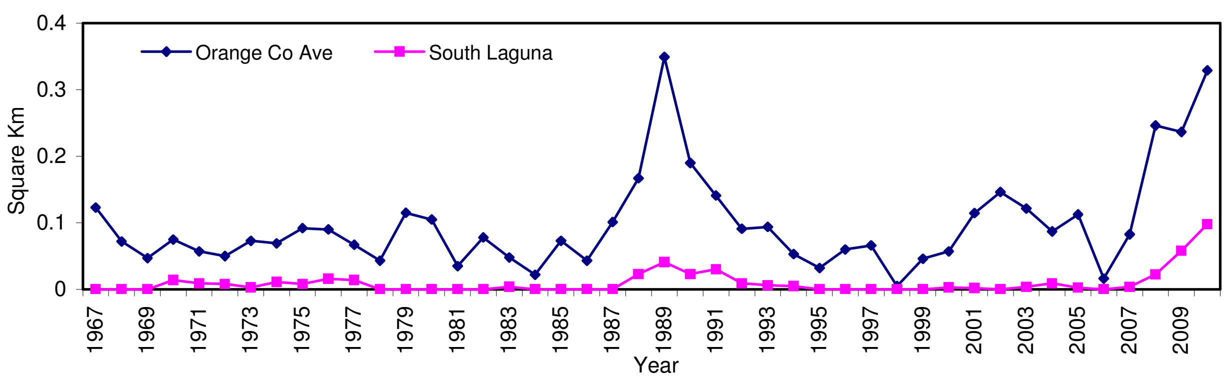

Figure 19. Comparisons between the average Orange County ABAPY and the canopy coverages of the kelp bed off South Laguna for the years shown.

2011. Kelp was present during the first aerial survey and was observed during several boat surveys through May 2011 and an aerial survey on 16 April 2011. It appeared to have decreased considerably; however, observations during boat surveys indicated kelp was found subsurface.

Salt Creek-Dana Point 2010. Kelp beds in the Salt Creek-Dana Point area were large in Crandall's 1911 survey, totaling 1.871 km^2 (Table 2). It appears that they were even larger in 1955, when a survey covering the Salt Creek-Dana Point beds and the relatively small South Laguna bed totaled 2.02 km^2 of canopy coverage. Thereafter the beds declined to 0.240 km^2 in 1967, and stayed relatively small for the next two decades until coverage peaked at 0.900 km^2 in 1989. Coverage was about 0.2 to 0.4 km^2 through 1993, but was much smaller through 1999. These beds had been in a continuing decline since the La Niña of 1989, but made a good recovery in 1999 due to the La Niña, which continued through 2002. Kelp canopy was extensive and on the surface from depths of 35 ft extending out to 64 ft by the end of 2002, covering an area of 0.432 km^2, and again becoming smaller and disappearing in 2006. By January 2006, boat surveys indicated that the area had a poorly defined canopy, but no canopy was visible during the first three quarterly aerial surveys of 2006 and only a trace was found during the December survey. Although no kelp was seen during the subsequent aerial surveys, diving and boat surveys indicated a few kelp were on the surface in late June and divers reported seeing a few adults and more small juvenile and sub-adults present on bottom in a mid-July survey. Kelp beds in the Salt Creek-Dana Point area were not visible in the March 2007 aerial survey, but were found during dive surveys in March and May on bottom where good recruitment of juveniles and sub-adults was recorded. During the June 2007 overflight, canopy had formed and was becoming extensive. By late December a canopy totaling 0.302 km^2 had formed. The bed responded favorably in 2008, and by mid-year canopy was extensive, but became smaller over the summer and re-emerged in the late fall as a thick canopy totaling 1.068 km^2 in area during the December overflight of 2008. Although it was still a very large bed in the March and June 2009 aerial surveys, it lost canopy size from 2008 and was reduced to a bed covering 0.892 km^2 in the March 2009 survey, with further reductions as the year progressed, and a slight recovery by the 17 December survey. Dive surveys in March and June 2009 continued to record active recruitment on the outer edges of the kelp bed, although the inner bed appeared to be very mature kelp with a large number of stipes and very few juveniles present. Due to improving conditions in mid- to late 2010, kelp canopy increased to a significant percentage (94%) of that seen in 2009 and canopy coverage totaled 0.839 km^2. As can be seen in the ABAPY for the Salt Creek-Dana Point kelp beds, this bed followed the ABAPY rather closely, although typically well above the average (Figure 20).

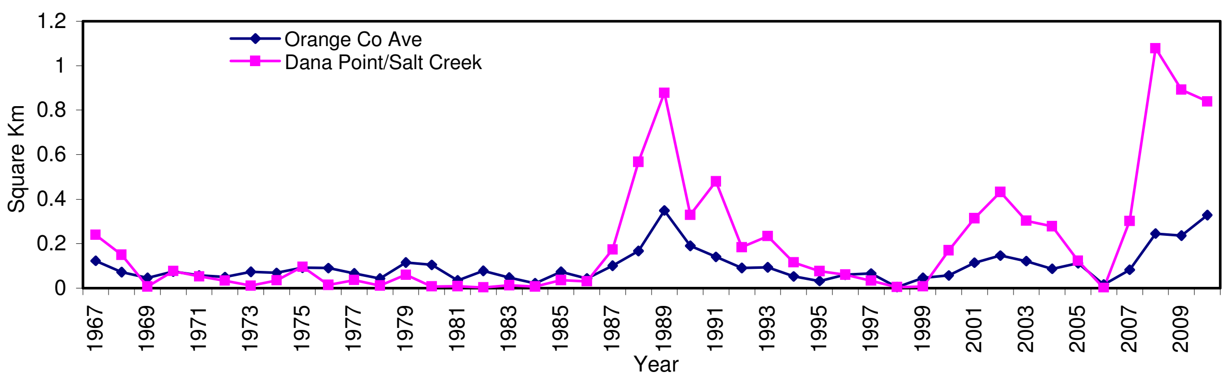

Figure 20. Comparisons between the average Orange County ABAPY and the canopy coverages at the Dana Point/Salt Creek kelp bed for the years shown.

2011. Numerous boat surveys and dive surveys of the kelp on bottom, as well as the first aerial survey of the year on 16 April 2011 indicate that the kelp bed decreased in the ensuing three months, but was still a large kelp bed above its average size.

Capistrano Beach 2010. The baseline for this stretch of the coastline is Crandall's map of 1911 showing canopy coverage of 1.153 km^2. The beds at Capistrano Beach were small in 1967, covering only 0.08 km^2, and stayed small or missing until 1989, when the beds increased in canopy size to 0.233 km^2. The beds were large until 1993, became either very small or non-existent through 2001, and then in 2002 they responded to stimuli to reach 0.118 km^2. The beds shrunk once again and have stayed small since. Kelp was also missing in most of 2004, but re-emerged by the December 2004 aerial survey. A trace of kelp was seen in early 2005, but kelp was again missing through the remainder of 2005. The kelp beds offshore of Capistrano Beach in 2006 were reduced to just a trace in April and December. A small recovery was recorded in 2008, but only to the level noted in early 2006. In 2009, however, kelp was recorded as very good and increased greatly by June 2009 from that seen in 2008 to 0.071 km^2, but still much lower than observed in the 1989 to 1992 period when the canopy covered from 0.15 km^2 to 0.23 km^2 (North and MBC 2001). The kelp canopy appeared healthy in all surveys of 2010 and increased from that found in 2009 to 0.124 km^2.The ABAPY for Capistrano Beach shows that this bed and the San Clemente beds respond typically to stimuli such as the El Niño and La Niña (Figure 21).

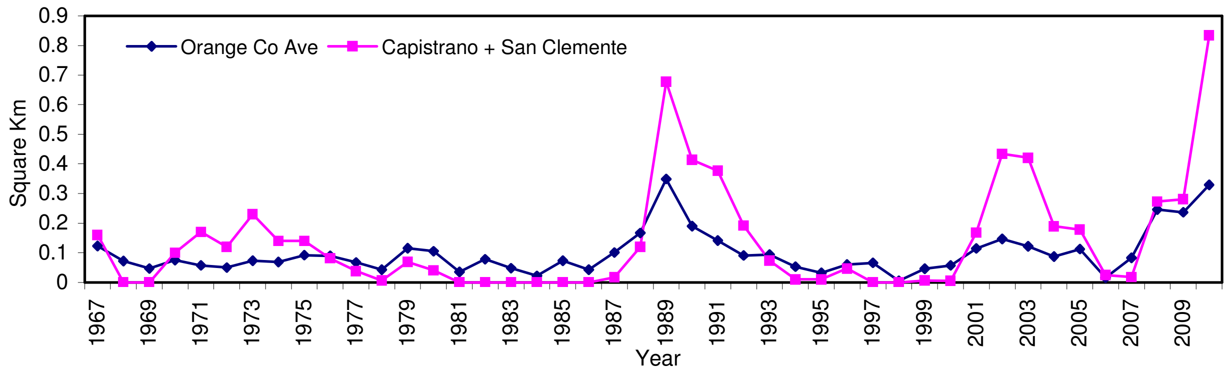

Figure 21. Comparisons between the average Orange County ABAPY and the canopy coverages at the Capistrano Beach plus San Clemente kelp beds for the years shown.

2011. A survey of the Capistrano kelp bed on 16 April 2011 recorded a reduced canopy from that observed in December 2010.

San Clemente 2010. In 1911, Crandall recorded the beds as covering an area of 1.390 km^2. The beds at San Clemente were small in 1967, covering only 0.08 km^2, and stayed small or missing until 1988, when the bed increased in canopy size to 0.124 km^2 and the next year to 0.444 km^2. After a major decline in 1994, kelp bed canopy coverage at San Clemente stabilized in 1995 and increased through 1996. With the advent of the 1997-98 El Niño, kelp disappeared for two years, but responded to stimuli to reach a canopy coverage of 0.124 km^2 in 2001 and then to 0.352 km^2 in 2003. Scattered giant kelp was noted throughout the region, but the largest change was the approximately 50 small artificial reefs measuring 40 by 40 m each that were placed offshore of San Clemente on barren sand at depths of about 40 to 50 ft. Kelp immediately recruited to these reefs and soon had canopies in the shape of small squares visible during most of the aerial surveys of 2002 and 2003. They appeared very productive during monthly boat surveys of the area. Each square reef canopy occupied an area of about 1,600 to 2,000 m^2 for a total of about 100,000 m^2 or about 0.10 km^2 resulting in the potential for approximately 30% more canopy coverage in the region. In spite of this additional substrate, poor nutrient conditions resulted in kelp declining by about 50% in 2004 and 2005, and by 90% in 2006, from that noted in 2003. In 2006, as noted during boat surveys, the artificial reefs in the area still had kelp subsurface, but the kelp appeared to be stressed, indicating that nutrients were probably limiting growth. A small canopy inshore of the main reefs was observed in the aerial photos from the December 2006 survey, but the kelp beds stayed small in 2007. In 2008, stimuli early and late in the year produced a canopy totaling 0.203 km^2. In early 2008, Southern California Edison (SCE) added additional reef material and kelp was reported as recruiting to the new reefs in late 2008. Kelp stayed fairly robust through both the March and June surveys, retreated in September, but recovered by December when 0.210 km^2 of kelp canopy was recorded. Kelp was beginning to be visible at the new SCE reefs, but much of the kelp was still subsurface by the end of 2009 (Table 3). Kelp covered the footprint of the new artificial reefs and reached a recorded high for the area of 0.710 km^2 of kelp canopy which was the highest recorded for this bed since at least 1959. The ABAPY for the San Clemente bed shows that this bed and the Capistrano Beach bed respond typically to stimuli such as the El Niño and La Niña (Figure 21).

2011. Kelp had decreased, but was still large during the first aerial survey in April 2011; kelp continued to fill the footprint of the new artificial reefs deployed in 2008. Kelp was also observed on the older artificial reefs in the area during the numerous boat trips through the area (Curtis 2011, pers. obs.).

San Mateo Point 2010. San Mateo kelp beds were large in 1911 when Crandall reported them as covering 1.272 km^2. Based on a total for several beds in the region, it was likely the beds remained fairly large during surveys of 1955 and 1959, but they were only about 0.057 km^2 by 1970. The beds again became fairly large by 1980 (0.360 km^2) and a large fraction of their 1911 size in 1989, when they covered 0.870 km^2. After that period they began a slow decline, becoming precipitous by 1994. After a major decrease in 1995, San Mateo kelp beds increased in 1996 and early 1997, but decreased through the remainder of the year and disappeared in 1998. No kelp beds were observed until a sparse canopy was seen in November and December 1999. San Mateo kelp beds decreased greatly in 2004 to one-half of their 2003 size (0.242 km^2), but kelp appeared robust through the March 2005 survey. Kelp subsequently decreased and disappeared during the remainder of 2006. As observed during boat surveys, small beds were beginning to form by the end of 2006. The San Mateo kelp beds were still small in March 2007 and a large hole was observed in the middle of the kelp (this area had previously been a urchin barrens), but the beds began to increase and dive surveys in the area in April and May reported abundant kelp on bottom (Moore 2007, pers. comm.). The canopy coverage totaled 0.201 km^2 by the end of 2007 and the stimulus of the La Niña in 2008 allowed the kelp beds to double in size totaling 0.487 km^2 by the December 2008 survey, larger than they had been since 1989. Although 2009 appeared to be limited in nutrients, kelp none-the-less increased by the March 2009 survey to 0.545 km^2, but decreased somewhat during the next two surveys and made a recovery in December. During 2010, kelp canopy increased with each survey and totaled 0.583 km^2 by the late December 2010 survey, the largest area since 1989. There is a perennial hole in the San Mateo kelp bed that we note from year to year. As questions had been raised about the nature of this hole (sand bottom, urchin barrens, etc.), a dive survey was conducted in January 2010 to make observations. As North noted (North and Jones 1990), the bathymetry below the hole is a rocky cobble and boulder reef area that is elevated above the surrounding reef area. North thought that the area preferentially recruits sea urchin larvae to this hillock. Diver observations indicated that it is a large sea urchin barrens and both red and purple urchins were massed in a front along the kelp bed one to two meters wide with 20 to 30 red urchins and 100 purple urchins per meter square. The urchins were actively eating giant kelp plants and expanding the hole. In 2010, the ABAPY for the San Mateo kelp beds showed that these beds respond typically to stimuli such as the El Niño and La Niña by following the Orange County average relatively close although responding slightly more positively in 2010 than the average of the Orange County beds (Figure 22).

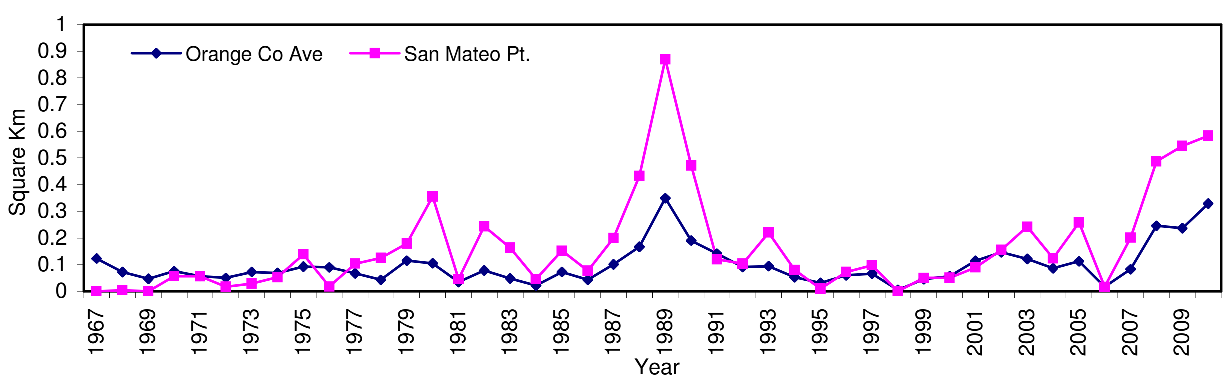

Figure 22. Comparisons between the average Orange County ABAPY and the canopy coverages of the San Mateo Point kelp bed for the years shown.

2011. Kelp decreased by the first aerial survey in April 2011, but the kelp bed remained large.

San Onofre 2010. The kelp beds at San Onofre were large in 1911 when Crandall reported them as covering 1.946 km^2. Based on a total for several beds in the region, it was likely the beds remained fairly large during surveys of 1955 and 1959, but were missing from 1967 to 1971, only to reappear in 1972 as relatively small beds totaling about 0.094 km^2. The beds gained a respectable size (about 0.20 km^2 or more) from 1973 through 1976, became much smaller and then increased in 1980 to 0.160 km^2 and again increased greatly from 1988 to 1990 culminating in a total canopy size of 0.763 km^2 in 1990. The beds waxed and waned during the next decade and a half, seldom getting larger than 0.10 km^2. In 2002, the beds were about 0.162 km^2, but by 2003 it was apparent that the beds had decreased by about 33%, and still further by 2004, mostly due to the disappearance of the inshore bed and scattered beds north of the diffusers. Kelp canopies appeared very good in the early part of 2005 and were larger than noted in December 2004. By July 2005 and through September, as would be expected in summer, the beds decreased greatly. They were, however, the only beds in the nearby region that persisted into January 2006. No surface canopy was present during the remainder of 2006 through March 2007. A boat survey indicated that small canopies were present and kelp was reported on bottom indicating recent recruitment; the beds became fairly robust by the end of December 2007and totaled 0.320 km^2 in canopy coverage. The aerial surveys of 2008 indicated that kelp beds stayed relatively similar in size in the spring, waning in the summer, and recovering well in the fall and winter, resulting in the canopy increasing in size to 0.476 km^2, the best it in almost two decades (1990). As 2009 began, the kelps beds appeared very good during the March aerial survey, but canopy coverage decreased to a still robust 0.419 km^2; however, kelp coverage decreased during the subsequent two aerial surveys, and then made a small recovery by December. The recovery continued through 2010 resulting in a robust canopy covering 0.458 km^2 that was larger than in 2009, but slightly smaller than the 2008 total. It is of interest to demonstrate that the San Onofre and San Mateo beds react very similar to stimuli as depicted in Figure 23. The ABAPY for the San Onofre kelp bed shows that this bed responds typically to stimuli such as the El Niño and La Niña following the San Diego County average relatively close (Figure 24).

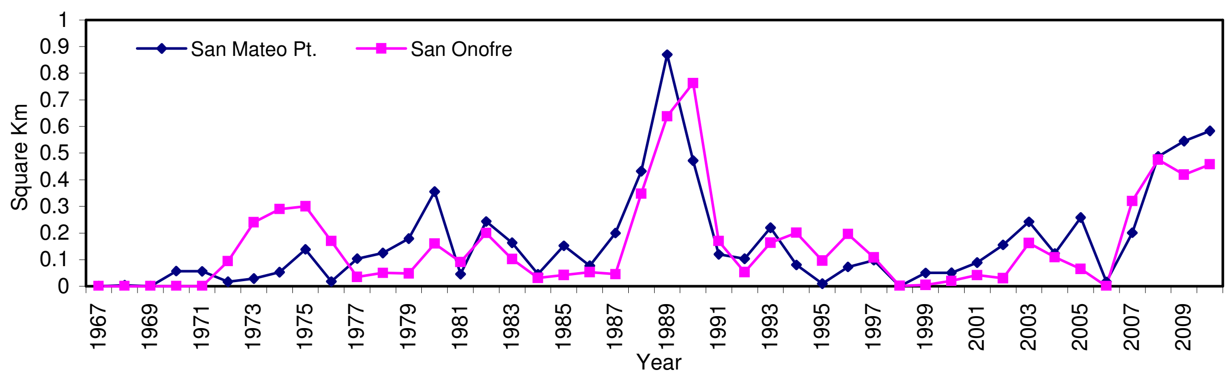

Figure 23. Comparison of histories of canopy coverages for the kelp beds off San Mateo Point and San Onofre. Operations at Unit 2 of the San Onofre Generating Station (SONGS) commenced in 1983. SONGS Unit 3 became operational in 1984.

2011. The San Onofre kelp bed had decreased by the April 2011 survey, but canopy coverage was still extensive. Kelp patches were observed frequently during boat and dive surveys throughout the area through June 2011 (Moore 2011, pers. comm.).

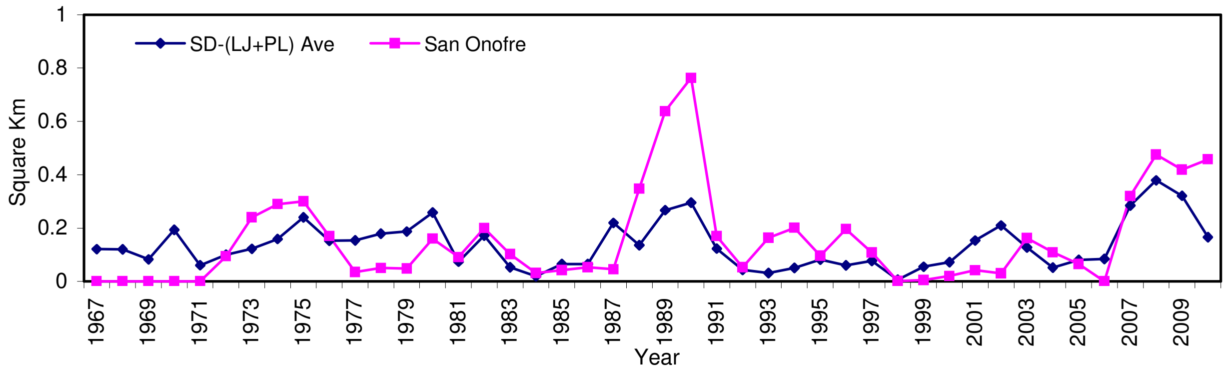

Figure 24. Comparisons between the average SD-(LJ+PL) ABAPY and the canopy coverages of the San Onofre kelp bed for the years shown.

Horno Canyon 2010. Kelp in this region appeared substantial in Crandall's maps of the 1911 survey, recording a canopy coverage of 0.352 km^2. Kelp was not recorded here again until it reappeared at Horno Canyon in 1988 as a very small bed of 0.006 km^2 and became as large as 0.040 km^2 before disappearing again in 1992. After an absence of another seven years, a small kelp canopy formed here in 2000. As conditions at Barn kelp were excellent from late 2000 through 2002, its proximity probably enhanced opportunities for kelp at this location and the few giant kelp found scattered in the area in 2002 had increased in density by 2003, but did not form a canopy. No canopy was noted at Horno Canyon or at nearby Pendleton Artificial Reef in 2005 as evidenced by boat surveys and the aerial surveys. Conditions began to deteriorate at nearby Barn kelp, indicating that nutrients were lacking in the area. No kelp was found in 2006 or through the early aerial surveys of 2007. During the December 2007 survey, small canopies formed and were covering an area of 0.015 km^2. A few giant kelp were also seen at Pendleton Reef (just upcoast of the Horno Canyon area) during a boat survey of the area in December 2007. Kelp canopies in this region appeared larger in 2008 than ever recorded and canopy covered an area of 0.083 km^2, indicating that kelp was responding to what appeared from the SSTs to be a favorable growing period. In 2009, kelp decreased to 0.018 km^2 and decreased further throughout the remainder of 2009. As it had been a long time since any diving surveys had been conducted at Pendleton Reefs, a diving survey was conducted in January 2010. Large numbers of sea fans and urchins, but only two ragged and grazed kelp recruits growing on isolated rocks in the area were found. Small kelp beds comprising the Horno Canyon kelp bed appeared numerous by the December 2010 survey and resulted in a total canopy coverge of 0.081 km^2, much larger than 2009 and very near the total in 2008. No kelp was observed on the surface at Pendleton Reef during any of the aerial surveys or boat surveys through the area in 2010. In 2010, the ABAPY for the Horno Canyon kelp beds indicated that these small beds are only viable during very large stimuli such as the La Niñas of 1989-1990, 2001, 2007-2008, and again in 2010 (Figure 25).

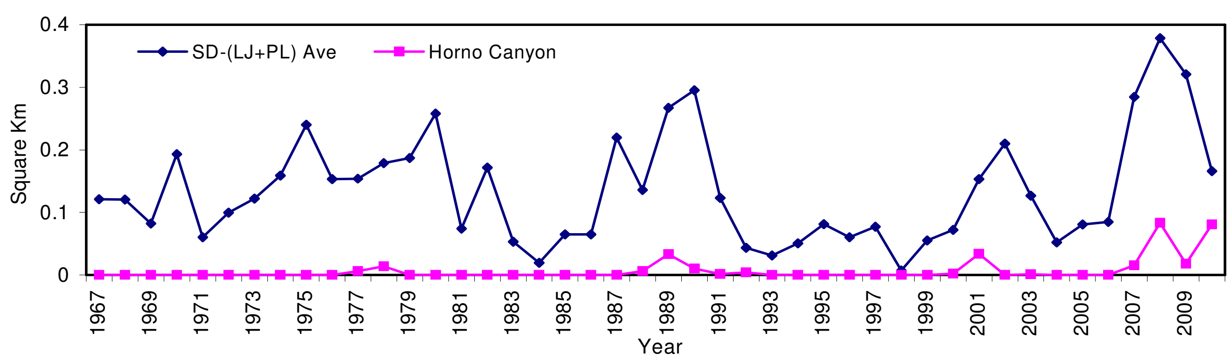

Figure 25. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Horno Canyon kelp bed for the years shown.

2011. Kelp canopies were still in evidence at the Horno Canyon kelp bed area, but much reduced by the April 2011 aerial survey.

Barn Kelp 2010. Barn kelp bed was very large during Crandall's survey of 1911, covering an area of 3.171 km^2. It was next recorded in 1967 as very small beds totaling about 0.017 km^2. The bed stayed small until 1973 when its coverage increased to 0.120 km^2, subsequently it became slightly larger and stayed substantial in size through 1978. It then again became much smaller and disappeared in 1981, not reappearing until a small bed was observed in 1988. In 1989 it increased in size to 0.116 km^2 and was much larger in 1990 at 0.382 km^2. During most of the next decade, to 1998, the bed vacillated in size between 0 and 0.260 km^2. In 1999, the bed reappeared and covered 0.310 km^2 and increased in size in 2000 (the La Niña of 1999-2000 apparently provided a similar stimulus to kelp growth), and was considerably larger during the overflights of 2001 and in 2002 and covered an area of 0.667 km^2, thereby becoming the largest it had been recorded since 1911. Thereafter, the bed began a decrease that accelerated with time from an apparent lack of nutrients in 2004, multiple factors in 2005, and again a lack of nutrients in 2006, resulting in the total loss of surface canopy. In 2007, Barn Kelp recovered to a large fraction (covering an area of 0.466 km^2) of its size last seen in 2003. This coverage was maintained in 2008, decreasing some in summer, but by the December 2008 aerial survey, Barn Kelp had increased greatly in size covering an area of 0.858 km^2 (larger than it had been since the 1911 survey), presumably reacting to cooler waters and adequate nutrients. Kelp in 2009 continued to respond to favorable conditions at the end of 2008 and increased to 0.926 km^2 by the March 2009 survey, but decreased thereafter. The bed again began increasing as evidenced by the larger beds seen with each succeeding aerial survey in 2010; however, the loss of kelp in the last half of 2009 resulted in a bed that was smaller than the 2009 total area coverage, but none-the-less it was still a substantial kelp bed of 0.5 km^2. The ABAPY indicated that this bed, other than for a severe downturn from 1980 to 1987, reacted similarly to the other beds in the San Diego region (Figure 26).

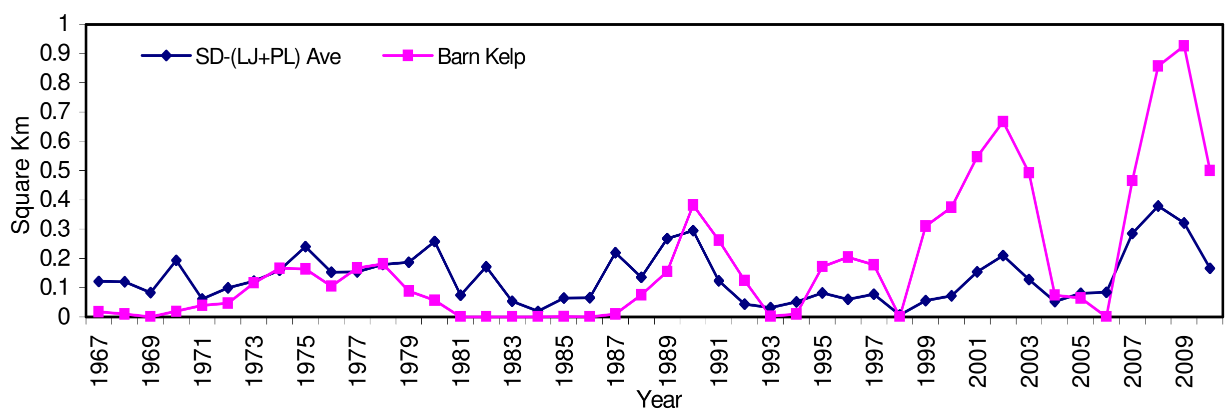

Figure 26. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of Barn Kelp for the years shown.

2011. The first aerial survey in April 2011 recorded a much reduced kelp bed. A boat survey in March through the area did not find any kelp on the surface, but kelp was recorded on the fathometer indicating that strong currents in the area were probably keeping the kelp subsurface.

Santa Margarita 2010. In 1911, Santa Margarita was the site of a substantial kelp bed covering 0.710 km^2; only a remnant of this formerly large bed has been seen since. Kelp disappeared here sometime before regular surveys began in 1967 by Dr. North. No kelp was seen during any of the boat or aerial surveys until 1991, when a small bed appeared covering an area of 0.049 km^2; it was much smaller in 1992 and disappeared and has not been seen since despite searching the area of the last known kelp beds. No kelp was observed at this location in 2010 despite careful viewing of the photos and efforts to find kelp during a 1 December 2010 boat survey.

2011. No canopy was noted at Santa Margarita during the aerial survey in April 2011.

North Carlsbad 2010. The small kelp beds that comprised North Carlsbad kelp bed were observed to be substantial covering 0.787 km^2 during Crandall's 1911 survey. The bed was next recorded in 1967 as a very small bed covering only 0.009 km^2, but increasing to 0.120 km^2 by 1980, and becoming larger with a canopy size of 0.165 km^2 by 1990. The interim period between these two periods saw a wide variation of kelp bed sizes from 0 to about 0.100 km^2. After 1990, the kelp bed again became smaller and disappeared during the last few years of the century. All canopy had disappeared from this site due to the El Niño of 1997-1998, but a sparse canopy was again found during the boat survey of November 2001. The bed continued to expand and became denser in 2002 indicating that environmental conditions continued to be favorable through late 2002. A small but dense bed was seen in 2003 (totaling 0.053 km^2), but it soon began to thin and was much less dense by the March 2004 survey and was not visible again until the December survey of 2004. A small bed was seen in early 2005, but it stayed small and was not seen during 2006. Diver observations in 2006 indicated numerous old holdfasts on the bottom, but only one small kelp recruit was noted during a 15-minute dive centered upon the last observed canopy. Apparently unfavorable environmental conditions (swells, turbidity, low nutrients, and persistent phytoplankton blooms) caused a decline in the bed through summer 2006 in the region. The bed was not observed during the first three aerial surveys of 2007, but the December 2007 survey depicted a newly expansive kelp bed larger than any seen since 2002. In 2008, the kelp bed was observed during the first survey, became smaller during the second, but resurged in December to 0.108 km^2, the largest recorded since 1990. By March 2009, the kelp canopy had increased to 0.135 km^2, but declined throughout the remainder of the year, with a robust resurgence by December 2009. This resurgence stalled by the November 2010 survey due to lack of nutrients in the area, but an increase was observed with a canopy in the region totaling 0.078 km^2 during the late December survey. In 2010, the ABAPY for the North Carlsbad and Agua Hedionda kelp beds indicated that these beds tended to disappear or become very small during periods of intermediate-to-low nutrient availability, and react strongly to stimuli such as large La Niña events (Figure 27).

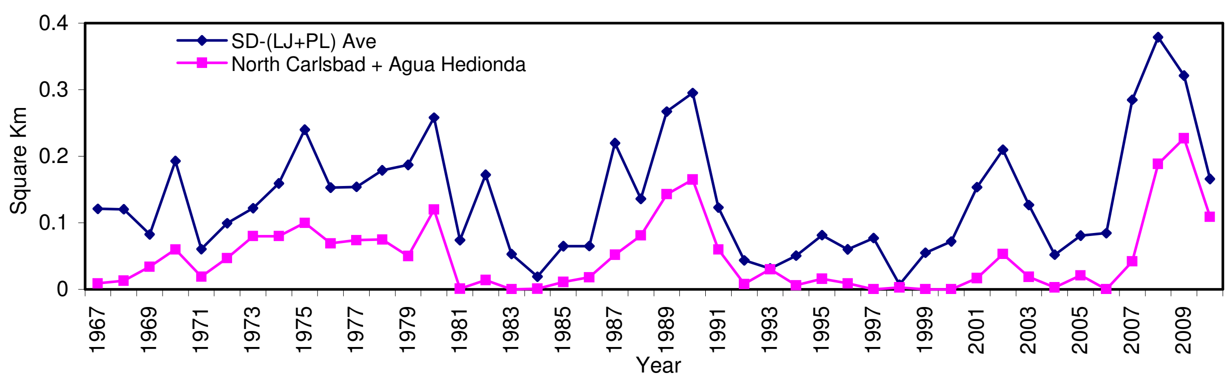

Figure 27. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the North Carlsbad plus Agua Hedionda kelp beds for the years shown.

2011. Kelp beds in the North Carlsbad region decreased substantially by the April 2011 aerial survey.

Agua Hedionda 2010. The kelp beds comprising Agua Hedionda kelp totaled 0.161 km^2 in Crandall's 1911 survey. No bed was recorded here from surveys between 1967 to 1969, but it reappeared as a very small bed covering only 0.006 km^2 in 1970. It increased to 0.036 km^2 by 1975, and became larger in 1989 (0.047 km^2), but declined thereafter. After 1990, the kelp bed again became smaller and disappeared during the last few years of the century. The kelp bed off Agua Hedionda was substantial in size in the last aerial survey of 1996. Subsequent surveys indicated that the increase in size of the kelp bed noted in late1996 was arrested and the El Niño of 1997-1998 devastated the bed. No kelp was observed at this site after the El Niño of 1997-1998 until a trace of kelp was noted in 2002. In 2003, this trace of kelp developed into a small but measurable bed (0.002 km^2). A trace of kelp was observed in the March aerial flight of 2005. The kelp bed actually increased in 2005 to a greater total surface canopy than seen since 1996, before surface canopy disappeared in 2006. The kelp bed off Agua Hedionda was not observed during 2006 aerial surveys; however, numerous sub-adult, juvenile, and recruiting kelp were found during a 15-minute survey in late 2006 in the vicinity of the last known bed indicating that the area was poised to recover pending adequate nutrients and favorable environmental conditions during the remainder of the year. No kelp was observed in the region during any of the first three aerial surveys of 2007, but a relatively large bed (0.016 km^2) appeared in December 2007 (larger than had been seen since 1991). The sudden appearance of the bed was indicative that the kelp was surviving below the thermocline (reinforced by the youthful appearance of the fronds during a boat survey in late 2007), taking advantage of good nutrient conditions. Kelp canopy at Agua Hedionda was smaller during the first three aerial surveys of 2008 than seen in December 2007, but was apparently doing well below the thermocline. When cool waters returned in late fall, the kelp bed increased greatly in size with a canopy coverage of 0.080 km^2. In 2009, the canopy grew through the March 10 survey to 0.092 km^2, but became progressively smaller during the next two surveys until finally responding to winter upwelling by regaining some canopy by December 2009. The large loss of canopy observed during the mid- to latter part of 2009 reversed in 2010 and began to increase again, but the canopy only measured 0.031 km^2 by the December 2010 aerial survey. The ABAPY in 2010 for the Agua Hedionda Kelp and North Carlsbad kelp beds indicated that these beds, other than a severe downturn from 1980 to 1986 and again from 1994 to 2000, reacted negatively to El Niño events, as did all the beds in the San Diego region. However, they did not recover (as most of the other beds did) from the downturns during relatively nutrient neutral periods; not returning until the large stimuli of the La Niña events (Figure 27).

2011. By the April 16 survey in 2011, the kelp bed of the Agua Hedionda region was reduced in size from that observed during the December 2010 survey.

Encina Power Plant 2010. The Encina Power Plant kelp canopy covered an estimated area of 0.642 km^2 during Crandall's survey of 1911. Kelp was not observed in the area during surveys from 1967 to 1969, but reappeared in 1990 as a small bed covering 0.025 km^2; by1975 it was much larger with surface canopy coverage totaling 0.144 km^2. It decreased in size until 1988, when favorable conditions produced canopies covering 0.161 km^2, increasing still further in 1989 to 0.251 km^2. After a few years the bed again decreased greatly in size and finally disappeared from 1997 to 2002. The Encina Power Plant bed in 2003 had increased in size while surrounding beds decreased. It was much larger than the few individual giant kelp observed in 2002 and was larger than it had been since the El Niño of 1997-1998. In late March 2005, the Encina Power Plant kelp bed had decreased substantially and by the June survey was not visible, nor was it seen in September or the first survey of 2006. An aerial survey conducted in April 2005 by Encina Power Plant for other required studies documented that the kelp bed increased from that noted in March 2005 (Weston 2005), indicative of the strong response the kelp bed can have to nutrient pulses. The loss of canopy by June 2005, caused apparently by a lack of nutrients as evidenced by Scripps SSTs, demonstrated how quickly the bed can deteriorate in their absence. Dive surveys conducted in the area offshore of Encina Power Plant in spring 2005 recorded much lower densities (about one-third less) of kelp on bottom as compared to that recorded in 2004 (Weston 2005). The kelp canopies were not visible during any surveys of 2006. A boat cruise in late July 2006 did not observe any surface canopy, but substantial numbers of sub-adult, juvenile, and recruiting kelp were noted on bottom indicating a recovery could take place in the late fall and winter with a return of favorable environmental conditions. A long, hot summer, with SSTs well above average, resulted in no kelp on the surface during either the September or December 2006 surveys. The bed was absent for the first three aerial surveys of 2007 following favorable environmental conditions, but returned in December 2007 as a relatively large bed covering an area of 0.081 km^2. The Encina Power Plant kelp bed had scattered canopies during the aerial survey of June 2008 and it was larger than observed in December 2007, becoming very large by the December 2008 survey when the bed covered an area of 0.306 km^2, larger than it was estimated to be in 1911. By the March 2009 survey, the kelp canopies had diminished by a third dropping to 0.215 km^2 and became smaller throughout the remainder of 2009, disappearing entirely in September, but reappearing in December 2009 almost as large as noted in March suggesting nutrients were again available. The bed was large in August and only slightly larger in the December 2010 survey (0.176 km^2) and attained a large percentage (81%) of its 2009 size. In 2010, the ABAPY for the Encina Power Plant kelp bed indicated that this bed mirrored the other beds in the San Diego region generally reacting favorably or negatively with large stimuli such as the La Niña and El Niño (Figure 28).

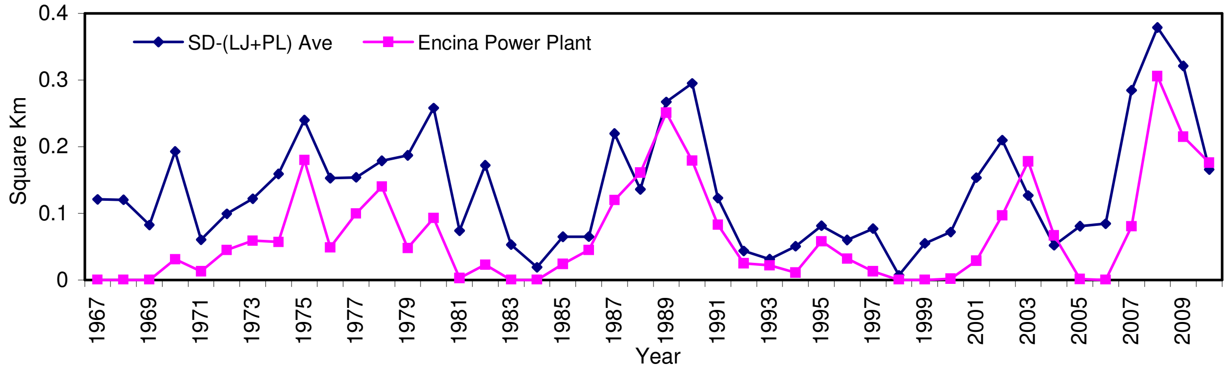

Figure 28. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Encina Power Plant kelp bed for the years shown.

2011. The April 2011 survey suggested that the kelp bed in the Encina Power Plant region had been substantially reduced in area since the December 2010 aerial survey.

Carlsbad State Beach 2010. This bed was estimated to be composed of many mid-size canopies during Crandall's survey of 1911, covering a total area of 0.278 km^2. The bed was not recorded again until 1967 during an aerial survey by North (North and MBC 2001) when small canopies covering an area of only 0.032 km^2 were observed. The kelp bed increased by 1975 to 0.200 km^2, but was less than one half that size thereafter until 1989 when it increased again to 0.251 km^2. After being absent since 1996, a trace of kelp was observed during the fall survey of 2000, and small canopies were noted during the last survey in December 2000. A sparse giant kelp bed was present in 2001, which became denser in 2002, but the bed began to deteriorate after the beginning of the year and did not maintain the canopy gains from a more productive 2002 survey year. Only a trace of kelp was seen by the end of 2003. Again, only a trace of kelp was noted at this location during 2004. The kelp bed was not observed in any of the aerial surveys of 2005, nor in any of the other aerial surveys of 2006. It reappeared as small (0.064 km^2) canopies with young kelp fronds in late 2007. By the December 2008 survey, the kelp bed offshore of Carlsbad State Beach was larger (totaling 0.121 km^2) than it had been since 1990. A slight increase in canopy size was recorded in early 2009 (0.127 km^2) suggesting nutrients were available in late December 2008 through March 2009, waning throughout the remainder of the year with a large canopy showing by the December 2009 survey. That canopy was reduced by the March survey and became further reduced by the early November survey, but rebounded by the late December survey to cover an area of 0.069 km^2 with canopy. In 2010, the ABAPY for the Carlsbad State Beach kelp bed indicated that this bed was similar to the other beds in the San Diego region through about 1980, but became generally a smaller bed thereafter, not reacting favorably to the 1998-1999 La Niña (Figure 29).

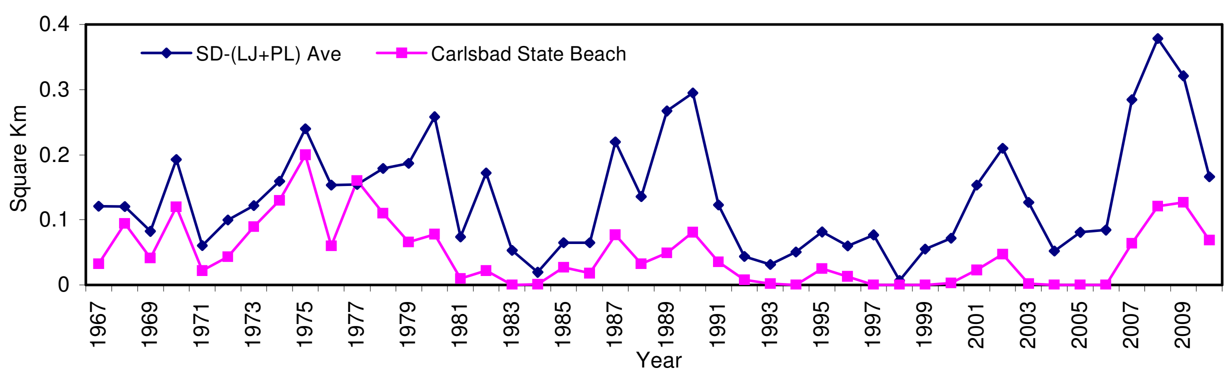

Figure 29. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Carlsbad State Beach kelp bed for the years shown.

2011. The kelp bed offshore of Carlsbad State Beach was smaller by the April 2011 aerial survey than observed in December 2010.

Leucadia 2010. The Leucadia kelp beds (sometimes referred to as the North, Central, and South Leucadia kelp beds) covered an estimated area of 1.224 km^2 during Crandall's survey of 1911. Kelp was next recorded in 1967 as substantial beds covering 0.240 km^2, becoming twice that size by 1975 (0.500 km^2), and larger still by 1980 (0.670 km^2). They were still substantial (over 0.150 km^2 in area) from 1987 to 1991, and again in 1995. Kelp disappeared from aerial surveys during 1998 but apparently survived below the thermocline, as the beds reappeared relatively soon in 1999. In the October 2000 survey, beds were observed in all three locations off of Leucadia and increased slightly in the December survey. The three beds continued to increase from 2001 through 2003, with a total surface canopy coverage of 0.185 km^2 in 2003. In 2003, the three main beds offshore of Leucadia appeared much smaller, as is common during the aftermath of the winter when light is limited, but atypically continued to decrease in overall canopy area throughout 2003. This decrease continued and the beds were reduced to about one-fourth their 2003 size (0.185 km^2) by the end of 2004 (0.045 km^2). The beds of Leucadia appeared to be increasing during the first two aerial surveys of 2005 with all three main beds improving by June. However, none of the beds were visible during the September or end-of-the-year overflights and they remained small in 2006. During the first three aerial surveys of 2007, kelp did not appear to be developing well, and no surface canopy was apparent in October. However, during a boat cruise in mid-December 2007, kelp appeared to be very healthy with young, yellowish brown blades signifying adequate nutrients, ultimately resulting in canopies that covered 0.233 km^2 in December 2007. The beds of Leucadia reacted well to nutrient pulses in the early part of 2008, and by the first aerial survey in May 2008, the beds were maintaining their 2007 size; they decreased during summer, but by late fall, they had increased to their largest size (0.421 km^2) since 1989. With nutrients available in early 2009, the beds increased slightly to 0.429 km^2 by the March 2009 survey, became smaller during the next two surveys, but were very close to their March size by the December 2009 survey. The beds were alternately large and small during the first three surveys of 2010, but ultimately were the largest during the December 2010 survey with a canopy total of 0.215 km^2, almost exactly one half what it was in 2009. In 2010, the ABAPY for the Leucadia kelp beds indicated that these beds mirrored the other beds in the San Diego region from about 1983 to the present, although they did not reach the magnitude of the changes recorded from 1967 to 1980 in the other beds (Figure 30).

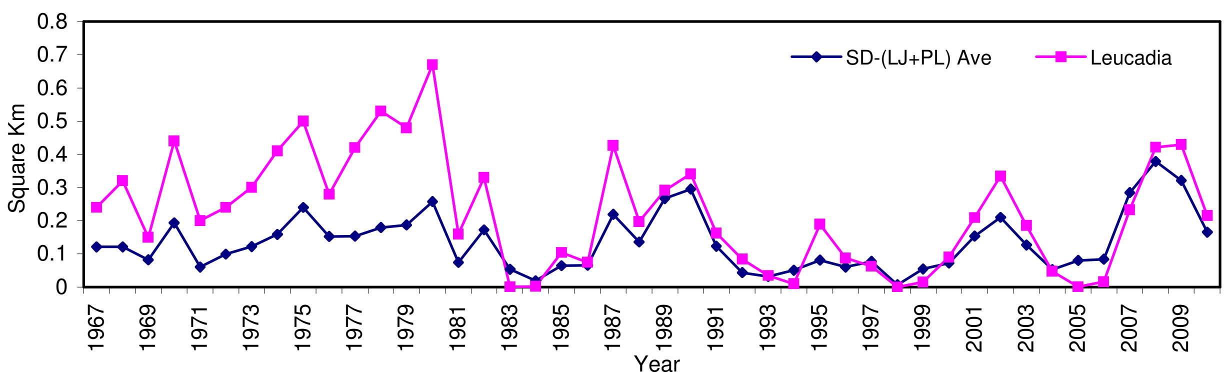

Figure 30. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Leucadia kelp bed for the years shown.

2011. In early 2011, the kelp beds of the Leucadia region appeared to have decreased and were thinner since the December 2010 aerial survey.

Encinitas 2010. Encinitas kelp bed was estimated to cover about 0.367 km^2 during Crandall's 1911 surveys. This bed was not recorded again until North's surveys of 1967 (North and Jones 1991), when it was observed to be small canopies covering an estimated 0.065 km^2. By 1970, the canopies had improved and covered 0.173 km^2 and by 1980 the bed covered 0.228 km^2. The bed was not that large again until 1987 through 1990 (reaching a canopy coverage of 0.241 km^2 in 1990), decreasing thereafter until about 2001 when it again covered 0.131 km^2. The kelp bed offshore of Encinitas formed a small canopy in 1999 following a total loss of canopy in 1998. By December 2002, the canopy was considerably larger and there was an uninterrupted expanse of kelp throughout all of the offshore area of Encinitas. Canopies decreased by two-thirds in 2003 and continued a downward trend, as by 2004 the bed was only about one-third the size noted in 2003. Kelp in this region increased during the first two surveys of 2005, but diminished during the last half of the year with only a trace of kelp by January 2006. This whole region was subjected to intense phytoplankton blooms during much of the 2006 year and this (combined with a weak nutrient regime), severely impacted the area. Only a trace of kelp was observed during the first survey of 2006 and kelp was not visible during the next two surveys, but there were very small canopies by the December 2006 overflight. Kelp canopies were thin and appeared very small during the first three surveys of 2007, but rebounded to become a substantial bed by the December 2007 aerial survey covering an area of 0.205 km^2. The kelp bed offshore of Encinitas increased by the June 2008 overflight, but was not substantially larger than that observed in December 2007, but by the December 2008 overflight, the canopies had increased to 0.346 km^2, a size not recorded since the 1911 survey. The kelp bed again decreased to 2007 levels by the March 2009 survey (0.205 km^2) and continued a downward trend until nutrients returned by the December survey resulting in a larger canopy. Although maintaining almost the same canopy size since December 2009, the Encinitas kelp bed was much reduced by the end of 2010 to 0.128 km^2, slightly larger than one half its size in 2009. In 2010, the ABAPY for the Encinitas kelp bed indicated that this bed almost exactly mirrored the other beds in the San Diego region (Figure 31).

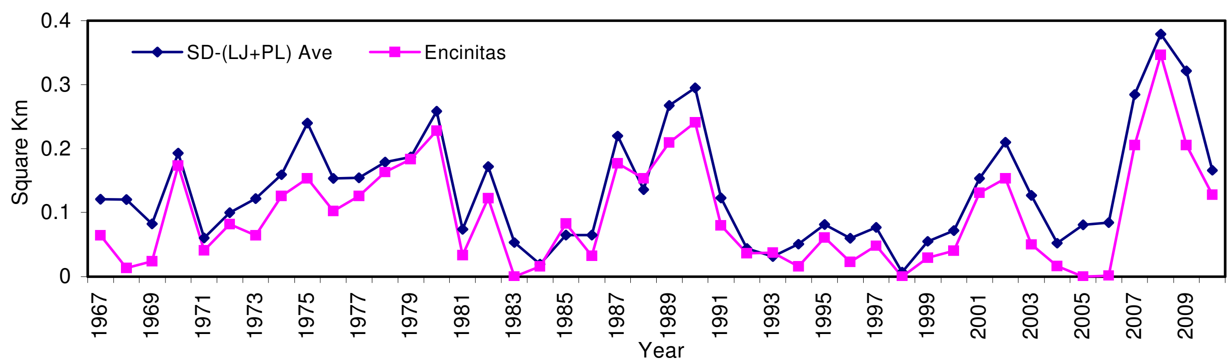

Figure 31. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Encinitas kelp bed for the years shown.

2011. By the April 2011 aerial survey, the kelp bed of the Encinitas region began to lose canopy and was recorded as only a remnant kelp bed indicating an apparent lack of nutrients in the intervening three months since the last survey.

Cardiff and Solana Beach 2010. From Crandall's maps, the kelp bed at Cardiff was estimated to be 0.713 km^2 and the Solana Beach bed was estimated to cover 1.097 km^2. Because of their close proximity and an almost arbitrary demarcation line between the two, they are treated together here. However, they are large enough that the north and south end of the beds can respond differently to environmental signals. These two large beds were not recorded again until 1955, but that total (0.340 km^2) included not only Solana Beach, but Del Mar kelp beds as well, as did a total of 0.400 km^2 recorded in 1959, and 0.160 km^2 recorded in 1963. In 1967, individual bed estimates were 0.125 km^2 for Cardiff and 0.290 km^2 for the Solana Beach beds. By 1975, the two kelp beds' individual total coverage was 0.125 km^2 for Cardiff and 0.290 km^2 for the Solana Beach beds, and by 1980 they had increased in area to 0.442 km^2 for Cardiff and 0.690 km^2 for the Solana Beach beds. Following a few poor years during the El Niño of 1982-1984, kelp ramped up to cover an area of 0.575

km^2 offshore of Cardiff and 0.488 km^2 offshore of Solana Beach in 1989. Kelp beds in both locations were relatively small through 1999. By the end of 1999, substantial numbers of scattered giant kelp were found throughout the offshore areas of Cardiff and Solana Beach, with several large canopies observed in both areas in December. In 2000, kelp beds were large and appeared healthy, and were more than double the size documented in 1999 at the beginning of the La Niña. The Cardiff and Solana Beach kelp beds continued to expand in 2002 (0.405 km^2 offshore of Cardiff and 0.488 km^2 offshore of Solana Beach), but 2003 documented a 50% reduction, a trend that continued in 2004 as both of these giant kelp beds decreased by more than 75% from their size in 2003. The March and June aerial surveys of 2005 recorded substantial increases in canopy in the south at Solana Beach from that observed in December 2004, but the more northern Cardiff kelp bed was not observed. By the 2005 year's end, the Cardiff bed had no canopy, while the Solana Beach bed increased. In April 2006, there was a slight amount of kelp in the Cardiff bed, but only a trace at Solana Beach and no kelp was observed at either bed in June. A boat survey in late July 2006 did not record any kelp on the surface, but a diver survey recorded substantial numbers of sub-adult, juvenile, and recruiting kelp on bottom. In addition, four adult pink abalone, ranging in size from 14 to 18 cm in length, were observed in about a 15-minute survey. Apparently, kelp remained below the thermocline and survived unfavorable environmental conditions (swells, turbidity, and low nutrients) which caused a decline in the adult kelp populations in the early portion of the year and through the summer. Small canopies formed by December 2006 at both sites. Both beds were larger but still below average in early 2007; they disappeared by the October 2007 survey, but again reappeared as very substantial kelp beds in December 2007 (0.286 km^2 offshore of Cardiff and 0.457 km^2 offshore of Solana Beach). They were larger than had been seen since 2002. Both beds increased in canopy coverage by the June 2008 aerial survey, with Cardiff appearing substantially larger, and Solana Beach somewhat larger. By the December 2008 survey, the total canopy coverage was 0.484 km^2 offshore of Cardiff (largest bed size since 1989) and 0.823 km^2 offshore of Solana Beach (a substantial portion of what Crandall reported in 1911 and its largest size since then). Cardiff increased in early 2009 to 0.520 km^2, while Solana Beach decreased to 0.505 km^2 by March. Both beds decreased during the next two surveys and rebounded to healthy but smaller beds by December 2009. The two beds decreased in 2010 along with most of the other beds in this region to about one half of their combined sizes in 2009: 0.213 km^2 at Cardiff and 0.318 km^2 at Solana Beach. In 2010, the ABAPY for the Cardiff and Solana Beach kelp beds indicated that these beds mirrored the other beds in the San Diego region from about 1983 to the present, although the magnitude of the changes was greater because of the relatively large size of these two beds compared to the remainder of the beds in the region (Figure 32).

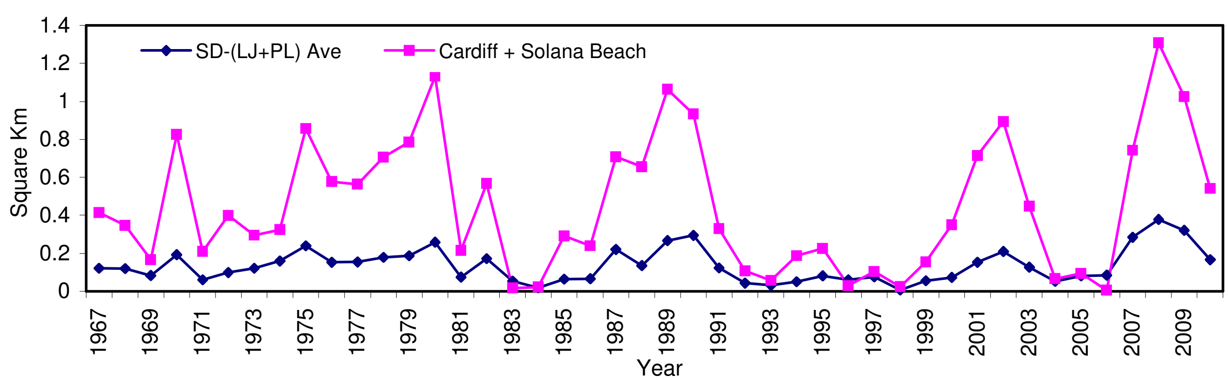

Figure 32. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Cardiff and Solana Beach kelp beds for the years shown.

2011. By the April 2011 survey, the kelp beds in the Cardiff and Solana Beach region were reduced to slightly below average conditions, as were most of the beds in the nearby region.

Del Mar 2010. Del Mar kelp bed was estimated at 0.540 km^2 during Crandall's survey of 1911. Although, the bed was reported in 1955, 1959, and 1963, its area was lumped with both Cardiff and Solana

Beach. The first individual record after 1911 was in North's 1967 survey when canopy coverage totaled 0.190 km^2 (North and MBC 2001). It was a small bed for a few years thereafter and then was similarly large in 1974 to 1980, reaching canopy sizes of 0.310 km^2 in 1979. The bed shrank until 1989, when it began responding favorably to La Niña, and then again was small to very small through 1995. In 1995, canopy again increased at Del Mar and then disappeared in 1996 and 1997. Only small kelp canopies were present along Del Mar by June of 1998, and these too disappeared and were not seen during overflights throughout 1999. By the October 2000 survey, a trace of kelp appeared, and small canopies were again present in December. Small kelp canopies at Del Mar were present in the April overflight of 2001, but did not increase substantially throughout the remainder of the year. The Del Mar bed more than doubled in size between 2001 and 2002, beginning as small canopies that were observed in the April 2002 aerial survey and becoming somewhat larger (but still very small) by the December 2002 survey (0.035 km^2). In 2003, the bed was only about one-third of its largest extent noted during the last two decades; it disappeared by the first aerial survey of 2004 and was not recorded during any of the subsequent aerial surveys of that year. Del Mar kelp bed was very small in 2005 and as such was not large enough to sustain the stresses of inadequate nutrients and disappeared from the surface during aerial surveys. Del Mar kelp bed was not observed during any of the surveys of 2006 and was not observed during a boat survey through the area in late July 2006. The bed reappeared in 2007 and was larger than had been seen since 1995, after an absence of three years. Almost all of the kelp fronds were dark yellow and young, indicating that adequate nutrients were recently available. The bed at Del Mar was present during the survey of June 2008, but became somewhat larger by December 2008 covering an area of only 0.057 km^2. Del Mar kelp bed was reduced by March 2009, but stayed substantial in June, kelp was below the thermocline in September and reappeared in December as a bed with a canopy coverage of 0.044 km^2. Although a small bed, it stayed substantially the same size (0.038 km^2) in 2010 as it was in 2009. In 2010, the ABAPY for the Del Mar kelp bed indicated that this bed mirrored the other beds in the San Diego region until about 1995, then from about 1983 to the present it stayed very small in spite of large stimuli that occurred and affected the other beds in the region (Figure 33).

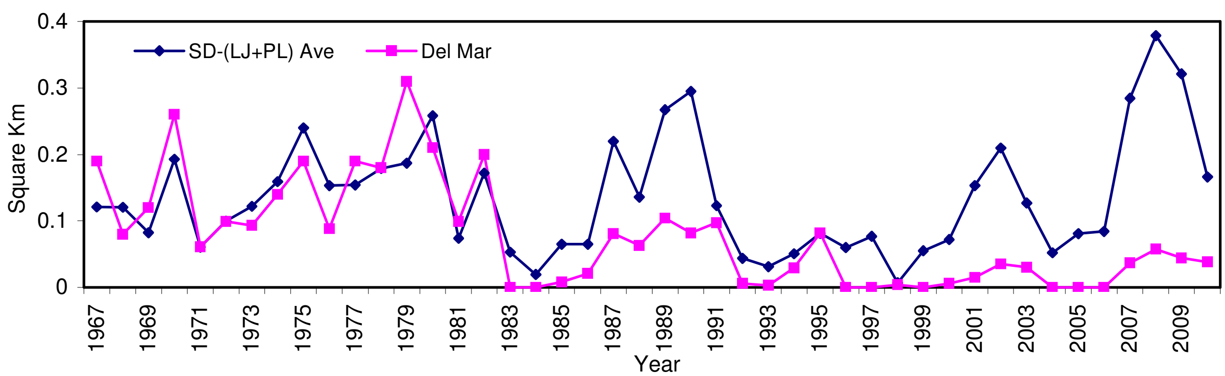

Figure 33. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Del Mar kelp bed for the years shown.

2011. The aerial survey of April 2011 suggested the Del Mar kelp bed was much reduced as only a remnant of kelp was recorded.

La Jolla 2010. La Jolla kelp bed was composed of two main canopies and were large when Crandall measured them in 1911, covering an area totaling 6.060 km^2. The canopy coverage was larger still in 1934 (8.161 km^2) and continued to be very large in 1941 (7.847 km^2), but apparently suffered a reversal during some portion of the next 14 years, as by 1955 it only covered an area of 1.660 km^2. In a survey conducted in 1959, the beds were again larger than observed in 1911, at 6.490 km^2, but by the time North began surveying in 1967, they were reduced to very "small" beds (for La Jolla) covering only 0.330 km^2 (North and MBC 2001). Over the next 13 years to 1980, the beds ranged between 0.290 and 1.900 km^2 and averaged about 0.800 km^2. The beds were very small during the El Niño of 1982-1984 (covering 0.032 and 0.034 km^2

during the later two years). The beds rebounded in 1987 covering over 2.0 km^2 and then increased to 4.755 km^2 in 1989, a significant fraction (78%) of the size seen in 1911. By 1990, they were 98% of their 1911 size with canopy coverage of 5.943 km^2. Kelp beds at La Jolla began to increase in late 1998 after a very poor year during the El Niño of 1997-1998. The beds rapidly increased in size during the La Niña of 1999-2000. They were very large in the April 2000 aerial survey and the beds appeared to be reclaiming canopy in the shallow portions of the bed that disappeared in 1998. In 2001, kelp was dense, extensive, and healthy and was located beyond the 80-ft depth contour on the north edge of the bed and out to 95 ft on the offshore edge of the beds. The beds stayed large through 2002 and for most of 2003 (reaching 3.444 km^2), decreased in 2004 (1.029 km^2) to about one-third of their 2003 size, and decreased still further in 2005 (0.873 km^2) and 2006 (about 1/30th - 0.117 km^2- of their 2003 size). By the September 2006 survey, only a trace of kelp was visible from the air, and by December 2006, any recovery was limited. A diver survey in relatively shallow water (80 ft) in a previously dense portion of the beds did not observe any kelp on bottom. Individual kelp were common, but no coherent canopy was present by late July 2007 and kelp appeared stressed during the first three aerial surveys of 2007, but the beds increased by the December 2007 survey by more than 25-fold (to 2.750 km^2) over their size noted in 2006. The La Jolla kelp beds continued to increase and by the December 2008 aerial survey were larger (4.145 km^2) than they had been since 1989. Again, nutrient conditions by March 2009 were apparently not adequate, or there were losses from powerful storms that occurred in mid-February 2009; in any case canopy coverage decreased to 2.274 km^2 by March and June 2009 and stayed smaller throughout the remainder of 2009. Both portions of La Jolla kelp peaked during the August 2010 survey, reaching 2.776 km^2 (larger than in 2009) and decreased drastically thereafter. In 2010, the ABAPY for the La Jolla kelp beds (based on the La Jolla and Point Loma kelp bed averages) mirrored the average for the two beds, suggesting that they are part of the same oceanographic regime (Figure 34).

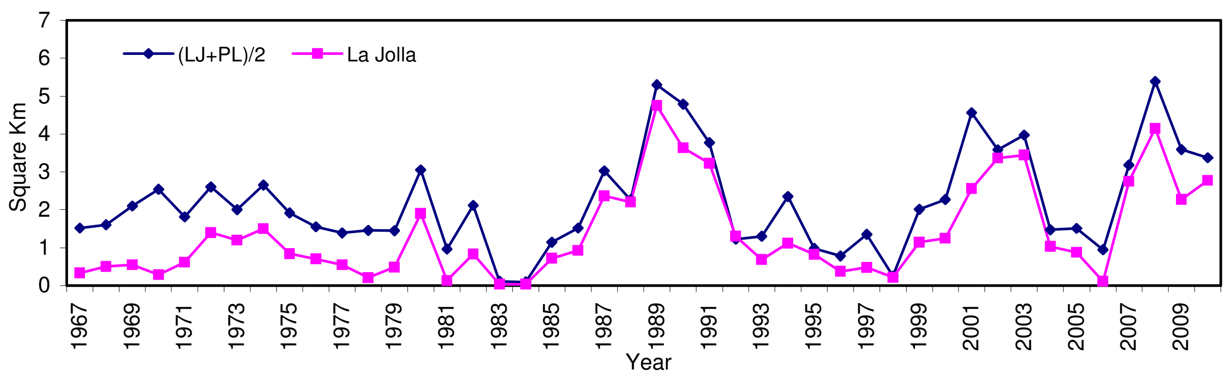

Figure 34. Comparisons between the (LJ+PL)/2 ABAPY and canopy coverages of the La Jolla kelp bed for the years shown.

2011. The two kelp beds of the La Jolla region were very small at the April 2011 aerial survey. It appeared that kelp was below the thermocline which could indicate a rapid recovery if nutrients become available.

Point Loma 2010. The Point Loma kelp bed is composed of many usually contiguous kelp canopies ranging from depths of 15 ft to over 100 ft during good nutrient years; they were very large in 1911 during Crandall's survey covering a linear distance of almost "eight nautical miles" and an area of 18.675 km^2 (North and Jones 1991).That survey total was the exact amount recorded during a survey conducted in 1857, indicating that Crandall's perimeter measurements (other than the inability to see holes) were probably accurate (Table 2, SWQCB 1964, Neushul 1981, Appendix B). The canopy coverage was considerably smaller, but still very large in 1934 (11.465 km^2) and in 1941 (8.286 km^2), but apparently suffered a reversal during some portion of the next 14 years, as by 1955 they only covered an area of 1.990 km^2. In a survey conducted in 1959, they were much smaller than observed in 1955 at 0.610 km^2, but by the time North (North and MBC 2001) began surveying in 1967, they covered 2.700 km^2, growing larger with a canopy coverage of 4.990 km^2 by 1970. Over the next 10 years to 1980, the beds ranged between 2.2 and 4.2 km^2, and averaged about 3.0 km^2. Following a low point with canopies covering less than 0.3 km^2 during the El Niño of 1997-1998, the kelp bed of Point Loma's peak (since 1941) canopy expanse of 6.6 km^2 occurred as a result of the La Niña of 1999-2000. In 2001, the canopies were substantially larger than in 2000, indicating that the La Niña probably had an effect on the growth of the bed equal to the 1989 La Niña. Kelp canopies grew well in 2001 during an exceptionally clear water period of intense upwelling. After the peak of 2001, the kelp bed areas began to dissipate and were noticeably less during all of the 2002 surveys, retreating from deeper depths, but still covering much of the same area. It was, however, noticeably more diffuse and scattered holes were noted along the entire length of the bed. After experiencing a loss of about 40% of its size in 2002, the kelp bed again increased in 2003 (covering 4.509 km^2). In early 2004, the bed at Point Loma again began to decrease and was less than one half its size noted in 2003 by December 2004. Point Loma kelp bed lost a large amount of surface canopy, but the loss was mostly confined to the deeper water areas. Overall the bed increased slightly in 2005 (to 2.152 km^2), but was still less than one half that noted in 2003. In 2006, the bed remained substantial, but a somewhat smaller bed than noted in 2005. Even though nutrients were again low in 2006 at nearby Scripps Pier, local upwelling apparently resulted in an ample supply of nutrients promoting good growth during a period when most of the beds typically lose canopy size. By the end of 2006, the kelp bed (an area of 1.767 km^2) was only about 40% of its size recorded in 2003. It appeared to be much reduced during the first three aerial surveys of 2007, but responded well to apparent increases in nutrients and increased to about double (3.616 km^2) the size noted in 2006 and was similar, though smaller, to the bed size last recorded in 2003. The Point Loma kelp bed continued to increase in 2008 and was much larger by June 2008, decreased somewhat during the summer, and by December 2008 rebounded to the largest (a total canopy coverage of 6.631 km^2) it had been since 1941. Although very large in 2009, the Point Loma kelp bed decreased to 4.909 km^2 by March, increased slightly to June 2009, and then decreased greatly throughout the remainder of 2009. In lockstep with La Jolla, this bed also peaked in August at a total canopy coverage of 3.977 km^2, but declined alarmingly throughout the remainder of 2010. In 2010, the ABAPY for the Point Loma kelp beds (based on the La Jolla and Point Loma kelp bed averages) mirrored the average for the two beds, suggesting that they are part of the same oceanographic regime (Figure 35).

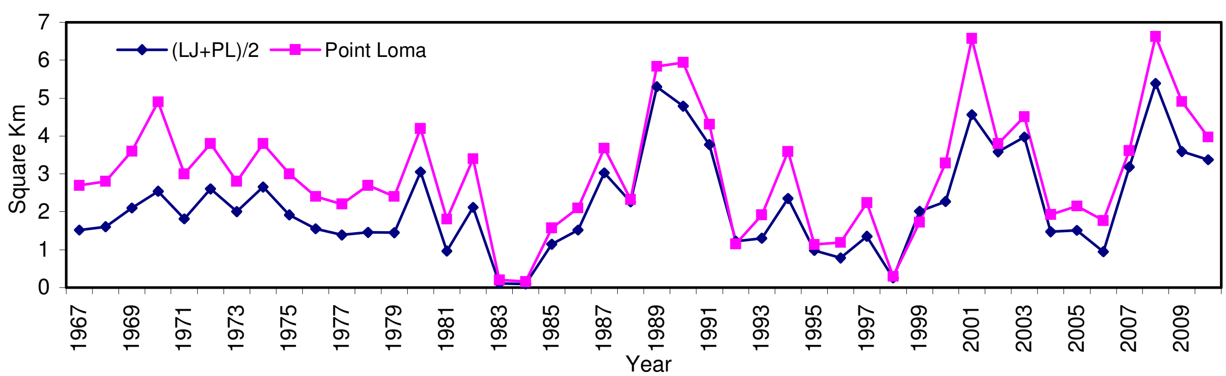

Figure 35. Comparisons between the (LJ+PL)/2 ABAPY and canopy coverages of the Point Loma kelp bed for the years shown.

2011. By April 2011, the kelp bed at Point Loma continued to lose canopy and was very thin with most of the canopy presumably subsurface.

Imperial Beach 2010. The Imperial Beach kelp bed canopies were recorded as covering 0.984 km^2 during Crandall's survey of 1911, but were not observed during surveys from 1967 to 1980. This area was the focus of restoration efforts by North in the mid-1960s and the 1970s; these beds had significant problems with urchins dominating the substrate and Dr. Wheeler North's considerable efforts in this area met with repeated failure as urchins overwhelmed the canopies. Ultimately, these efforts culminated in the appearance of a relatively large kelp bed (0.350 km^2) in 1980, but only about one-third the size noted by Crandall in his 1911 survey. The beds were alternately small and then large through 1990. Their high point (0.727 km^2) in 1987 was atypical compared to the remainder of the San Diego beds, as those did not reach their highs until the

1989 La Niña. After 1991, the beds were relatively small until they disappeared in 1998, reformed as a single small bed in 1999 and 2000, but were further south than their previous location off of the Imperial Beach Pier. The beds at Imperial Beach in 2005 became larger with each succeeding aerial survey. By late September they were larger (0.400 km^2) than they had been since 1990; but, in the final survey for the year, they were greatly reduced in size. The Imperial beach kelp beds have responded differently than most of the other beds in the region during much of the past two decades. The Imperial Beach kelp bed canopies increased significantly in 2005 and 2006 while most other beds in the region decreased greatly from lack of nutrients, persistent phytoplankton blooms, and large swells that were prevalent in most of the region through 2006. By the December survey 2006, the kelp beds were very robust and regained the size (0.400 km^2) recorded in 2005. The beds did not appear to be reacting favorably to environmental conditions during the first three aerial surveys of 2007, but by the December survey, the display of canopy was significantly increased with the aerial survey recording a larger bed (1.493 km^2) than had been recorded historically, far larger than Crandall (considered the baseline) recorded in 1911. The Imperial Beach kelp bed canopies continued to increase by the June 2008 aerial survey and by the December 2008 survey were extending further south than noted in 2007. The December survey recorded a new high in canopy coverage for this bed with a canopy covering 1.895 km^2. The extremely large kelp canopies found in December 2008 did not last into March 2009, when a bed of 0.862 km^2 was recorded (almost as large as Crandall recorded in 1911). This bed became progressively smaller in 2009 and disappeared between the 17 December 2009 and 28 March 2010 surveys. The almost entire loss of this bed by the end of 2010 (canopy of only 0.004 km^2) is not explained but indicates that a major disruption occurred earlier in the year. Sea urchin grazing and storms have been implicated in losses in the past at this bed; however, a diving survey which would have elicited information on urchin status was not conducted until the end of 2010. The other possible culprit (upon which information could be obtained post-event) was large swells. Examining the swell record from the CDIP Point Loma South station which is offshore of Imperial Beach, it appears swells may have been the cause or at least contributed to the loss (Figure 36). Wave heights in late December and January reached 3 to 4 m on several occasions. This included a one week period in January with sustained swells exceeding 3 m. It is very likely that these sustained swells had a serious deleterious effect on the kelp found on the cobble bottom of this region. The bed was represented only by remnants in the August and November surveys and was not much greater by the 31 December 2010 aerial survey. In 2010, the ABAPY for the Imperial Beach kelp beds indicated that this bed followed the San Diego region kelp bed ABAPY by decreasing greatly (Figure 37).

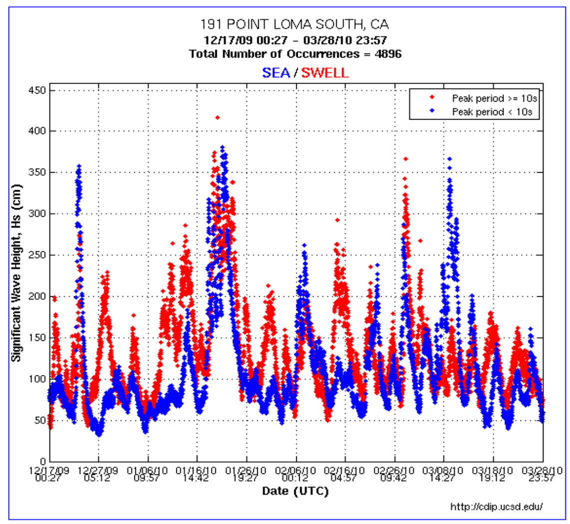

Figure 36. Significant wave heights offshore Point Loma South, CA. 17 December 2009 through 28 March 2010.

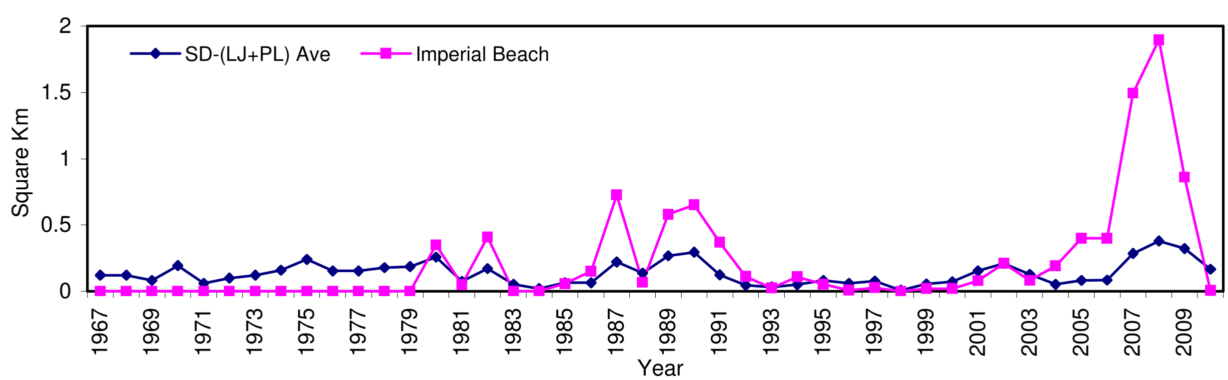

Figure 37. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverages of the Imperial Beach kelp bed for the years shown.

2011. No kelp was noted during the review of the April 2011 survey of Imperial Beach kelp bed.

DISCUSSION

Based on the analysis of the oceanographic data and the aerial overflight surveys in 2010, kelp growth within the 25 kelp beds monitored as part of the Region Nine program was reduced in the early portion of the year, and then responded to nutrient pulses from mid-March until the end of September, with a short hiatus in October, and again began to increase during the latter part of the year. About one half of the beds in the region increased and the other one half decreased in 2010. Most of the kelp beds saw their largest canopies in December as is typical; however, the two largest beds in the region (La Jolla and Point Loma) peaked in August which typically is a very poor month for growth. Sea surface temperatures in 2010 were generally below average during most of the year in the north and slightly below average in the southern portion of the range. For the 2010-2011 season, the NQ for the waters off Scripps Pier was 17, while off Imperial Beach the NQ was 20, indicating nutrients were marginal during this period. This would explain why the kelp beds in the extreme southern region (La Jolla, Point Loma, and Imperial Beach) all but disappeared during the latter part of 2010.The surface waters of Newport Beach (in the 2010-2011 season) had an NQ of 35, suggesting more than adequate availability of nutrients explaining the growth in the northern section. However, the nutrient availability at San Clemente Pier with an NQ of 19 appeared to be marginal. Therefore kelp beds in the San Clemente to Del Mar area had mixed reactions based on the availability of nutrients. By the final survey of 2010, the strong response of the kelp beds across the region suggested that nutrients were available in the region that were not necessarily being detected by SSTs. These stealth nutrient pulses were apparently due to local upwelling which gave an impetus to the kelp canopies in the region beyond what was recorded in the SSTs resulting in canopies along the Region Nine coastline reconstituting to sizes that were a large percentage of that recorded in early 2009.

CONCLUSION

Kelp canopy coverage was very good in 2010 and would have been considered phenomenally good if not for the size of the canopies that were measured at the end of 2008 (and in 2009). The differing responses of the Region Nine kelp beds are indicative that during marginal nutrient conditions their viabilities are determined by differing localized factors, which reflect the variability in flow regimes and oceanographic conditions, from locally and regionally determined sources.

Based on the results of the 2010 surveys, there was one kelp bed (Imperial Beach kelp bed) that appeared to be responding atypically to environmental inputs when compared to neighboring beds in the region. The almost entire loss of this bed is not fully explained but it progressively became smaller in 2009 and disappeared between the late December 2009 and late March 2010 surveys, with only very small canopies present in the remainder of 2010. An examination of the swell record potentially implicates large swells in the reduction as the kelp there grows on cobble bottom, which is especially susceptible to storm damage. Although the data would suggest very poor growth in 2009, the larger canopies seen in 2008 provided a buffer for the effects of the El Niño in early 2009 resulting in larger canopies than would typically be expected with the poor nutrient regime. As 2009 progressed, canopies were seriously impacted during the remainder of the year resulting in very poor conditions as 2010 began. It appears the relatively good nutrient conditions (at least in the north) contributed to a fairly large resurgence of kelp canopy in Region Nine with 2010 ending with 11.706 km^2 of canopy coverage. The relative paucity of nutrients in the southern portion partially explains the losses in that region, but variability noted (such as La Jolla increasing while Point Loma decreased) is not adequately answered nor does it account for the changes in canopy conditions from bed to bed. As discussed earlier, it would appear that the local oceanographic regime is likely a product of influences to varying degrees by larger scale meteorological cycles such as Pacific Decadal Oscillation, Inter-decadal Pacific Oscillation, and the El Niño Southern Oscillation (Power et al. 1999, Verdon et al. 2004, Verdon and Franks 2006).

The 2010 kelp study again demonstrated that oceanographic environmental factors controlled the fate of the Region Nine kelp beds. There was no evidence to suggest any perceptible influence of the various dischargers on the persistence of the regions giant kelp beds.

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PERSONAL COMMUNICATIONS

Curtis, M. 2010, 2011. Michael Curtis is a kelp biologist with MBC Applied Environmental Sciences working with kelp ecosytems in the Southern California Bight.

Elwani, H. 2007. Dr. Hany Elwani is the founder of Coastal Environments and is a scientist working on sediment transport in the Southern California Bight.

Moore, R. 2007, 2010. Robert Moore is a biologist working on kelp ecosystems for MBC Applied Environmental Sciences.

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 has investigated the distribution of phytoplankton species within Santa Monica Bay and their relationship to coastal processes.

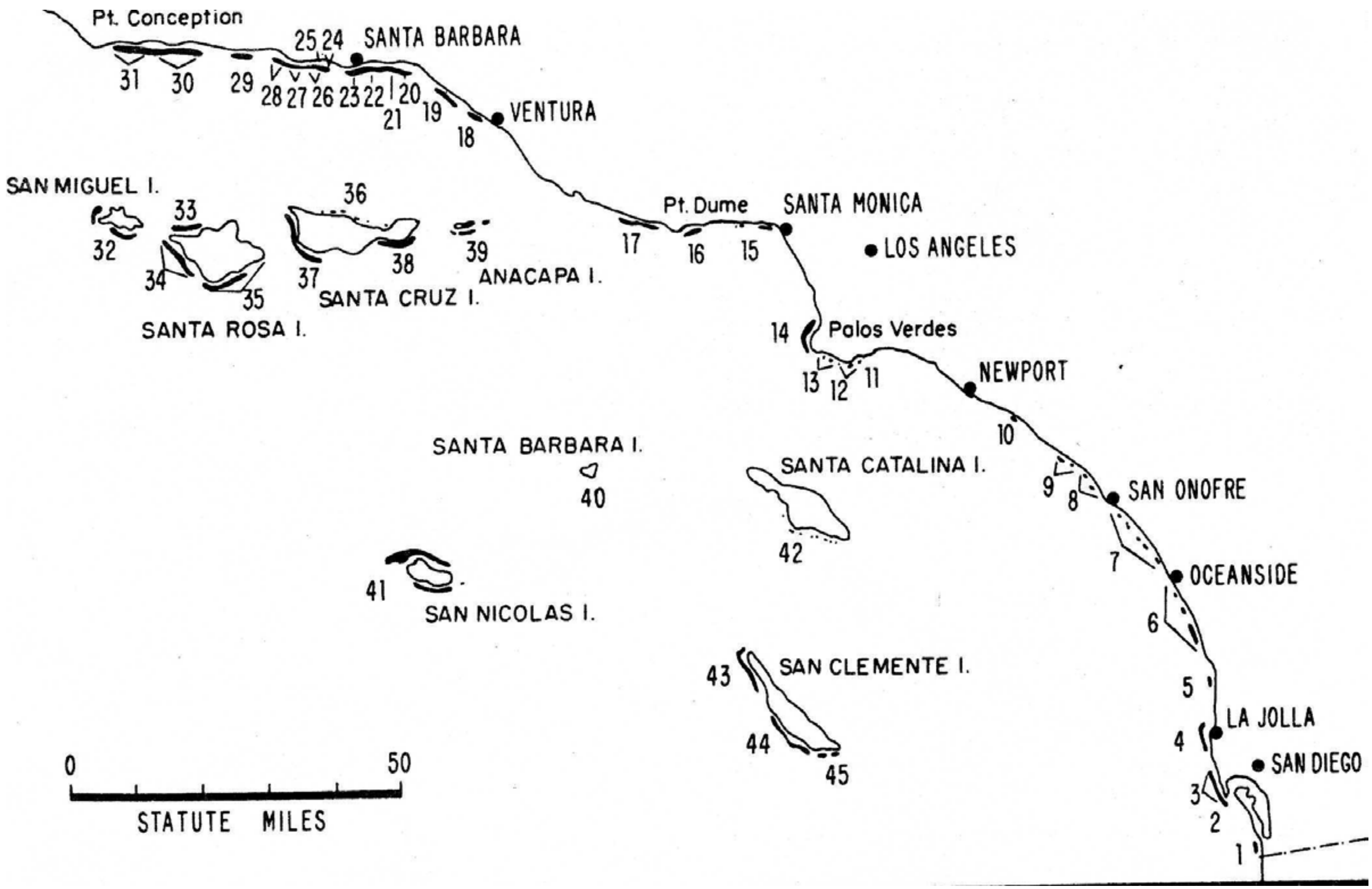
WEB SITES

National Oceanic and Atmospheric Administration (NOAA). 2011. www.cdc.noaa.gov

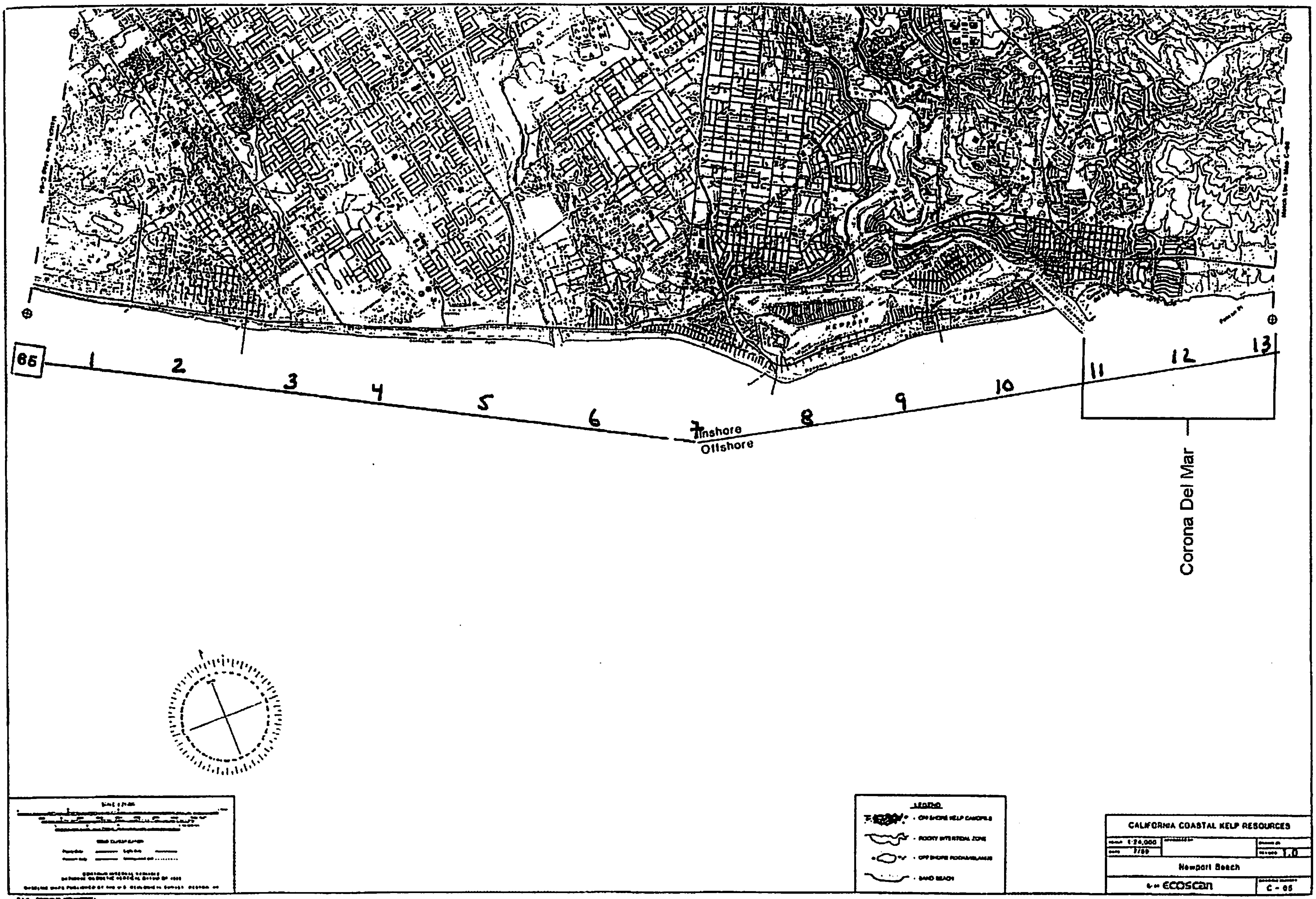
SCCOOS (Southern California Coastal Ocean Observing System). 2011. www.sccoos.org

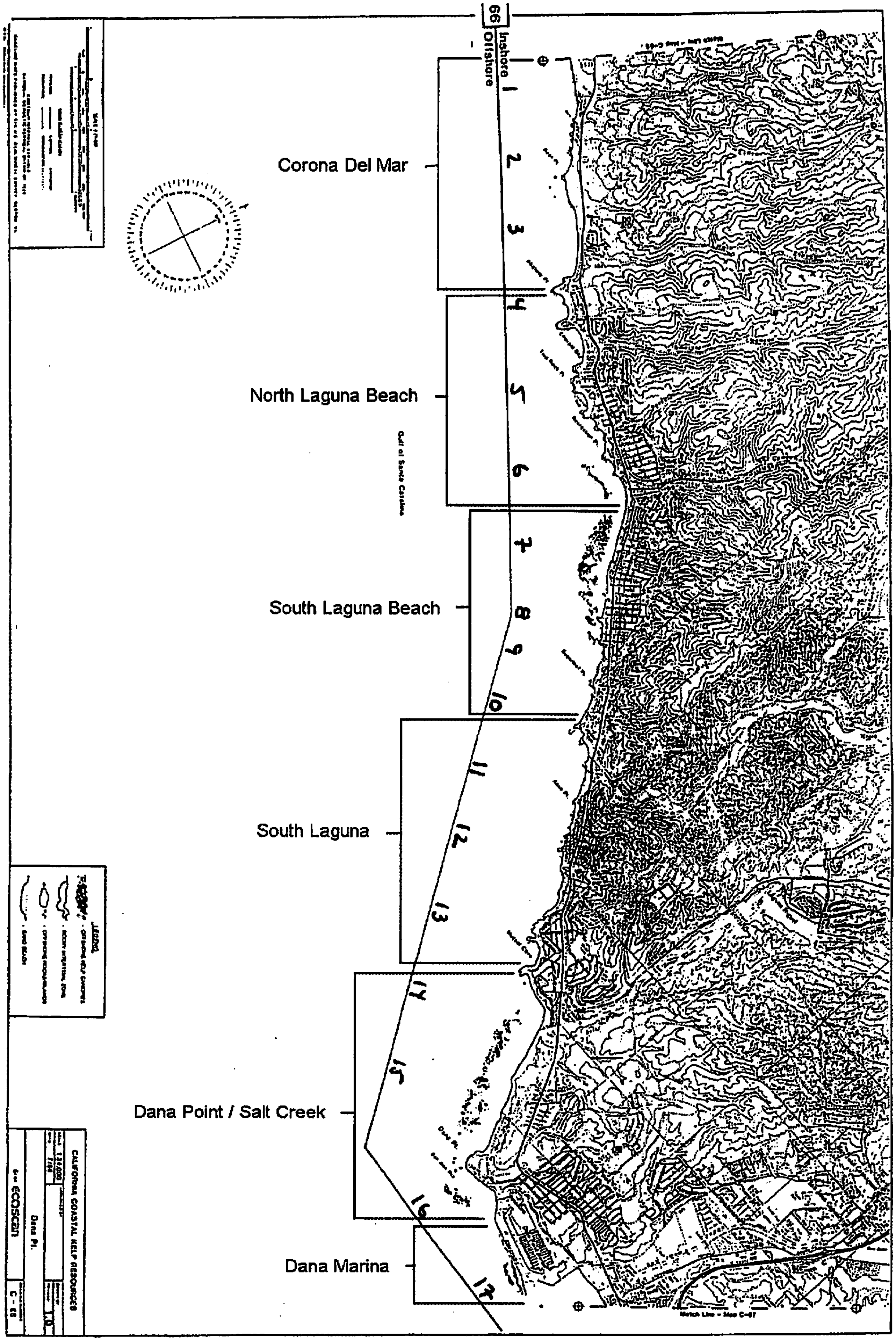
APPENDIX A

Kelp Canopy Maps

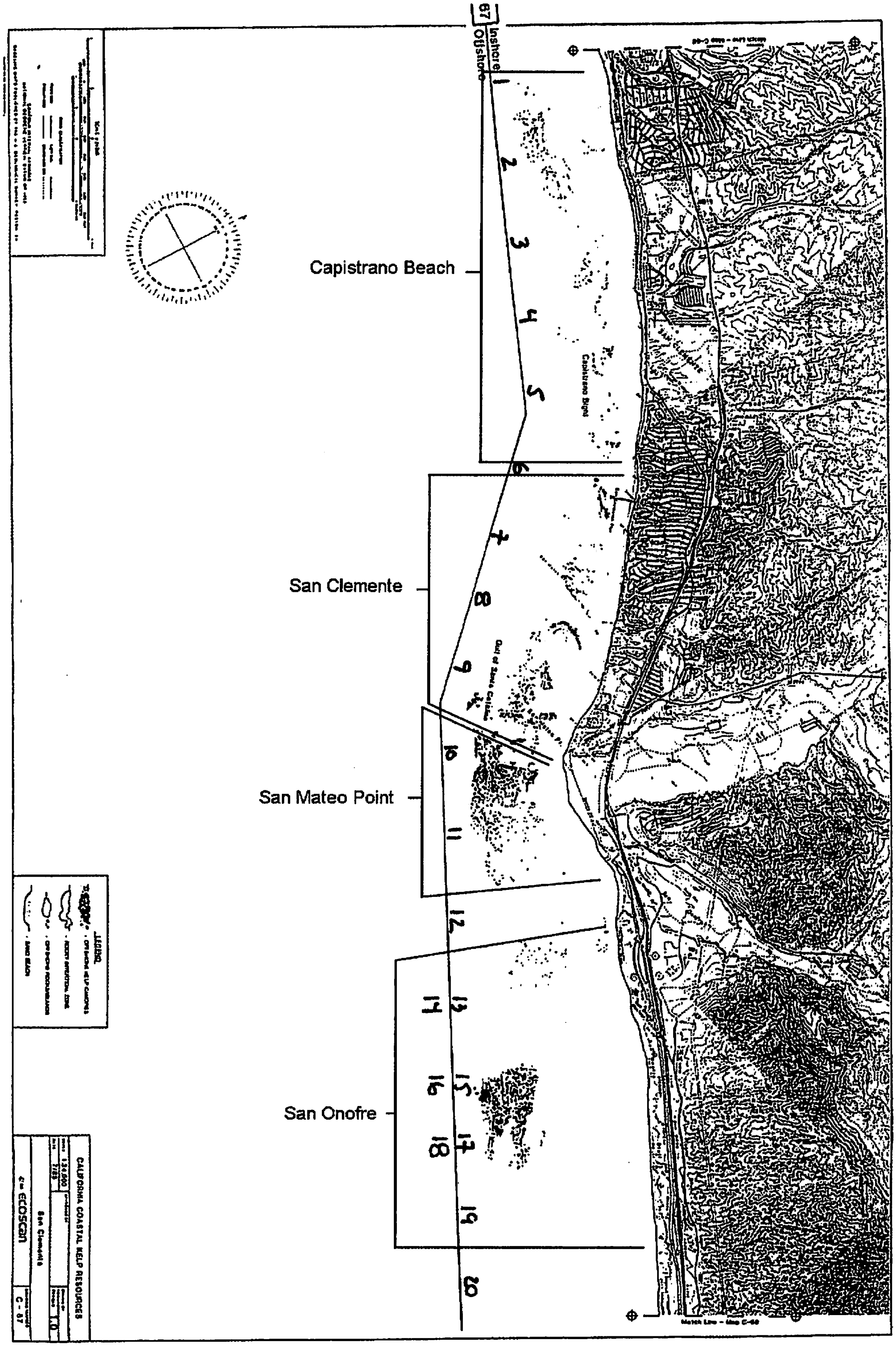


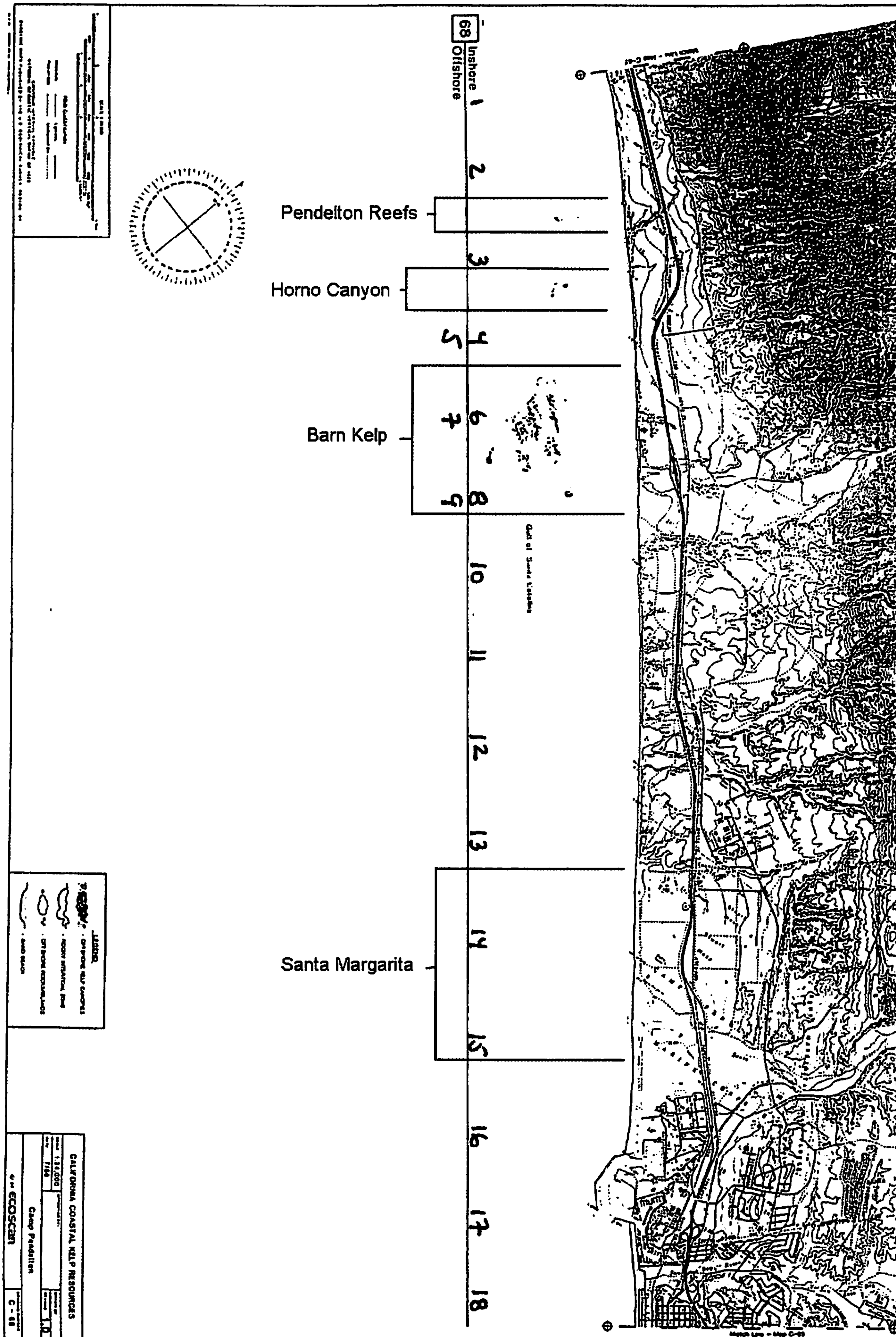
Appendix A. Fish and Game designated kelp bed numbers in the Southern California Bight.

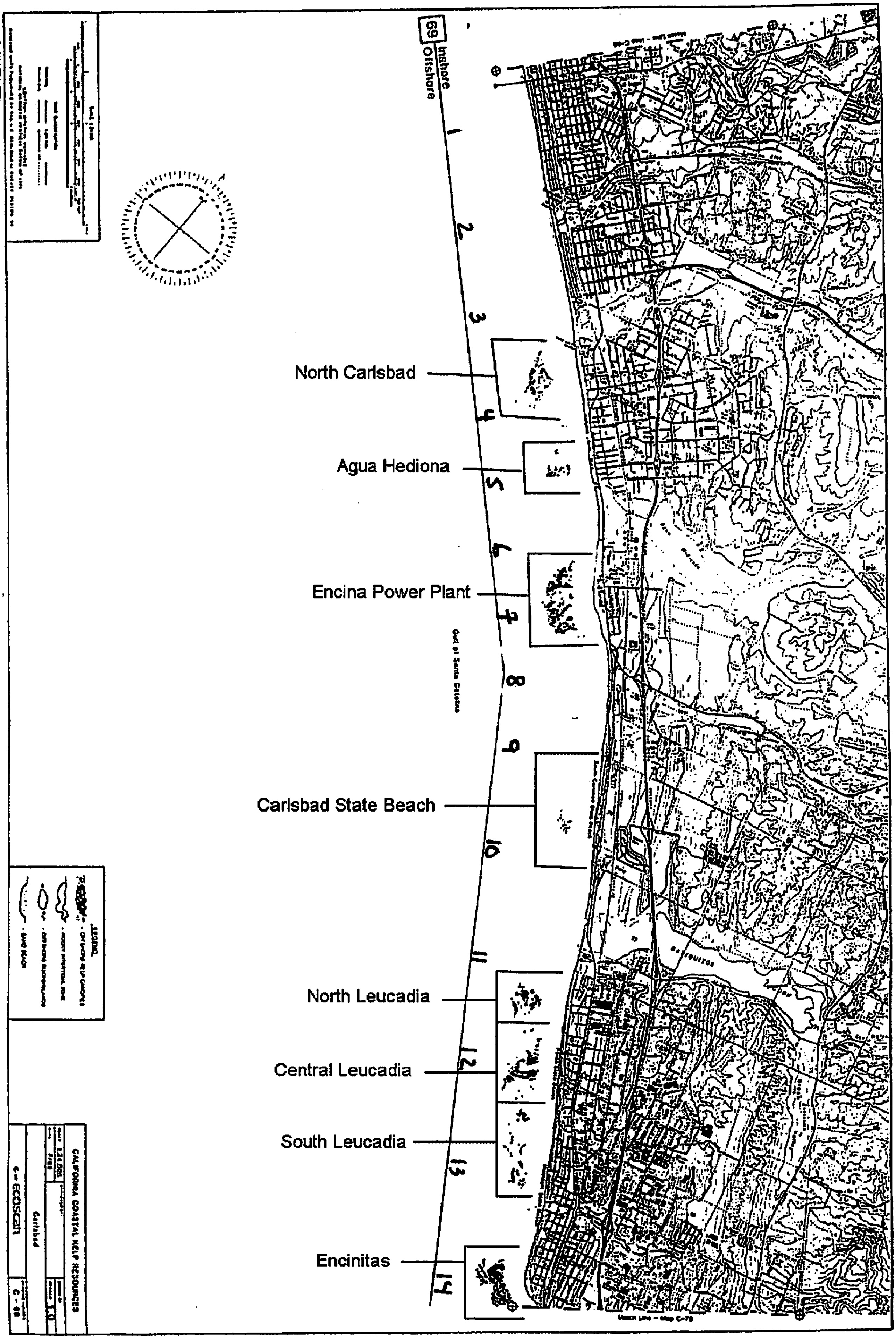

65
1
2
3
4
5
6
7
8
9
10
11
12
13
Inshore
Offshore
Corona Del Mar
LEGEND
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Newport Beach
ECOSCAN
C - 65



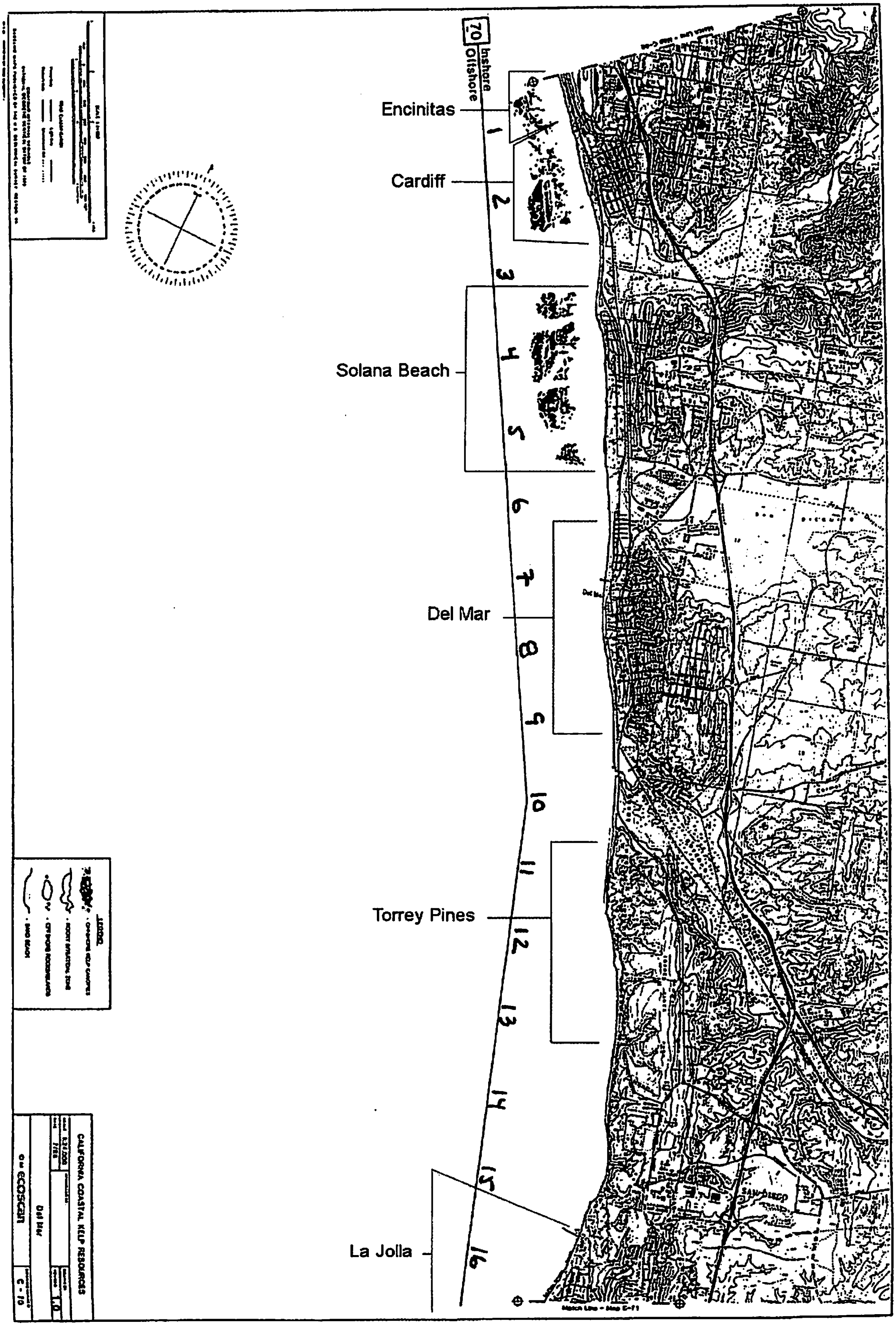
Inshore
Offshore
Corona Del Mar
North Laguna Beach
South Laguna Beach
South Laguna
Dana Point / Salt Creek
Dana Marina
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
CALIFORNIA COASTAL KELP RESOURCES
Dana Pt.
ECOSCAN

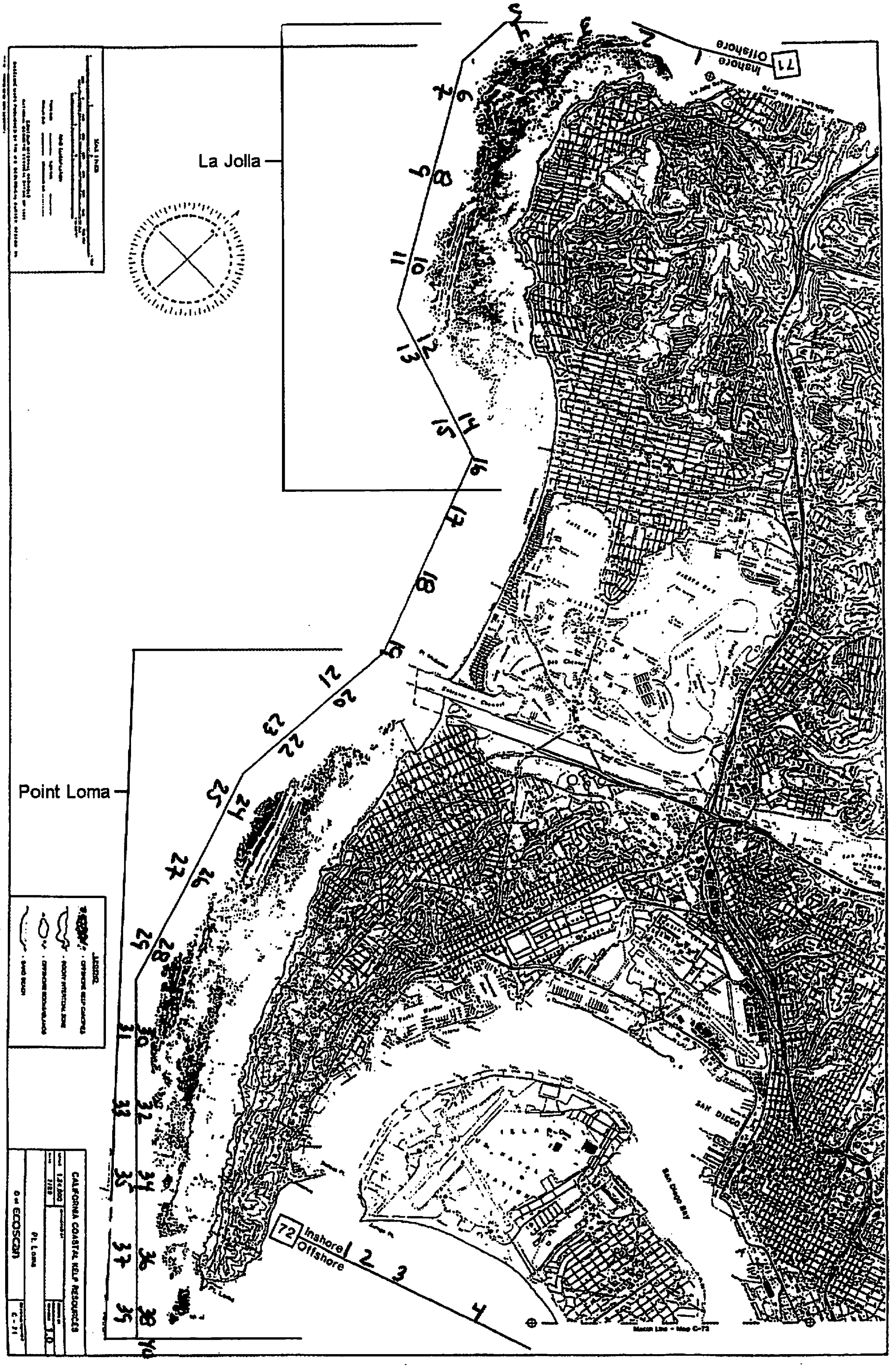

67
Inshore
Offshore
Capistrano Beach
San Clemente
San Mateo Point
San Onofre
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Capistrano Bight
CALIFORNIA COASTAL KELP RESOURCES
ECOSCAN
C - 67

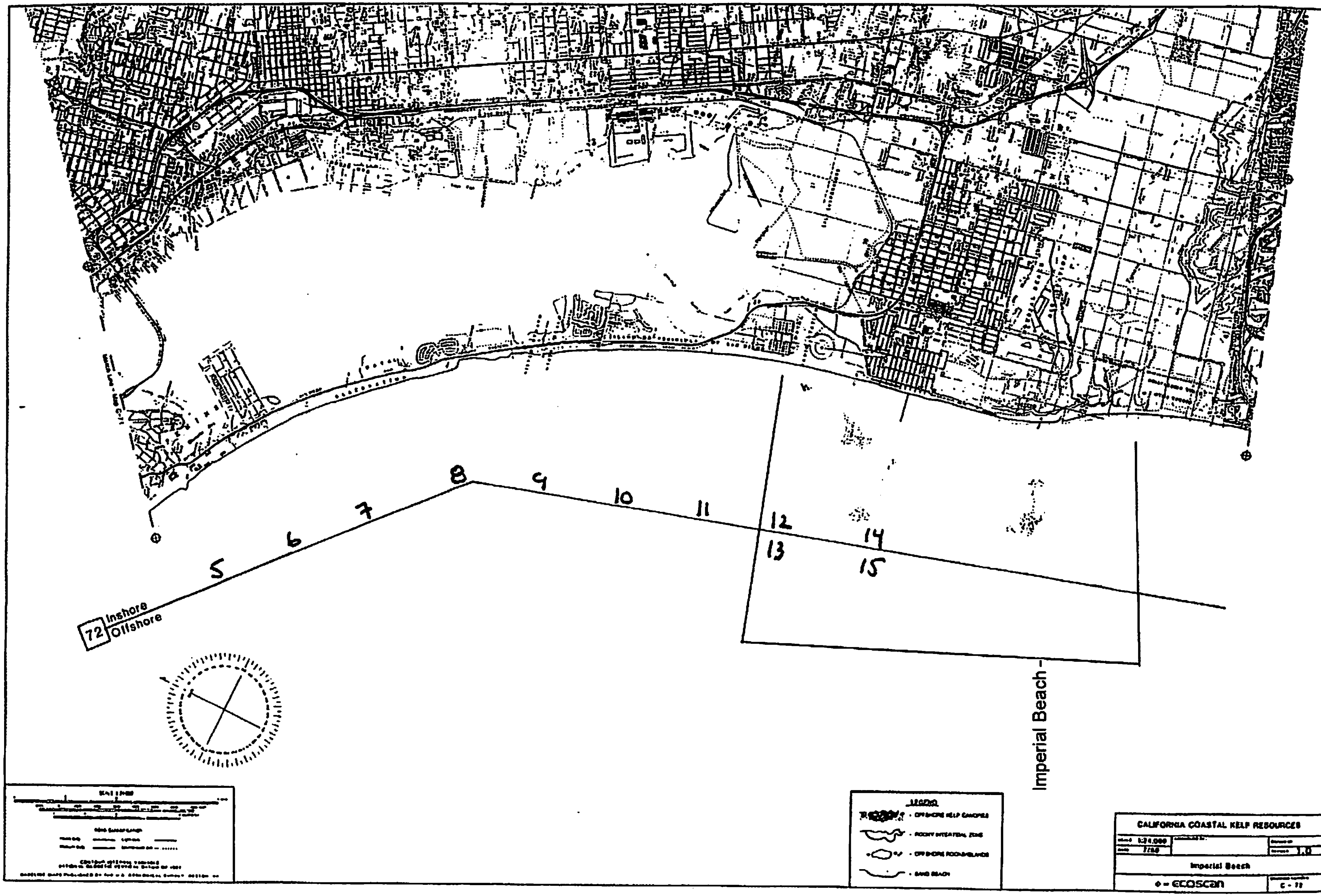

Pendelton Reefs
Horno Canyon
Barn Kelp
Santa Margarita
68
Inshore
Offshore
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
CALIFORNIA COASTAL KELP RESOURCES
Camp Pendleton
ecoscan
C - 68

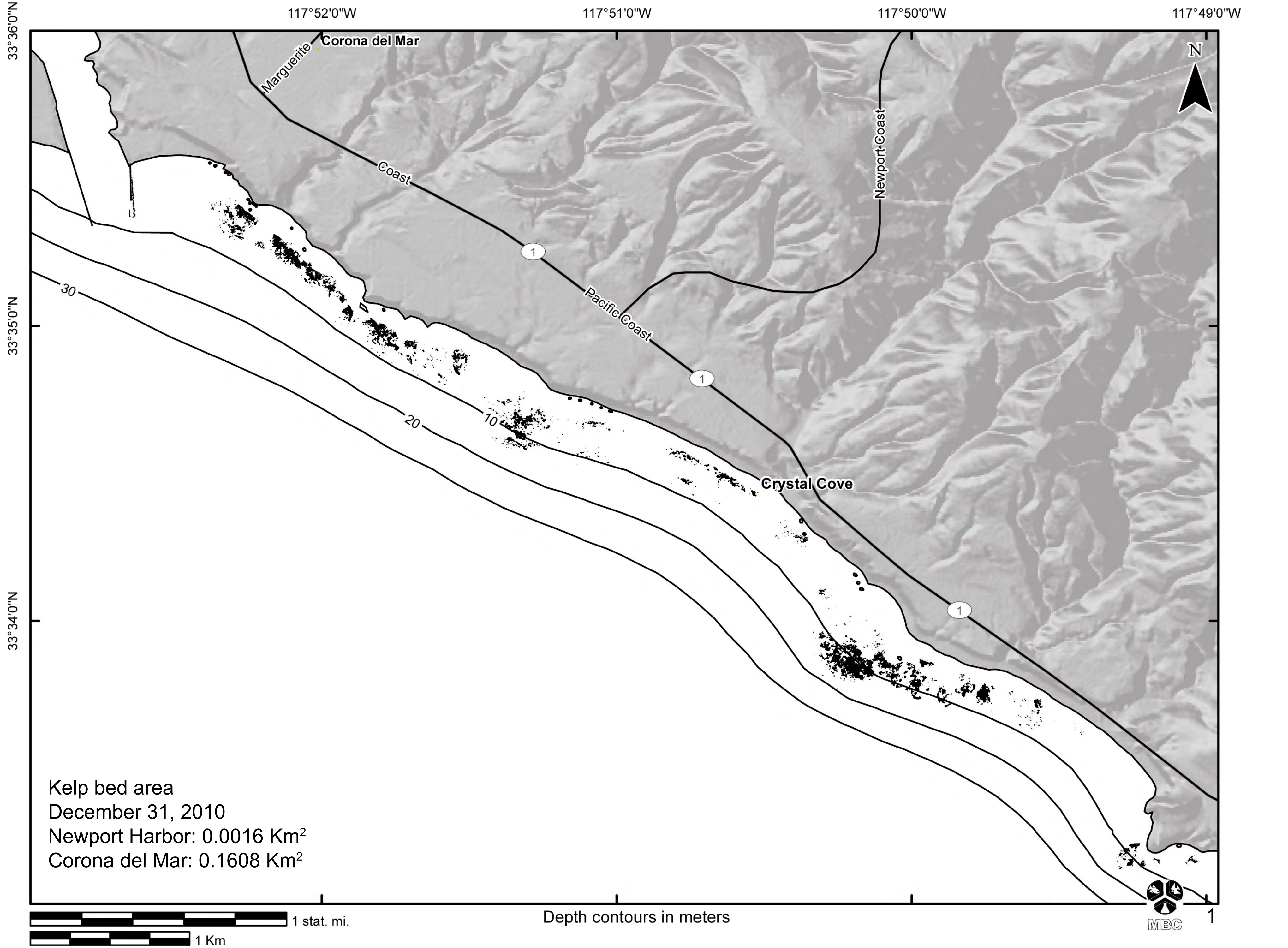


69
Inshore
Offshore
North Carlsbad
Agua Hediona
Encina Power Plant
Carlsbad State Beach
North Leucadia
Central Leucadia
South Leucadia
Encitas
1
2
3
4
5
6
7
8
9
10
11
12
13
14


70
Inshore
Offshore
Encinitas
Cardiff
Solana Beach
Del Mar
Torrey Pines
La Jolla
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CALIFORNIA COASTAL KELP RESOURCES


La Jolla
Point Loma
71 Inshore Offshore
72 Inshore Offshore
SAN DIEGO
San Diego Bay
CALIFORNIA COASTAL KELP RESOURCES
Pt. Loma
ECOSCAN


72 Inshore
Offshore
5
6
7
8
9
10
11
12
13
14
15
Imperial Beach -
LEGEND
- OFFSHORE KELP CANOPIES
- SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
Imperial Beach
ECOSCAN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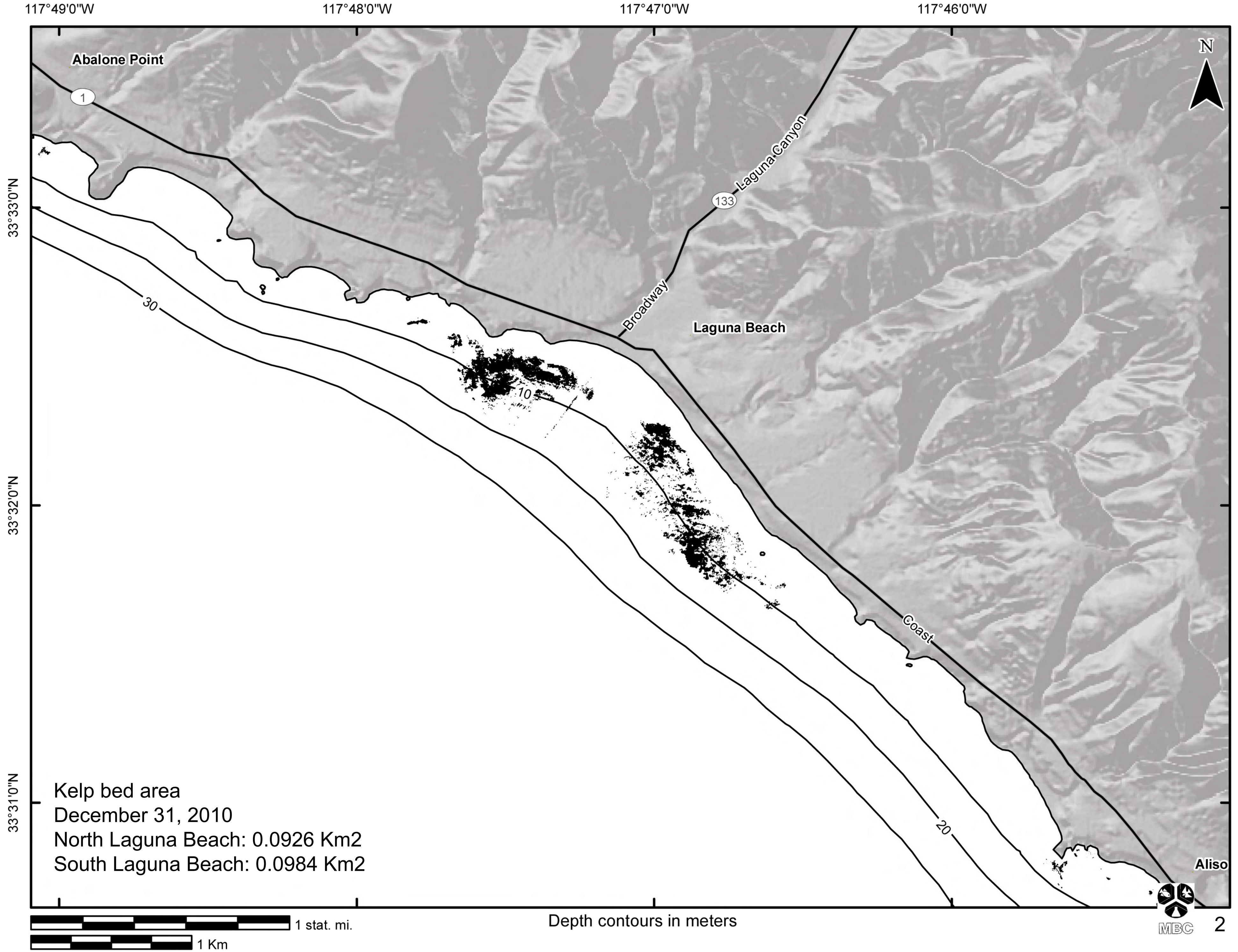
117°51'0"W
117°50'0"W
117°49'0"W
33°36'0"N
33°35'0"N
33°34'0"N
Corona del Mar
Marguerite
Coast
Pacific Coast
Newport Coast
1
Crystal Cove
30
20
10
N
Kelp bed area
December 31, 2010
Newport Harbor: 0.0016 Km2
Corona del Mar: 0.1608 Km2
1 stat. mi.
1 Km
Depth contours in meters
MBC

1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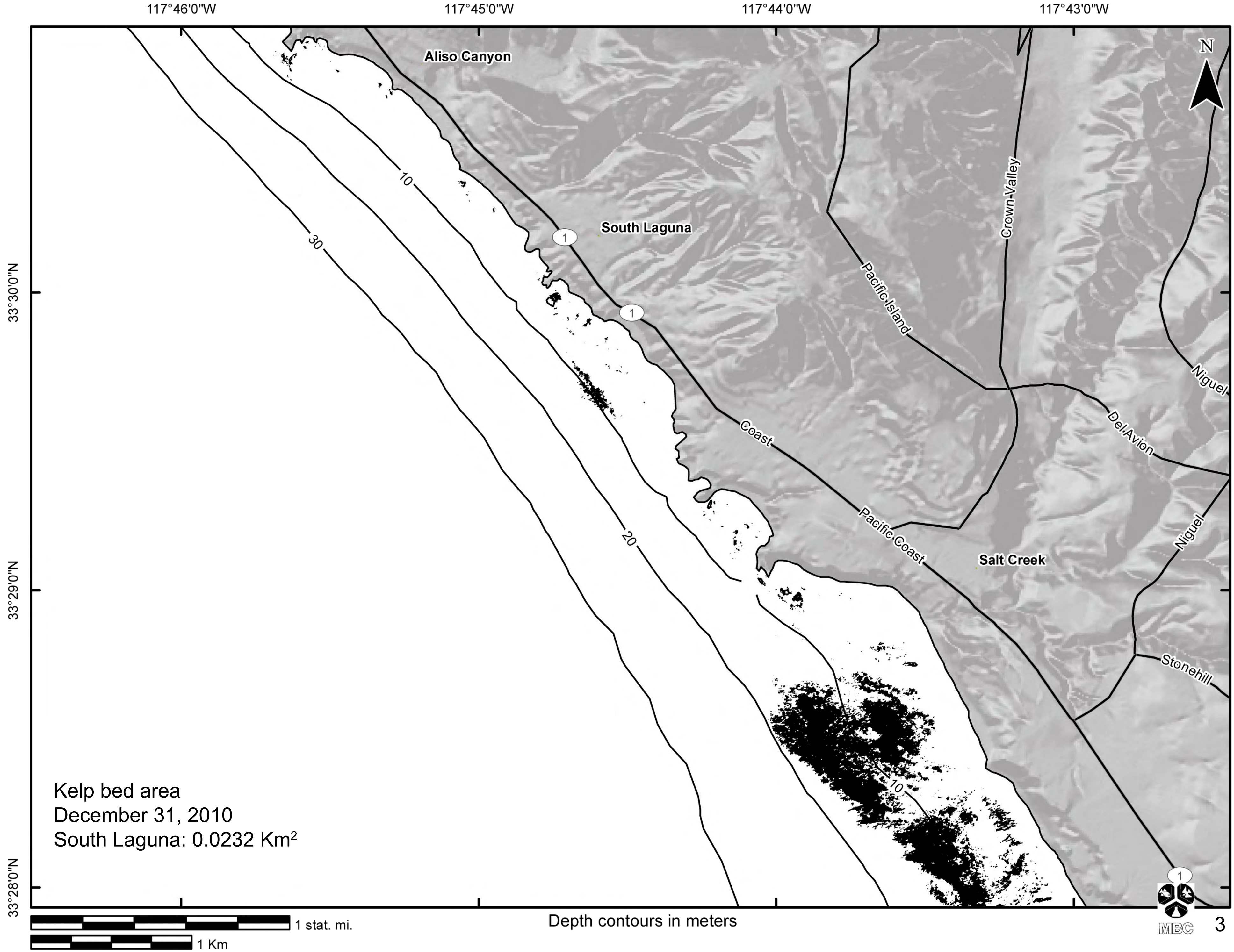
33°31'0"N
N
Abalone Point
1
133
Laguna Canyon
Broadway
Laguna Beach
Coast
Aliso
30
20
10
Kelp bed area
December 31, 2010
North Laguna Beach: 0.0926 Km2
South Laguna Beach: 0.0984 Km2
1 stat. mi.
1 Km
Depth contours in meters
MBC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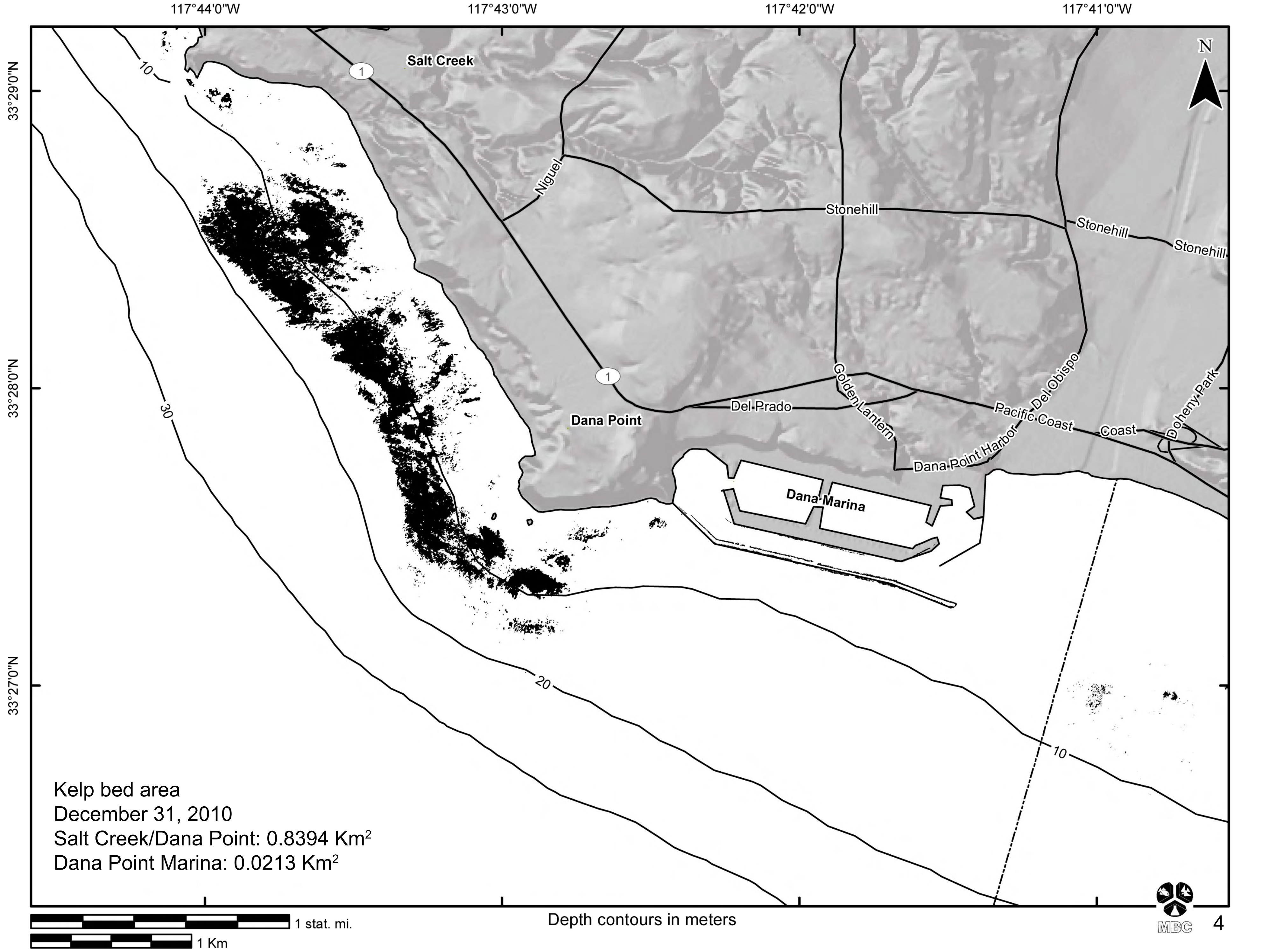
N
Aliso Canyon
South Laguna
Salt Creek
Crown Valley
Pacific Island
Niguel
Del Avion
Coast
Pacific Coast
Niguel
Stonehill
1
1
1
10
30
20
10
Kelp bed area
December 31, 2010
South Laguna: 0.0232 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC



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117°41'0"W
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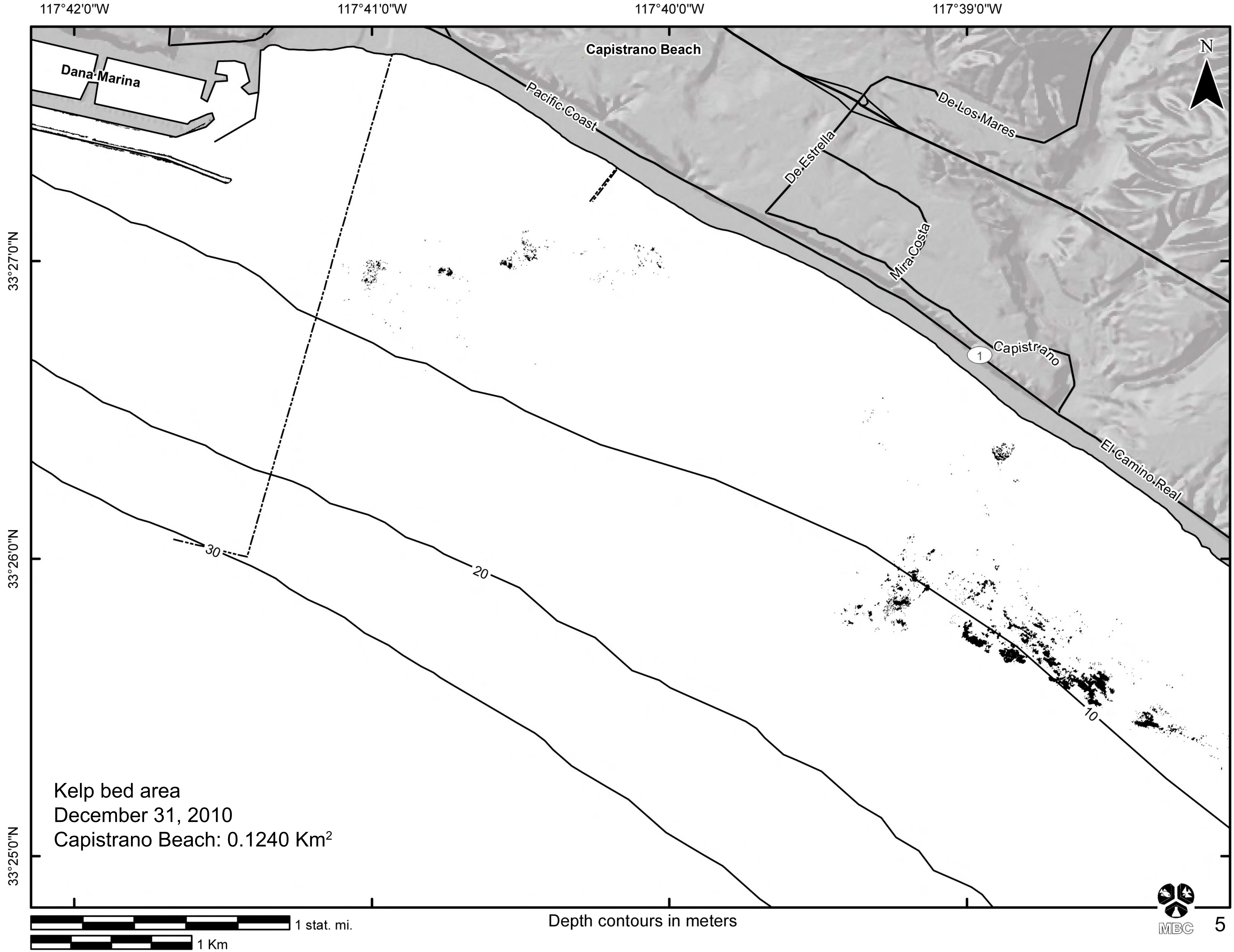
33°28'0"N
33°27'0"N
N
Salt Creek
1
Niguel
Stonehill
Golden Lantern
Del Obispo
Doheny Park
Del Prado
Pacific Coast
Coast
Dana Point
Dana Point Harbor
Dana Marina
10
20
30
Kelp bed area
December 31, 2010
Salt Creek/Dana Point: 0.8394 Km²
Dana Point Marina: 0.0213 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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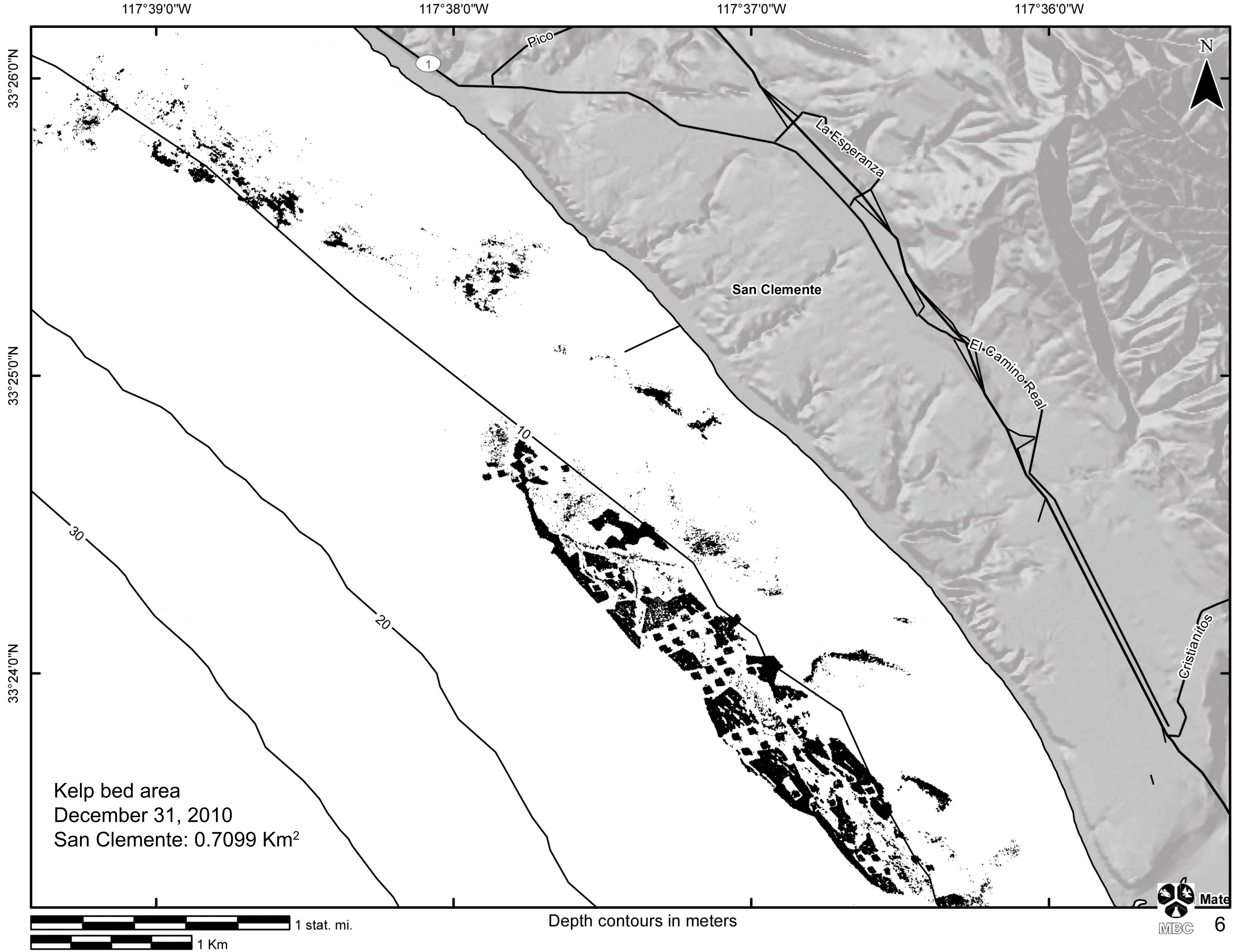
117°41'0"W
117°40'0"W
117°39'0"W
33°27'0"N
33°26'0"N
33°25'0"N
Capistrano Beach
Dana Marina
Pacific Coast
De Los Mares
De Estrella
Mira Costa
1
Capistrano
El Camino Real
N
30
20
10
Kelp bed area
December 31, 2010
Capistrano Beach: 0.1240 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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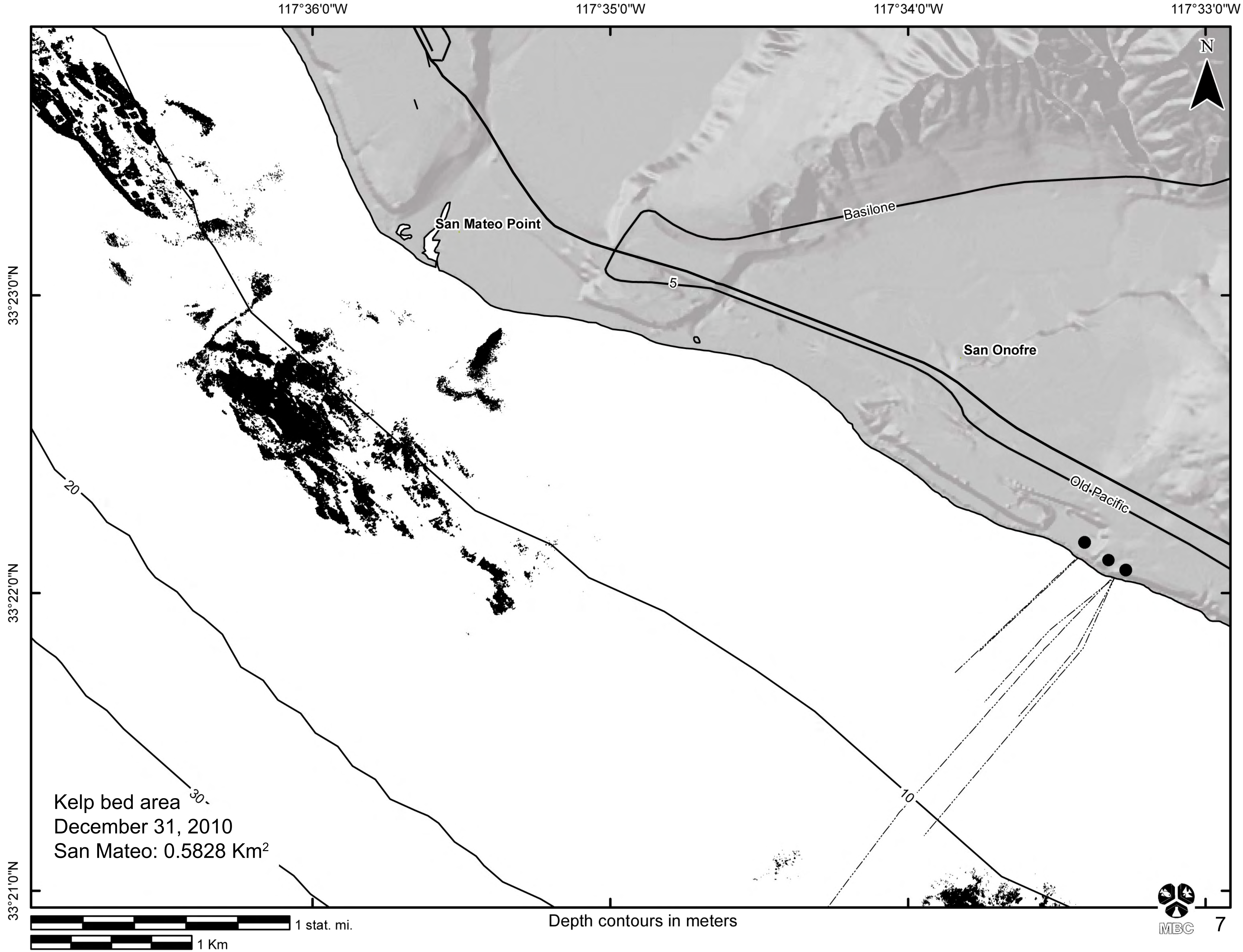
33°24'0"N
N
Pico
1
La Esperanza
San Clemente
El Camino Real
Cristianitos
10
20
30
Kelp bed area
December 31, 2010
San Clemente: 0.7099 Km²
1 stat. mi.
1 Km
Depth contours in meters
Mate
MBC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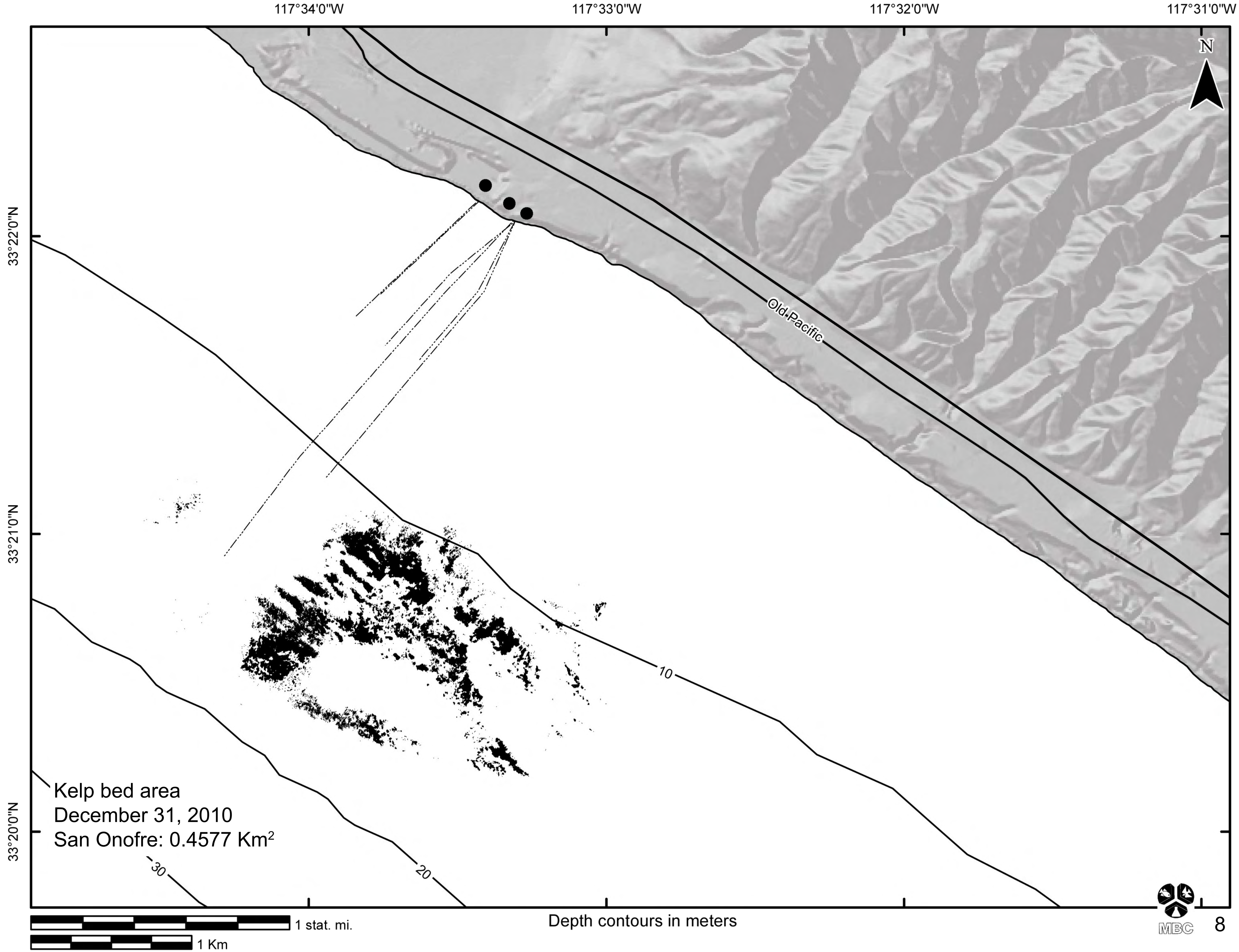
117°33'0"W
33°23'0"N
33°22'0"N
33°21'0"N
N
San Mateo Point
Basilone
5
San Onofre
Old Pacific
20
30
10
Kelp bed area
December 31, 2010
San Mateo: 0.5828 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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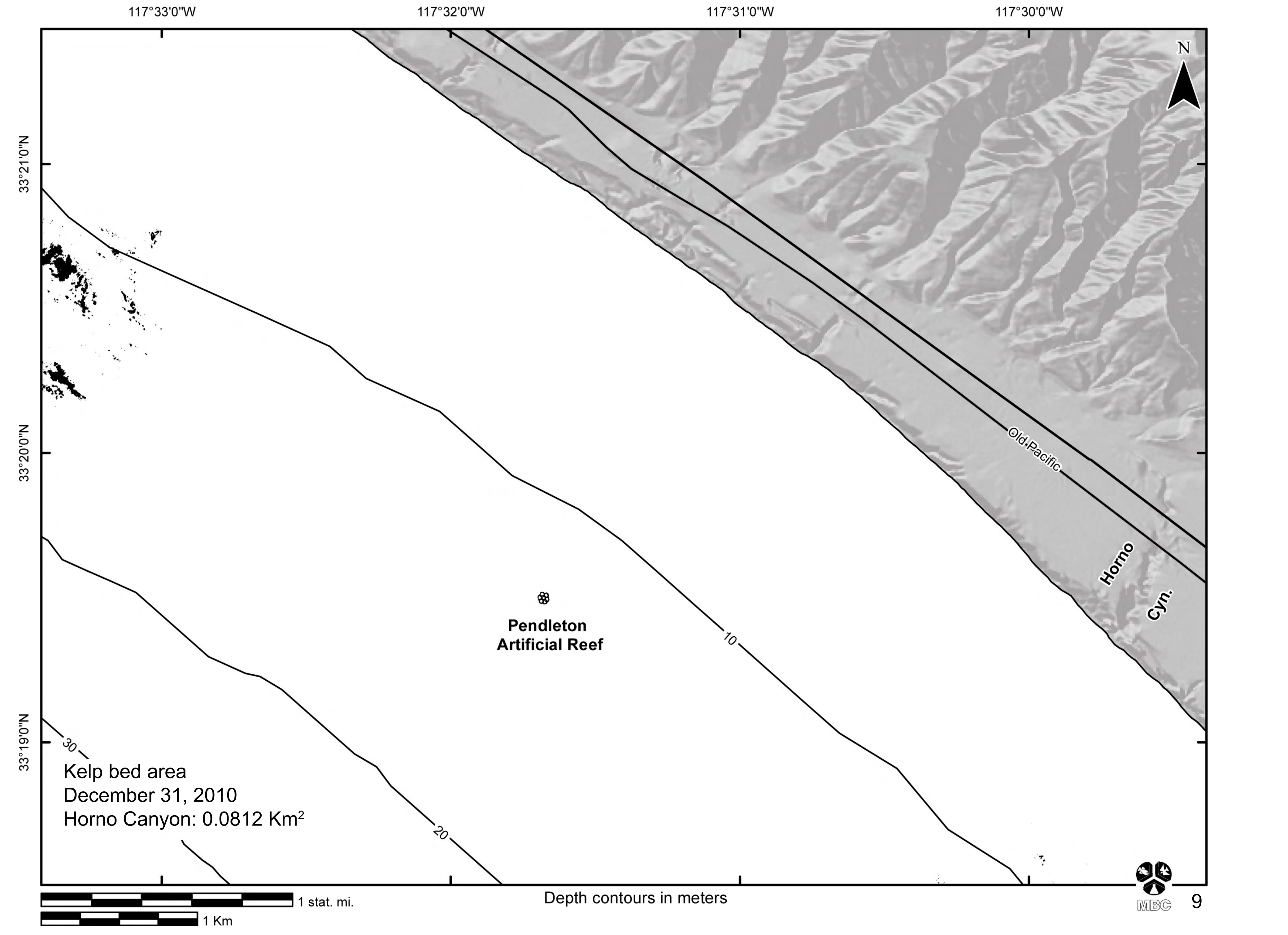
117°33'0"W
117°32'0"W
117°31'0"W
33°22'0"N
33°21'0"N
33°20'0"N
N
Old Pacific
10
20
30
Kelp bed area
December 31, 2010
San Onofre: 0.4577 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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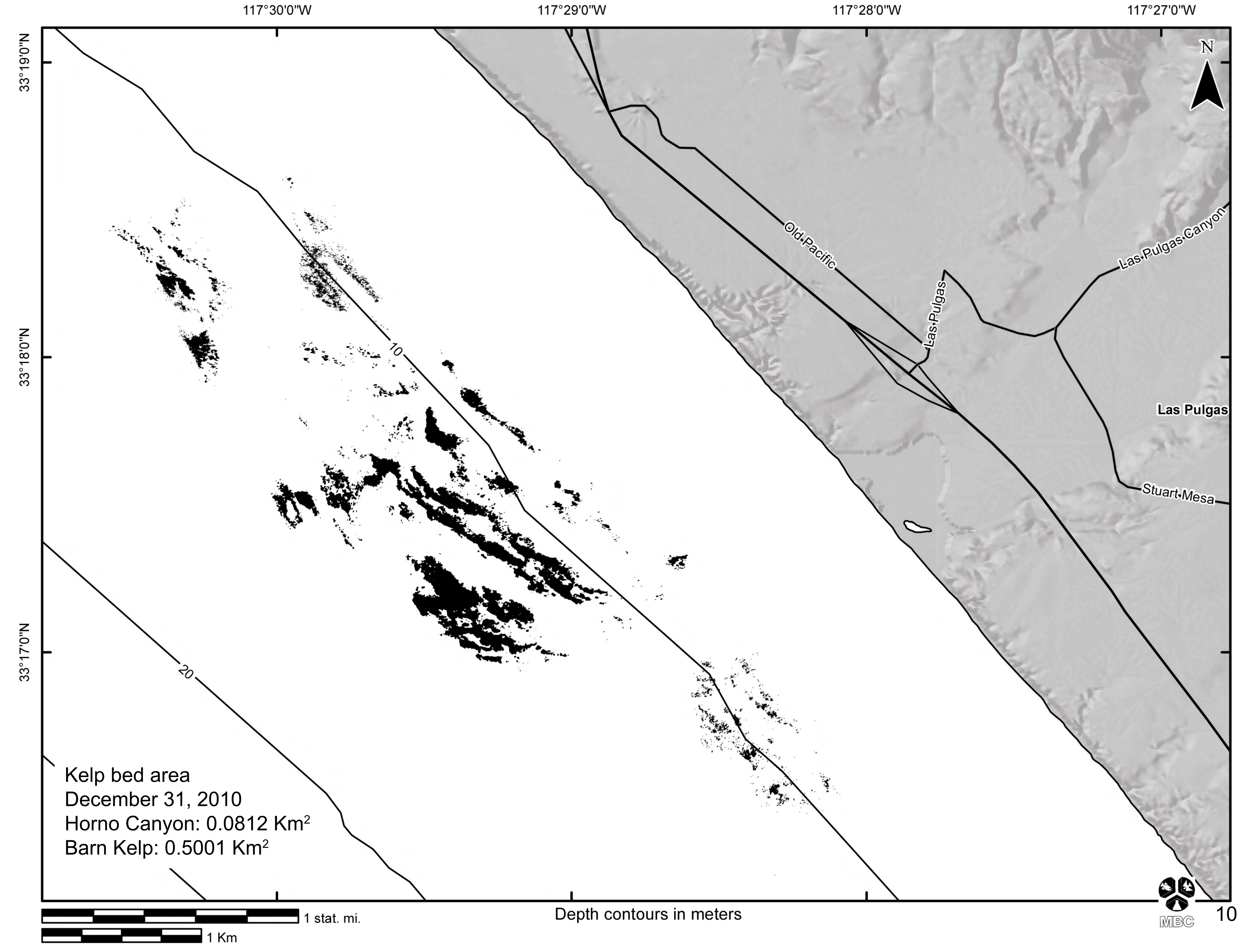
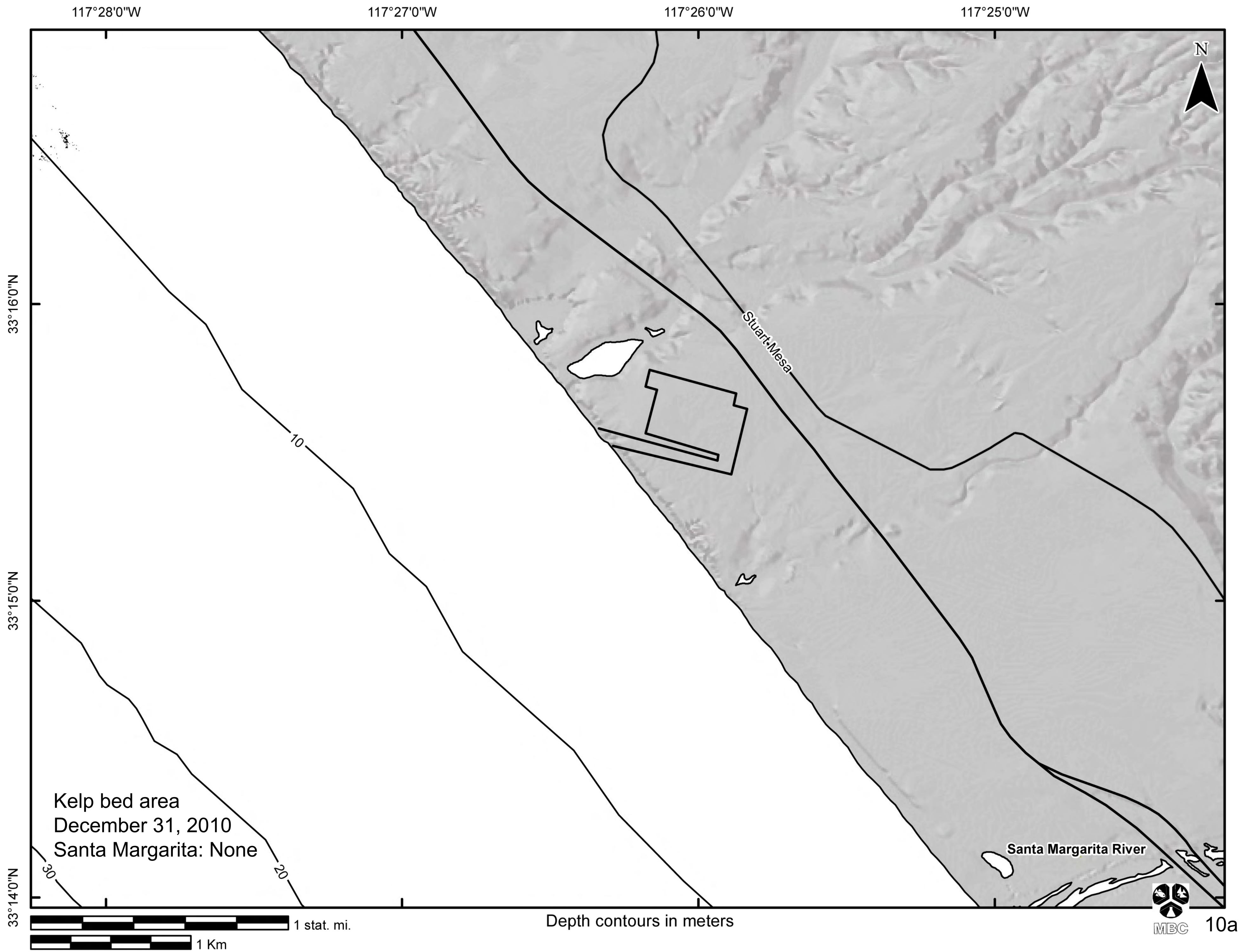
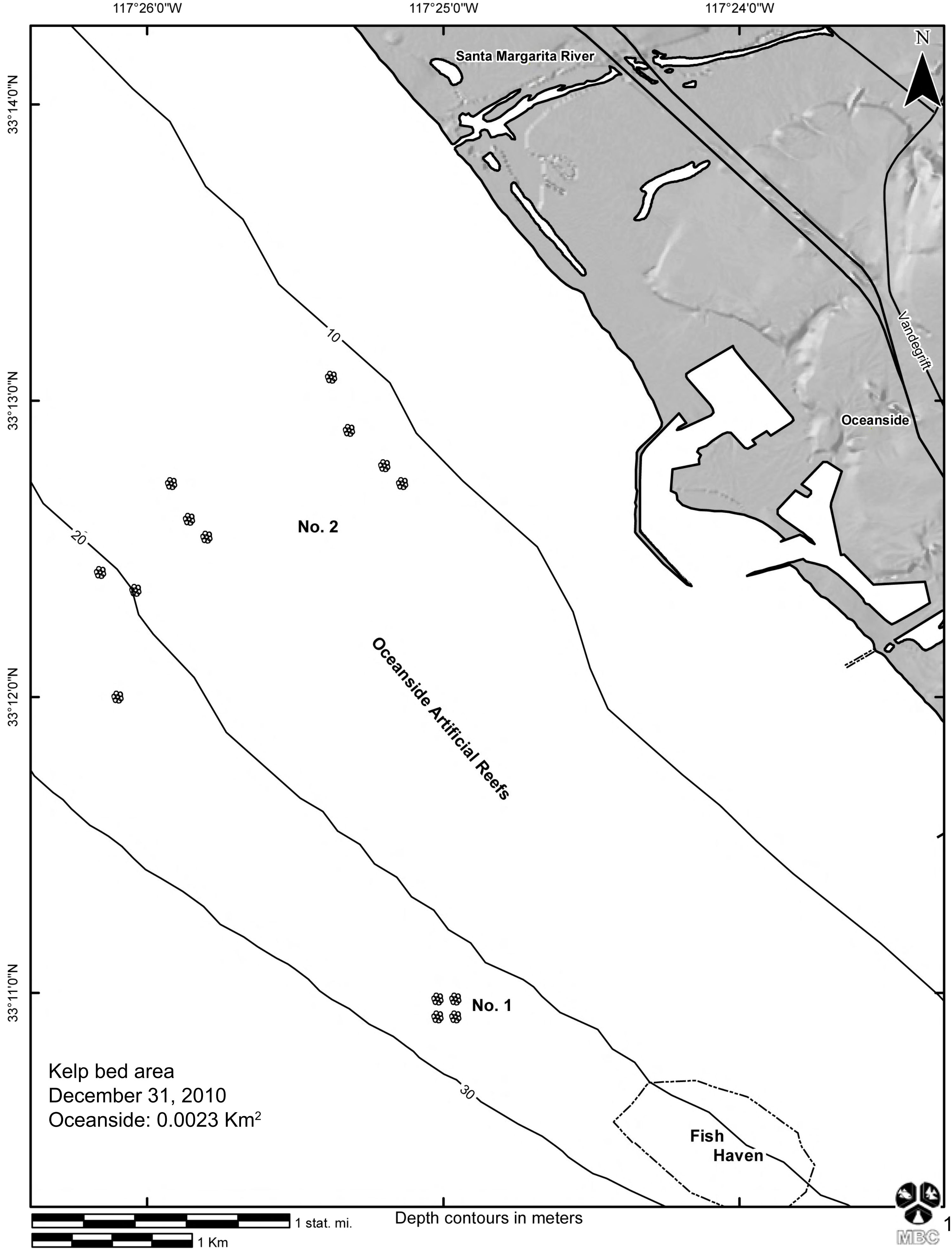
117°32'0"W
117°31'0"W
117°30'0"W
33°21'0"N
33°20'0"N
33°19'0"N
N
Old Pacific
Horno
Cyn.
Pendleton
Artificial Reef
10
20
30
Kelp bed area
December 31, 2010
Horno Canyon: 0.0812 Km2
1 stat. mi.
1 Km
Depth contours in meters
MBC



Depth contours in meters


117°28'0"W
117°27'0"W
117°26'0"W
117°25'0"W
33°16'0"N
33°15'0"N
33°14'0"N
N
Stuart Mesa
10
20
30
Santa Margarita River
Kelp bed area
December 31, 2010
Santa Margarita: None
1 stat. mi.
1 Km
Depth contours in meters
MBC
10a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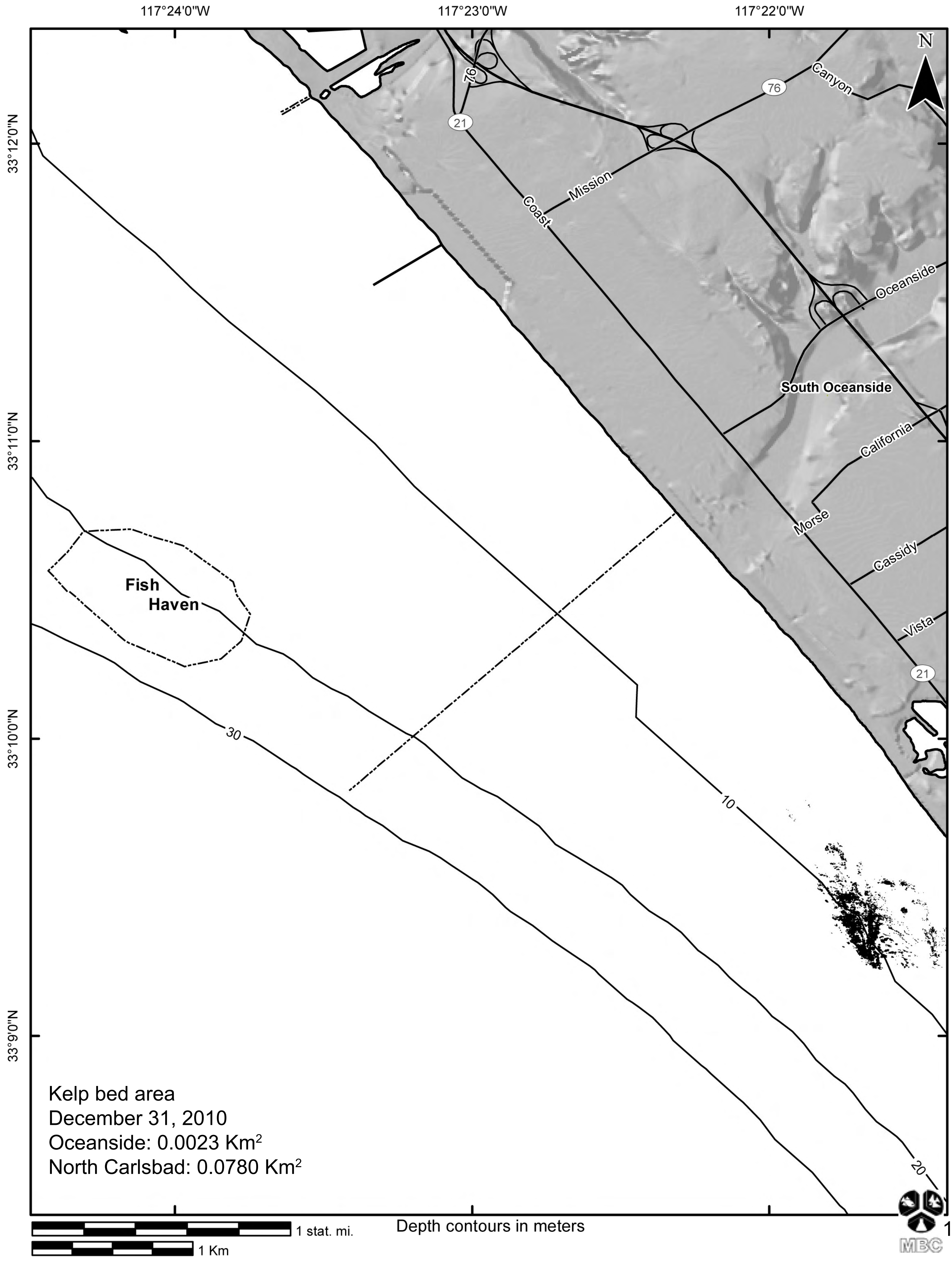
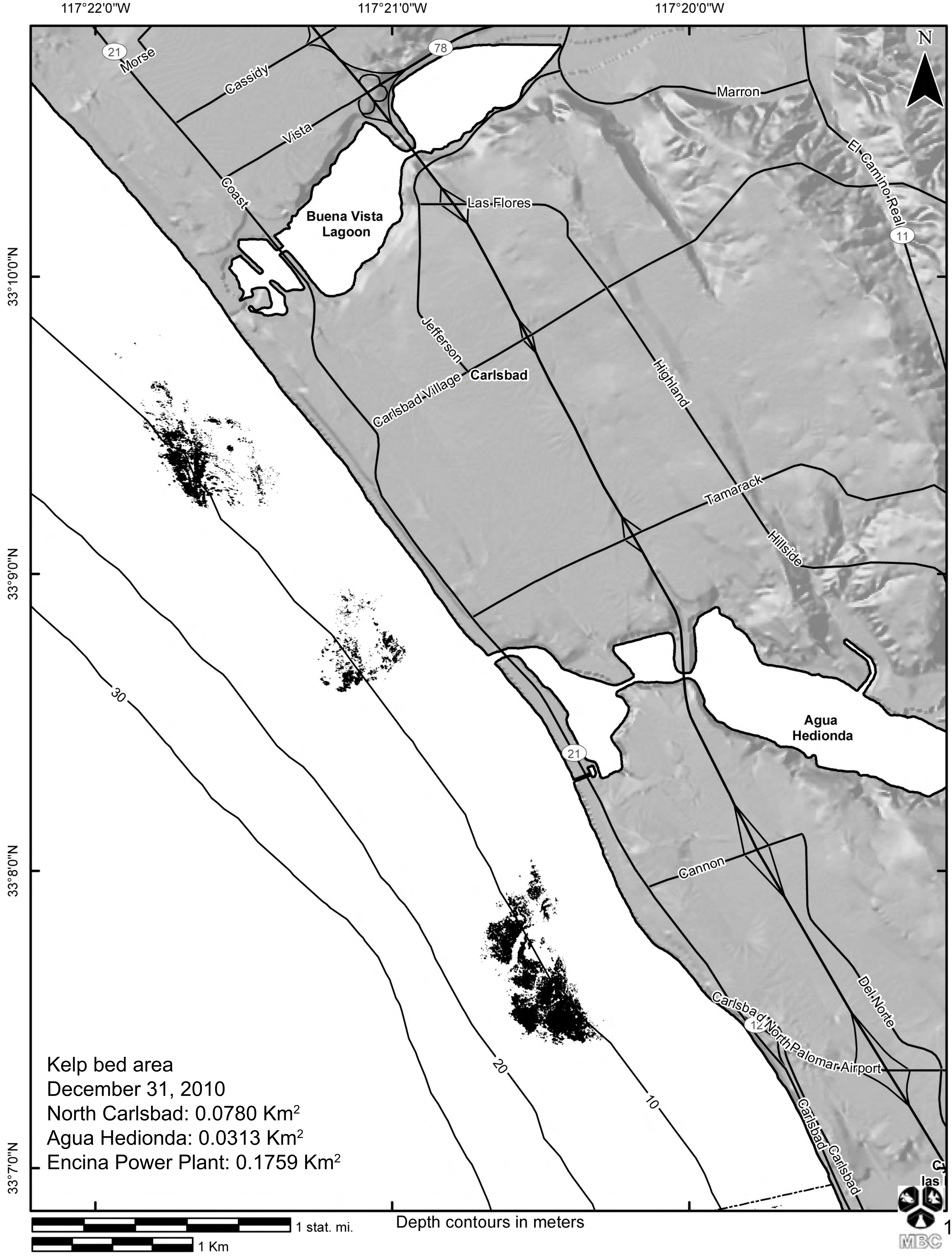
117°25'0"W
117°24'0"W
33°14'0"N
33°13'0"N
33°12'0"N
33°11'0"N
N
Santa Margarita River
Vandegrift
Oceanside
10
20
30
No. 2
No. 1
Oceanside Artificial Reefs
Fish Haven
Kelp bed area
December 31, 2010
Oceanside: 0.0023 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

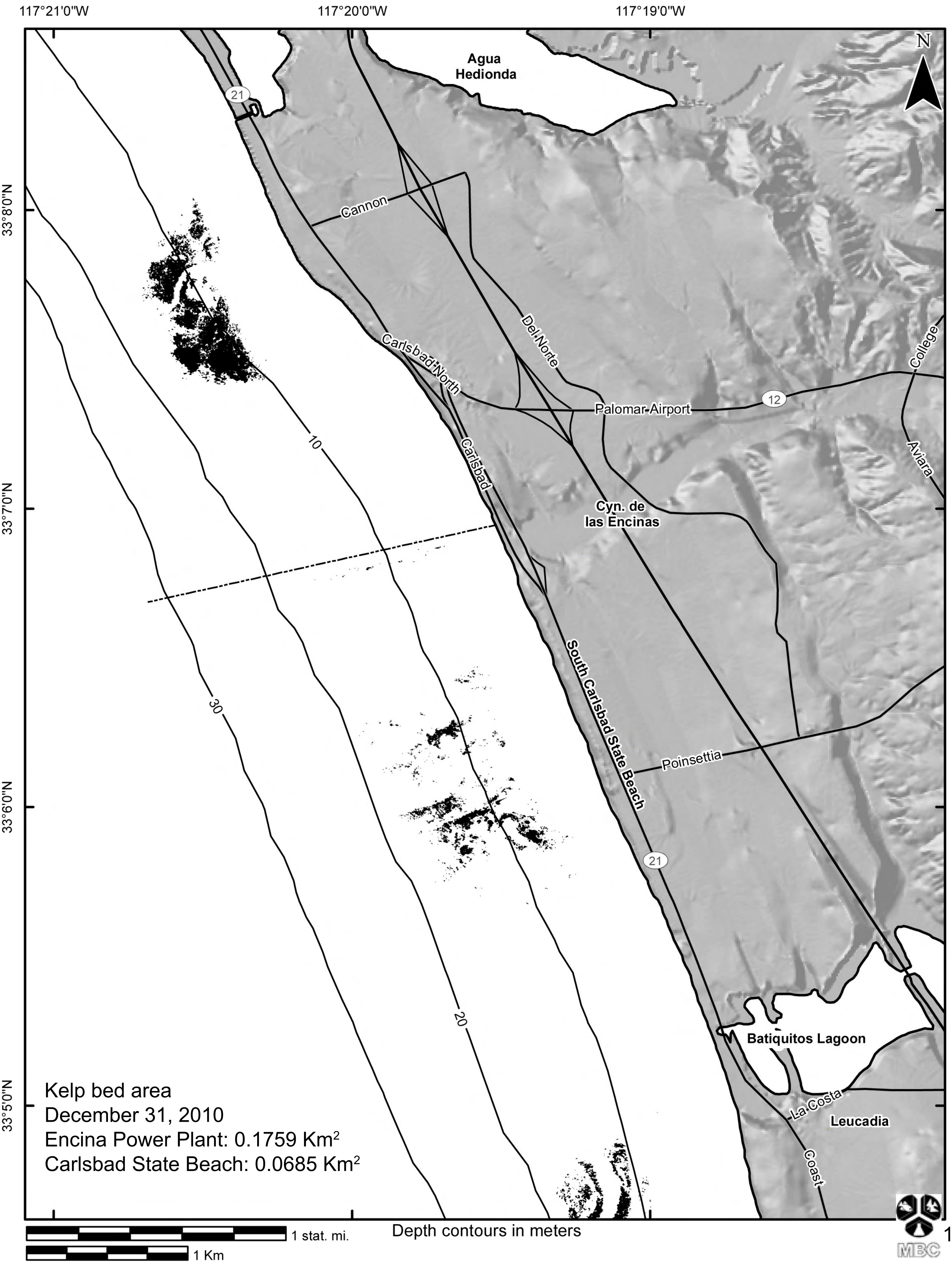
10b



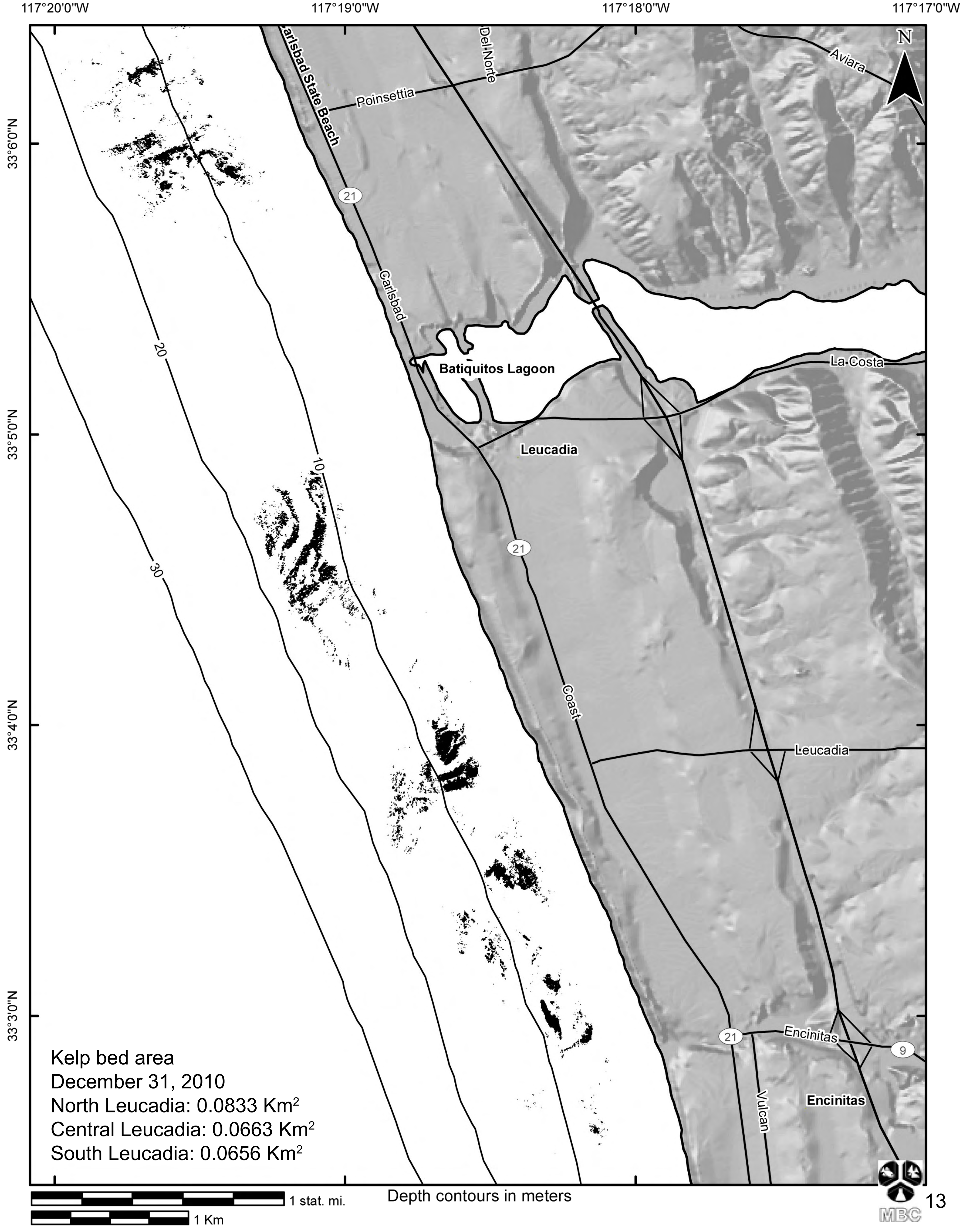
Kelp bed area
December 31, 2010
Oceanside: 0.0023 Km²
North Carlsbad: 0.0780 Km²

10c


117°22'0"W
117°21'0"W
117°20'0"W
33°10'0"N
33°9'0"N
33°8'0"N
33°7'0"N
N
Morse
Cassidy
Vista
Coast
78
21
Marron
El Camino Real
11
Las Flores
Buena Vista Lagoon
Jefferson
Carlsbad Village
Carlsbad
Highland
Tamarack
Hillside
Agua Hedionda
Cannon
Del Norte
Carlsbad
12
Palomar Airport
30
20
10
Kelp bed area
December 31, 2010
North Carlsbad: 0.0780 Km^2
Agua Hedionda: 0.0313 Km^2
Encina Power Plant: 0.1759 Km^2
1 stat. mi.
1 Km
Depth contours in meters
MBC



117°21'0"W
117°20'0"W
117°19'0"W
33°8'0"N
33°7'0"N
33°6'0"N
33°5'0"N
N
Agua Hedionda
21
Cannon
Del Norte
Carlsbad North
College
12
Palomar Airport
Aviara
Carlsbad
10
Cyn. de las Encinas
South Carlsbad State Beach
30
Poinsettia
21
20
Batiquitos Lagoon
La Costa
Leucadia
Coast
Kelp bed area
December 31, 2010
Encina Power Plant: 0.1759 Km²
Carlsbad State Beach: 0.0685 Km²
1 stat. mi.
Depth contours in meters
1 Km
MBC



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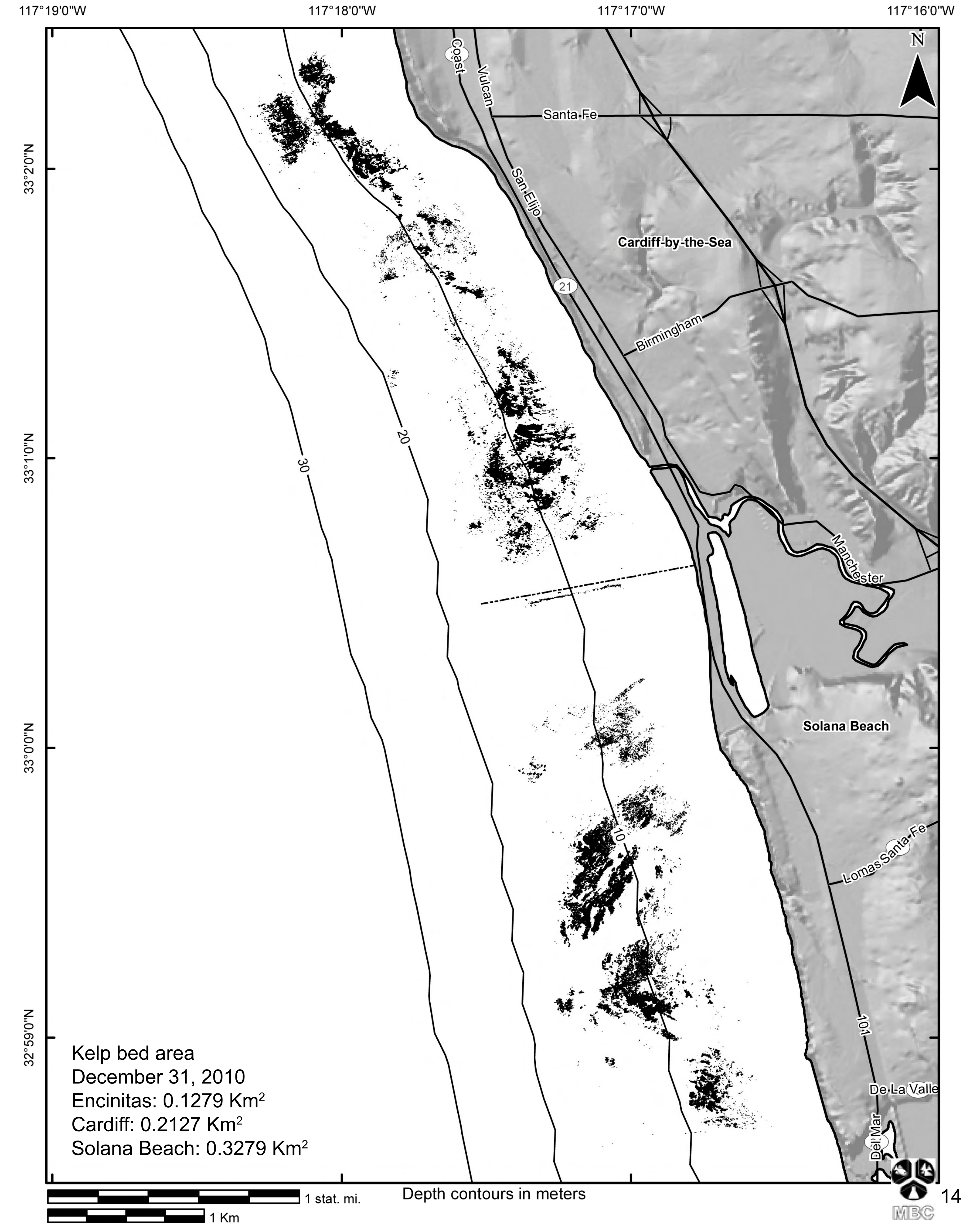
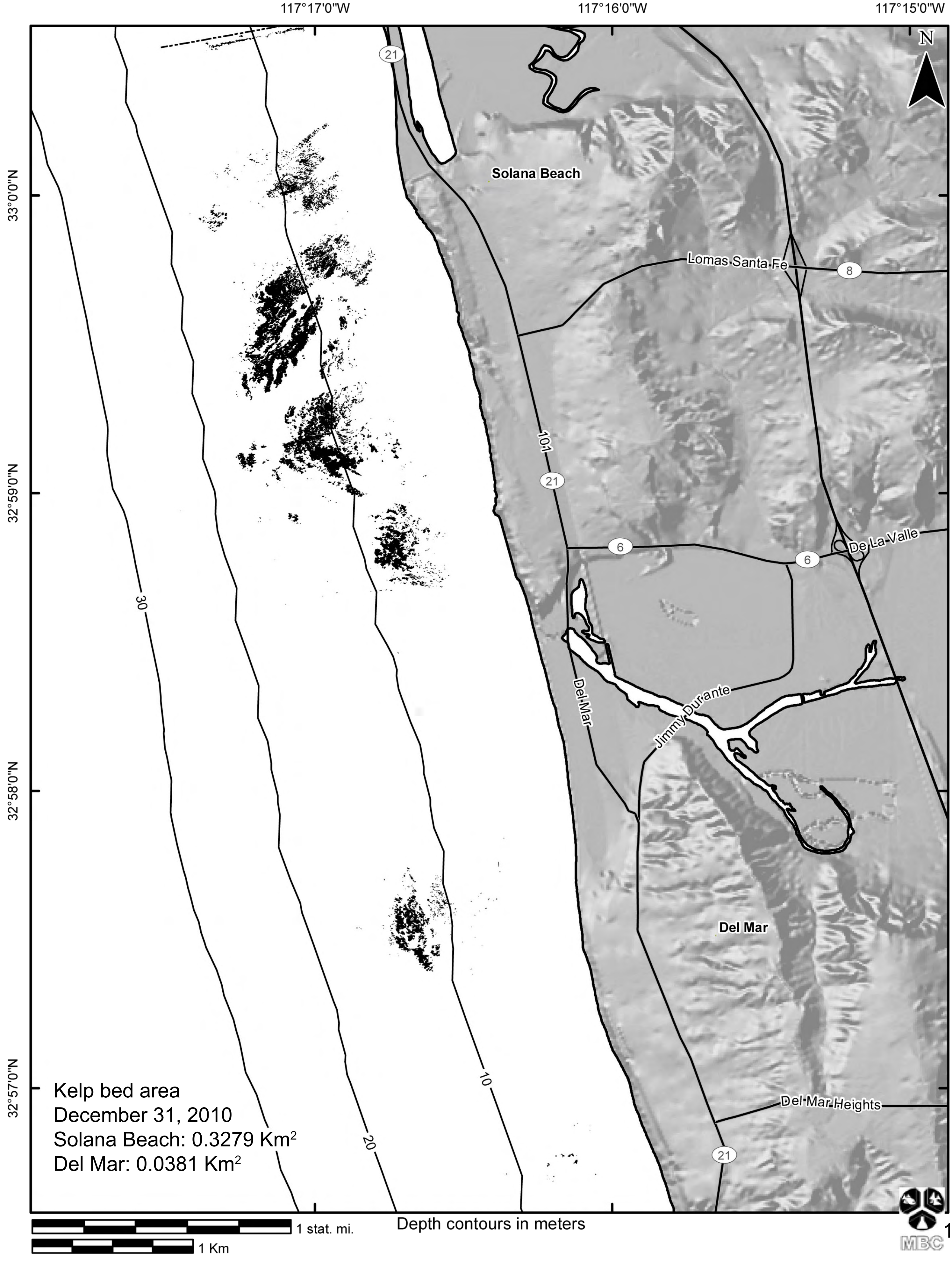
117°19'0"W
117°18'0"W
117°17'0"W
33°6'0"N
33°5'0"N
33°4'0"N
33°3'0"N
N
Carlsbad State Beach
Del Norte
Poinsettia
Aviara
21
Carlsbad
Batiquitos Lagoon
La Costa
Leucadia
10
20
30
21
Coast
Leucadia
21
Encinitas
9
Vulcan
Encinitas
Kelp bed area
December 31, 2010
North Leucadia: 0.0833 Km²
Central Leucadia: 0.0663 Km²
South Leucadia: 0.0656 Km²
1 stat. mi.
Depth contours in meters
1 Km
MBC



117°19'0"W
117°18'0"W
117°17'0"W
117°16'0"W
33°2'0"N
33°1'0"N
33°0'0"N
32°59'0"N
N
Coast
Vulcan
Santa Fe
San Elijo
Cardiff-by-the-Sea
21
Birmingham
Manchester
Solana Beach
Lomas Santa Fe
101
De La Valle
Del Mar
30
20
10
Kelp bed area
December 31, 2010
Encinitas: 0.1279 Km2
Cardiff: 0.2127 Km2
Solana Beach: 0.3279 Km2
1 stat. mi.
1 Km
Depth contours in meters
MBC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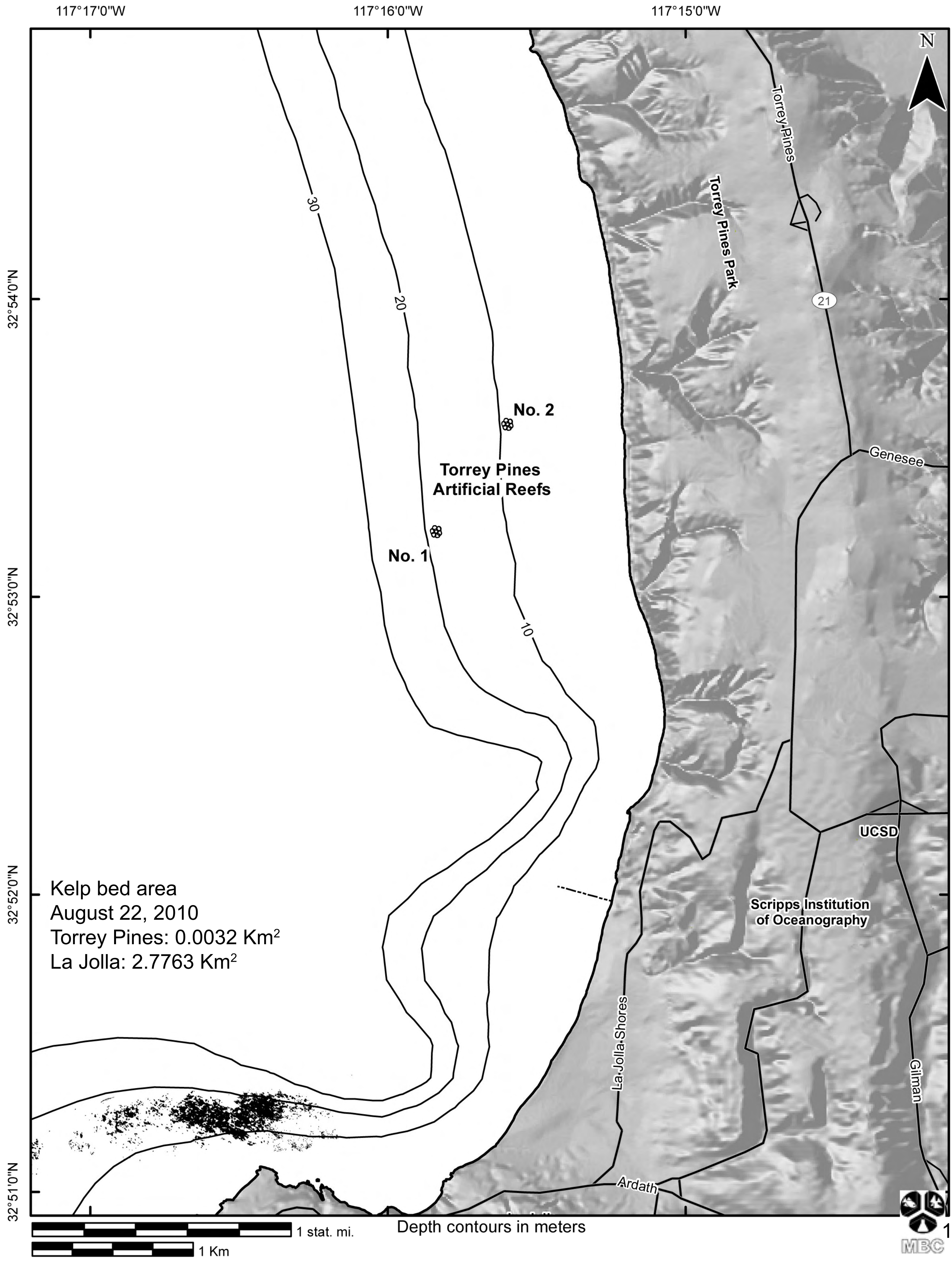
117°16'0"W
117°15'0"W
33°0'0"N
32°59'0"N
32°58'0"N
32°57'0"N
N
21
Solana Beach
Lomas Santa Fe
8
101
21
6
6
De La Valle
Del Mar
Jimmy Durante
Del Mar
30
20
10
Del Mar Heights
21
Kelp bed area
December 31, 2010
Solana Beach: 0.3279 Km²
Del Mar: 0.0381 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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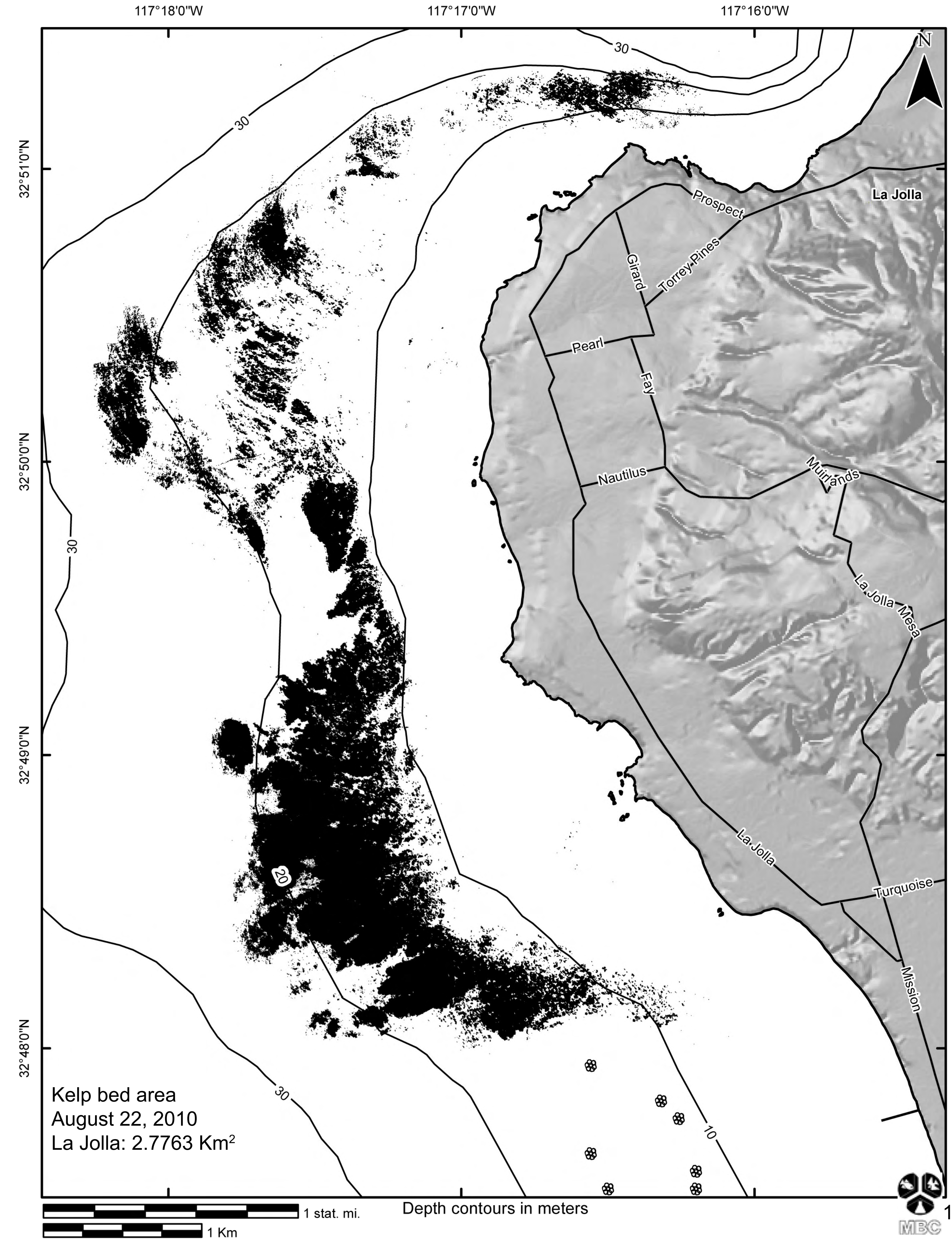
117°15'0"W
32°54'0"N
32°53'0"N
32°52'0"N
32°51'0"N
N
Torrey Pines
Torrey Pines Park
21
Genesee
No. 2
Torrey Pines
Artificial Reefs
No. 1
30
20
10
UCSD
Scripps Institution
of Oceanography
La Jolla Shores
Gilman
Ardath
Kelp bed area
August 22, 2010
Torrey Pines: 0.0032 Km²
La Jolla: 2.7763 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

15a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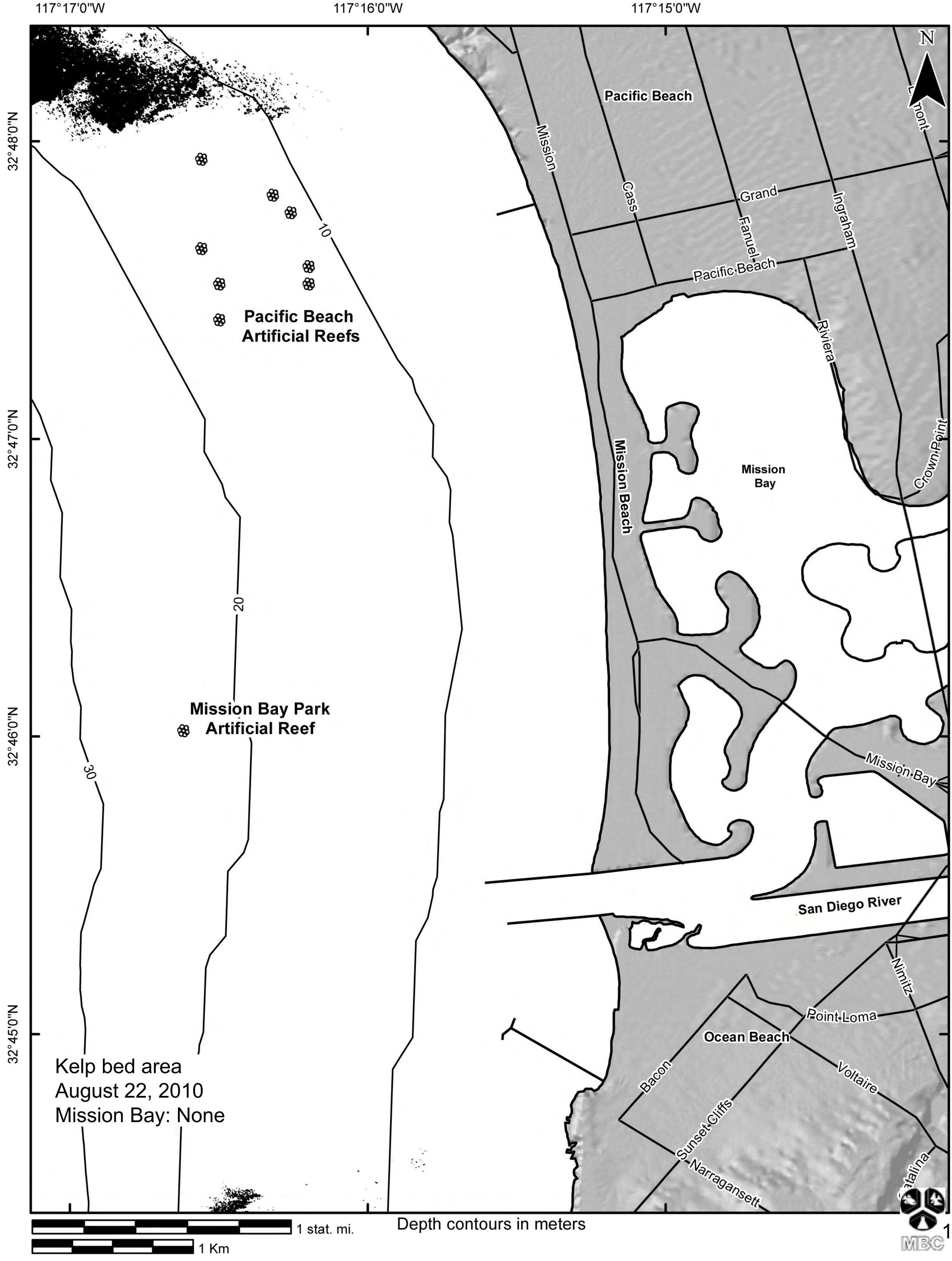
117°17'0"W
117°16'0"W
32°51'0"N
32°50'0"N
32°49'0"N
32°48'0"N
N
30
30
30
30
20
10
La Jolla
Prospect
Torrey Pines
Girard
Pearl
Fay
Nautilus
Muirlands
La Jolla Mesa
La Jolla
Turquoise
Mission
Kelp bed area
August 22, 2010
La Jolla: 2.7763 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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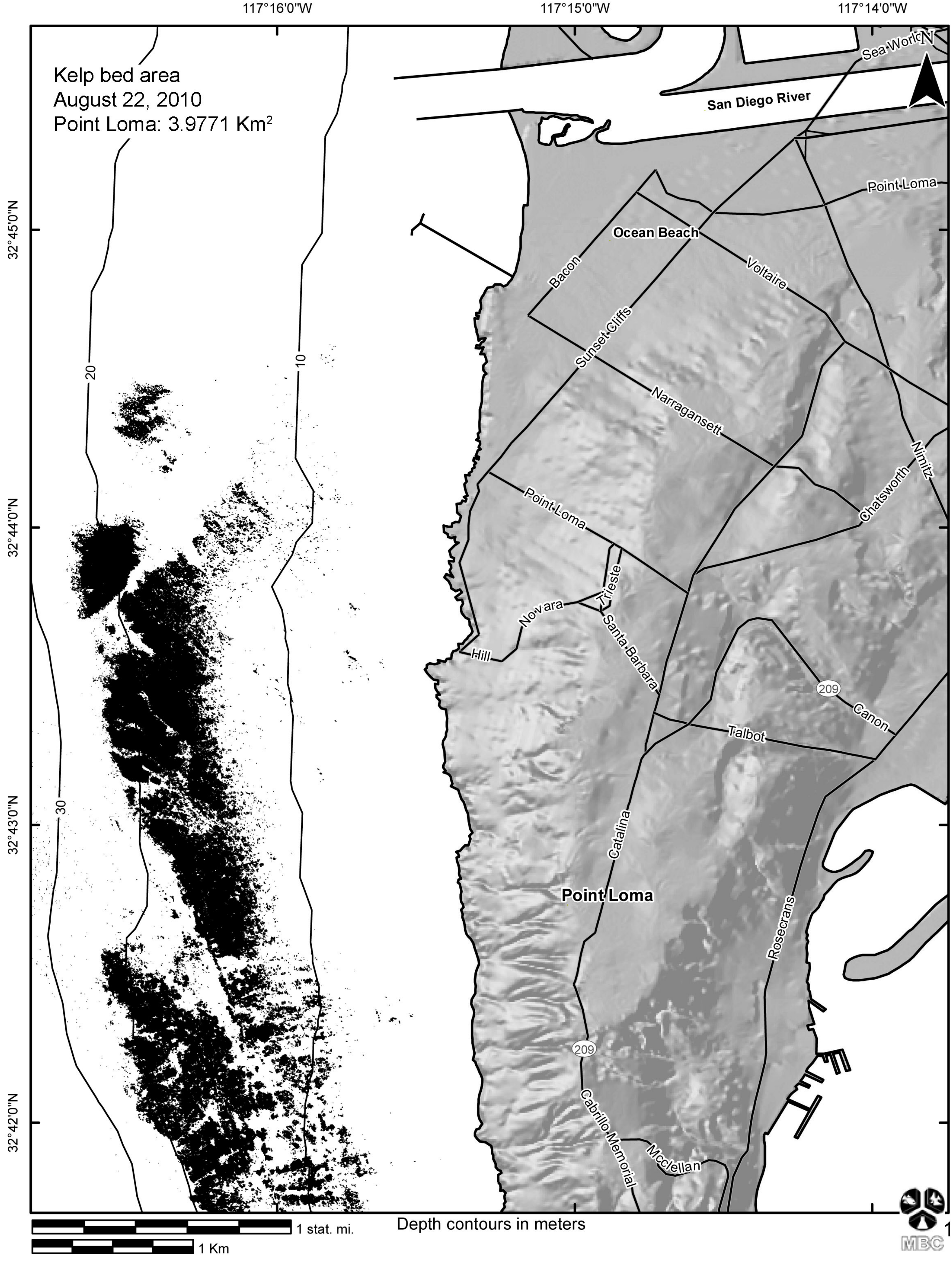
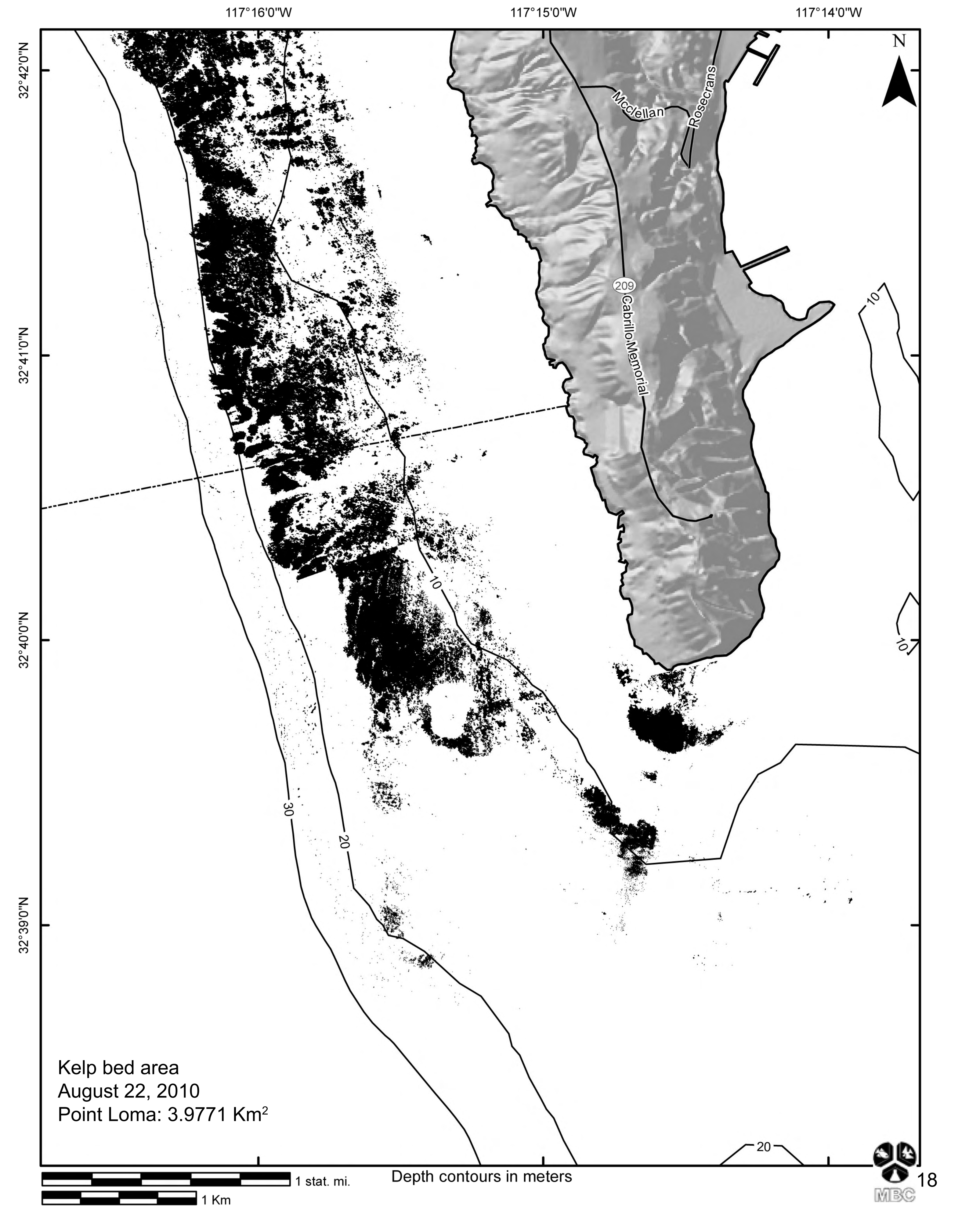
117°16'0"W
117°15'0"W
32°48'0"N
32°47'0"N
32°46'0"N
32°45'0"N
N
Pacific Beach
Mission
Cass
Grand
Fanuel
Ingraham
Pacific Beach
Riviera
10
Pacific Beach
Artificial Reefs
Mission Beach
Mission
Bay
Crown Point
20
Mission Bay Park
Artificial Reef
30
Mission Bay
San Diego River
Nimitz
Point Loma
Ocean Beach
Bacon
Voltaire
Sunset Cliffs
Narragansett
Catalina
Kelp bed area
August 22, 2010
Mission Bay: None
1 stat. mi.
1 Km
Depth contours in meters
MBC

16a


Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km²
117°16'0"W
117°15'0"W
117°14'0"W
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
20
10
30
N
Sea World
San Diego River
Point Loma
Ocean Beach
Bacon
Voltaire
Sunset Cliffs
Narragansett
Nimitz
Chatsworth
Point Loma
Trieste
Novara
Hill
Santa Barbara
209
Canon
Talbot
Catalina
Point Loma
Rosecrans
209
Cabrillo Memorial
Mcclellan
1 stat. mi.
1 Km
Depth contours in meters
MBC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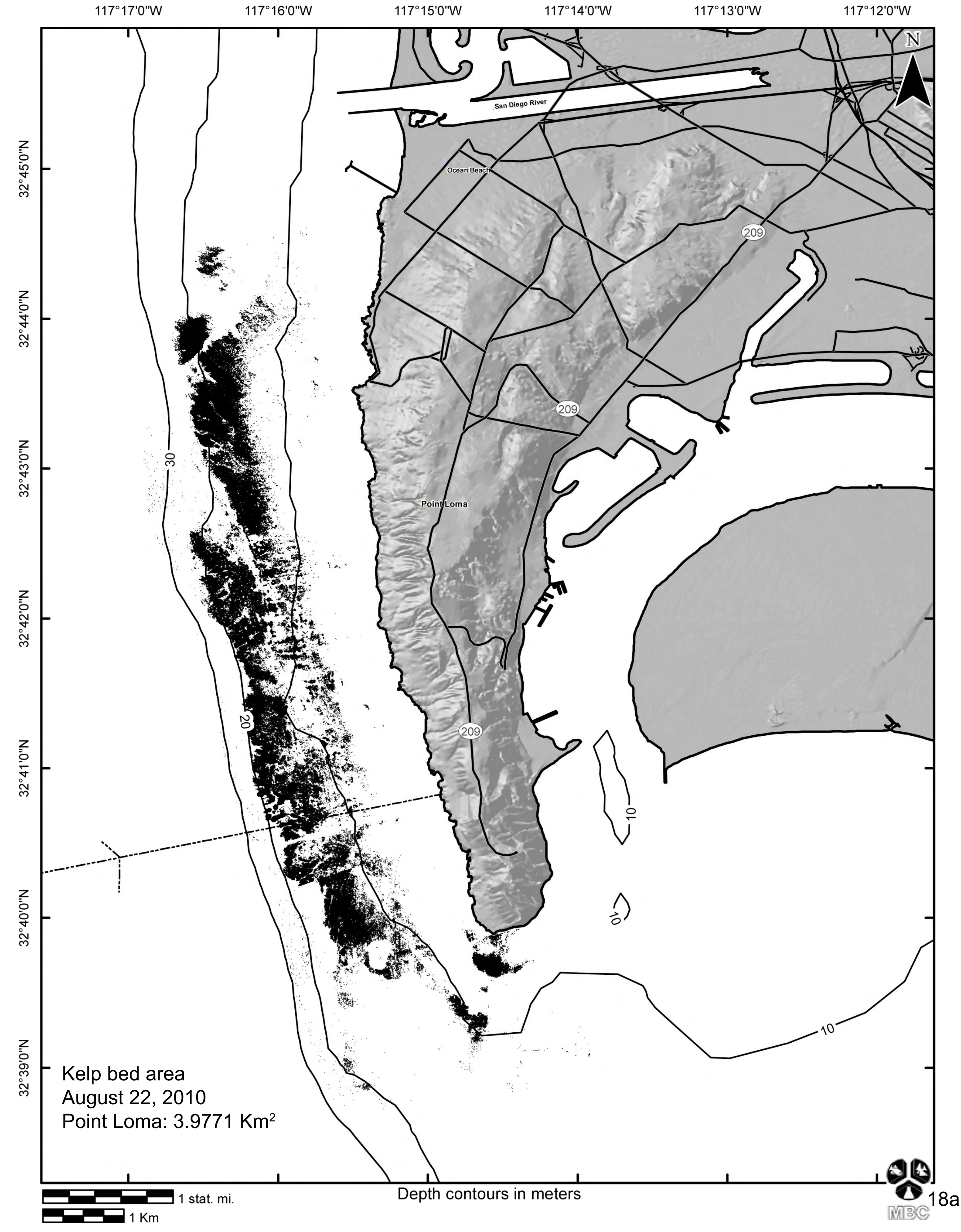
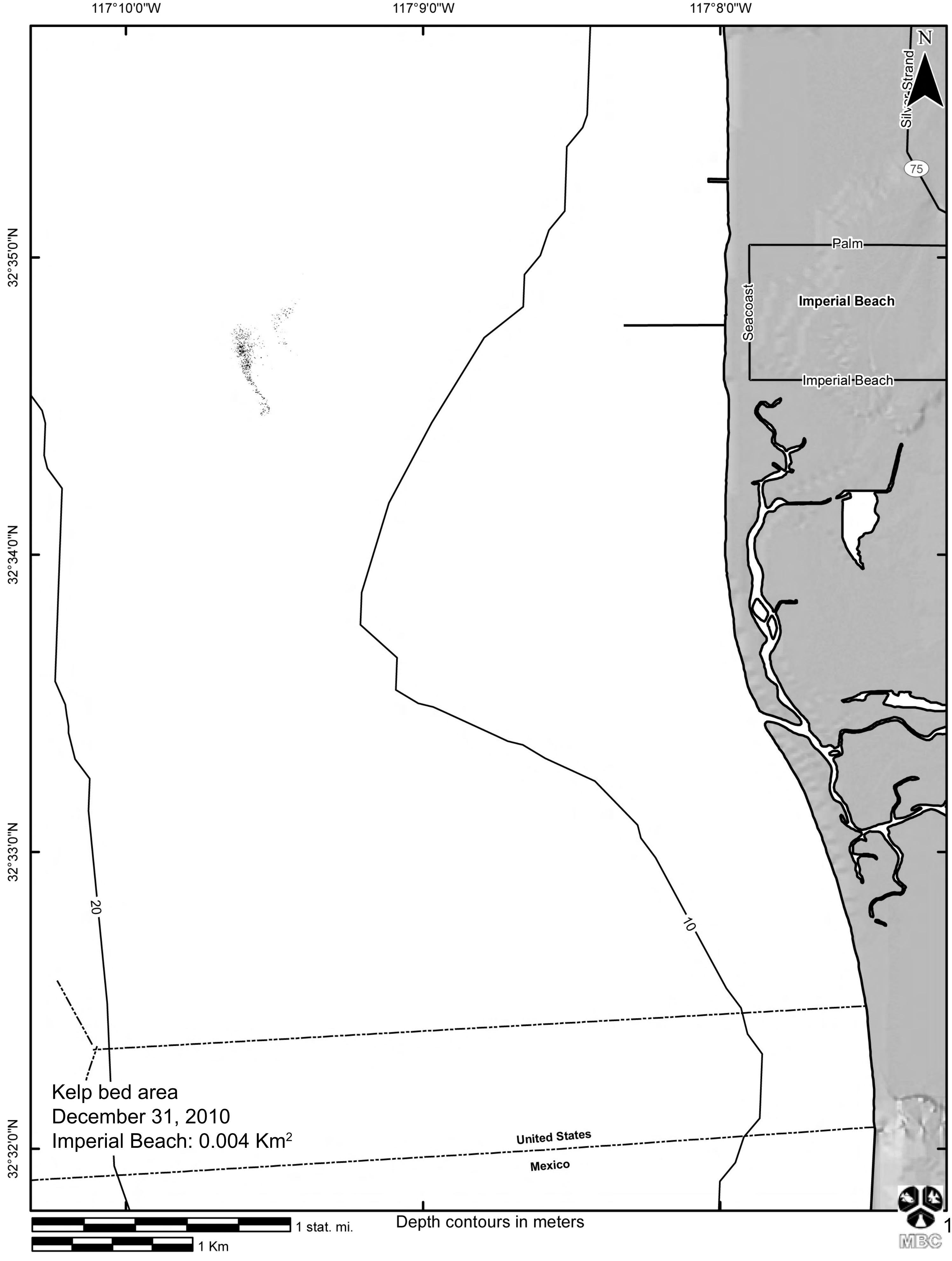
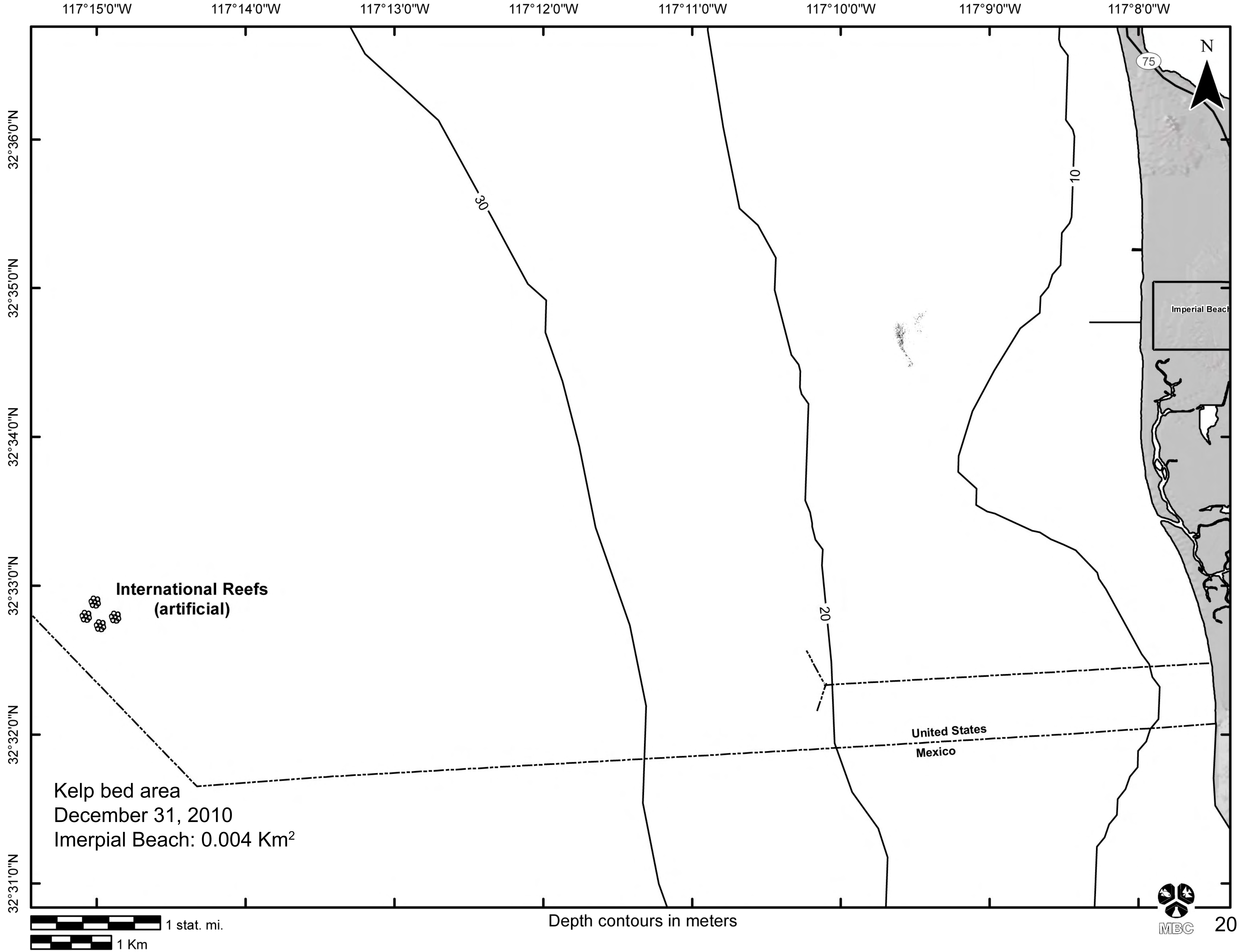
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
Mcclellan
Rosecrans
209
Cabrillo Memorial
10
20
30
Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC



117°17'0"W
117°16'0"W
117°15'0"W
117°14'0"W
117°13'0"W
117°12'0"W
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
San Diego River
Ocean Beach
Point Loma
209
30
20
10
Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km^2
1 stat. mi.
1 Km
Depth contours in meters
MBC

18a


117°10'0"W
117°9'0"W
117°8'0"W
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
N
Silver Strand
75
Palm
Seacoast
Imperial Beach
Imperial Beach
20
10
United States
Mexico
Kelp bed area
December 31, 2010
Imperial Beach: 0.004 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC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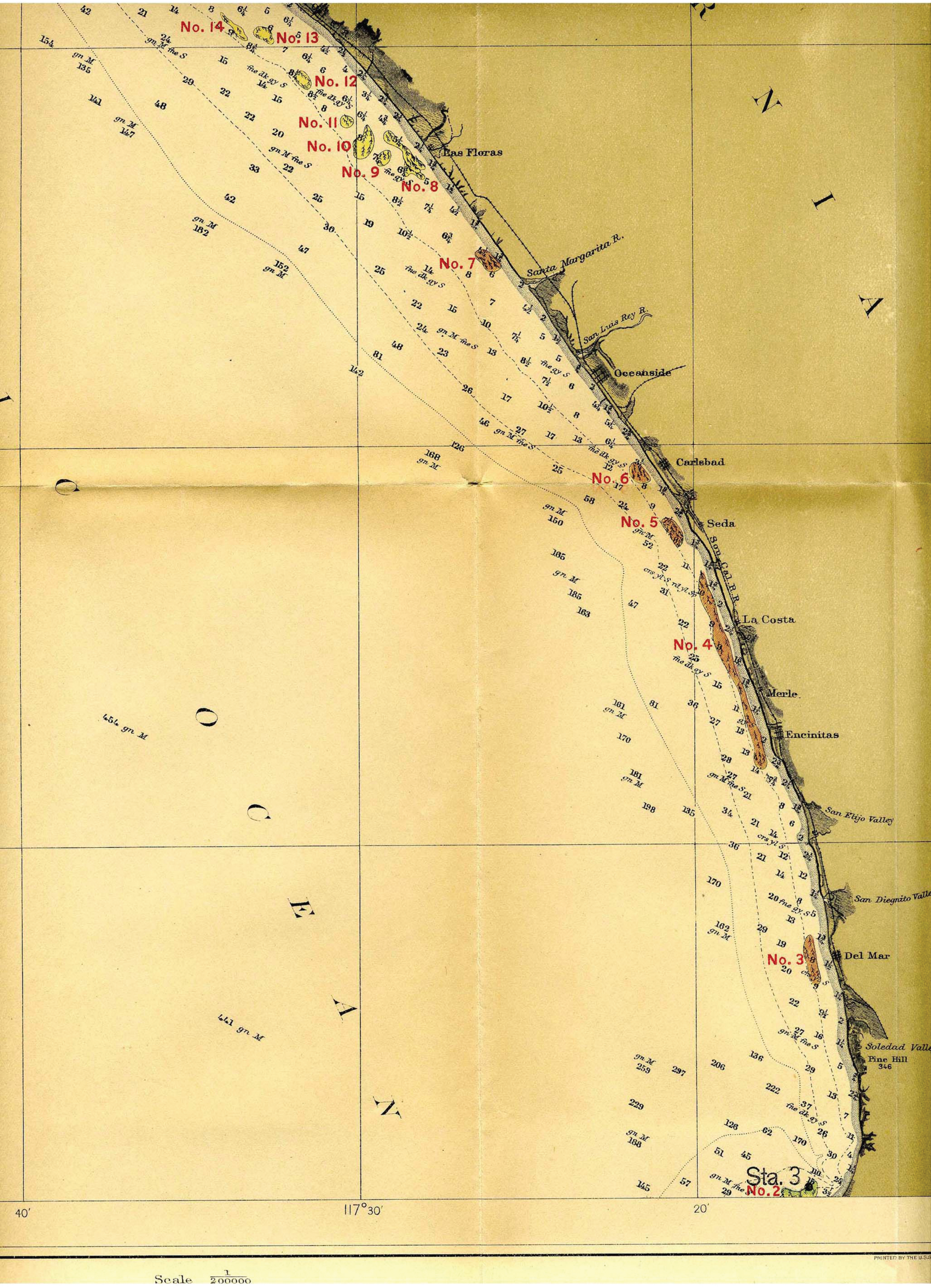
117°14'0"W
117°13'0"W
117°12'0"W
117°11'0"W
117°10'0"W
117°9'0"W
117°8'0"W
32°36'0"N
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
32°31'0"N
N
75
30
20
10
Imperial Beach
International Reefs
(artificial)
United States
Mexico
Kelp bed area
December 31, 2010
Imerpial Beach: 0.004 Km2
1 stat. mi.
1 Km
Depth contours in meters
MBC

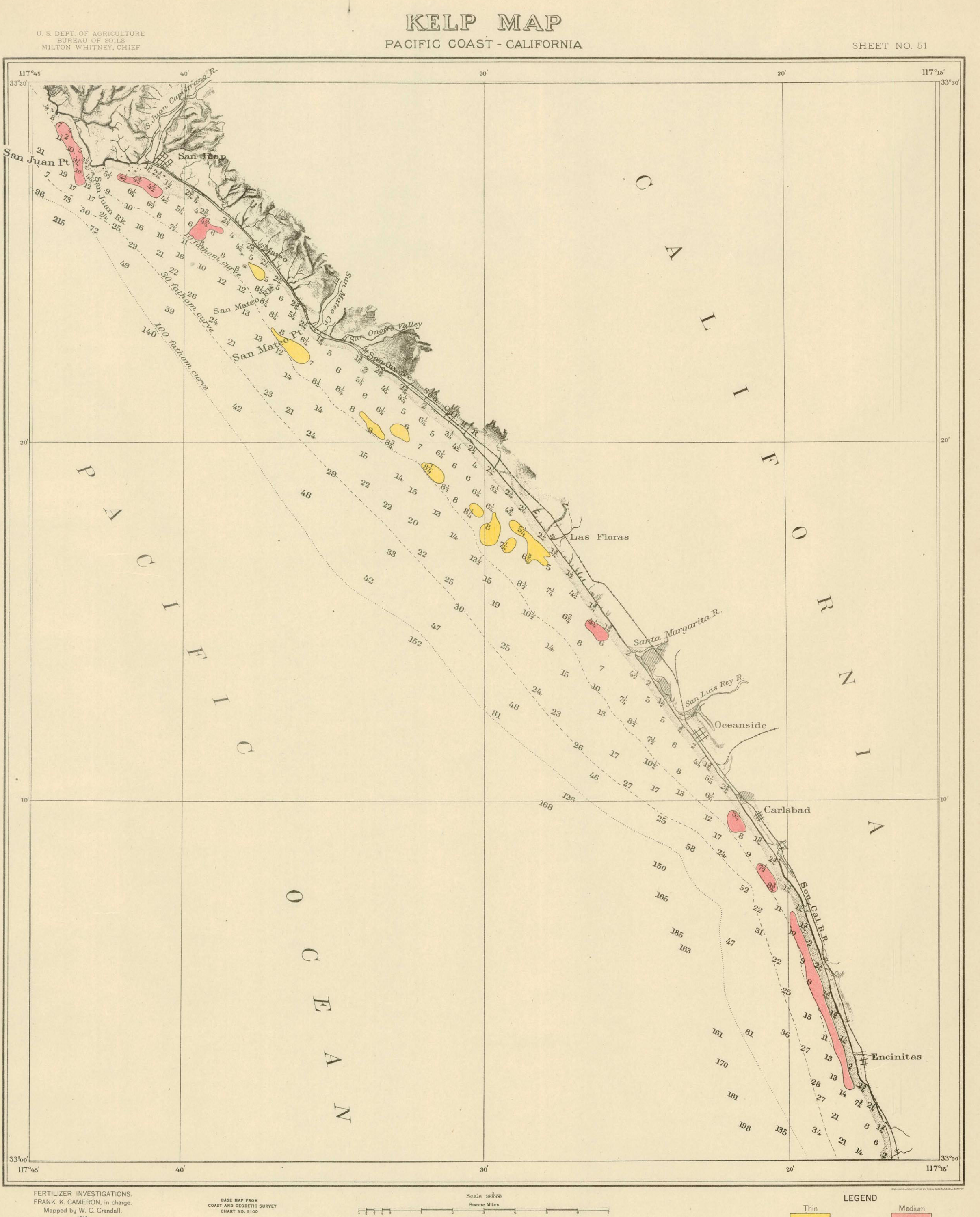
APPENDIX B

Historic Coverage Area of Kelp Canopies

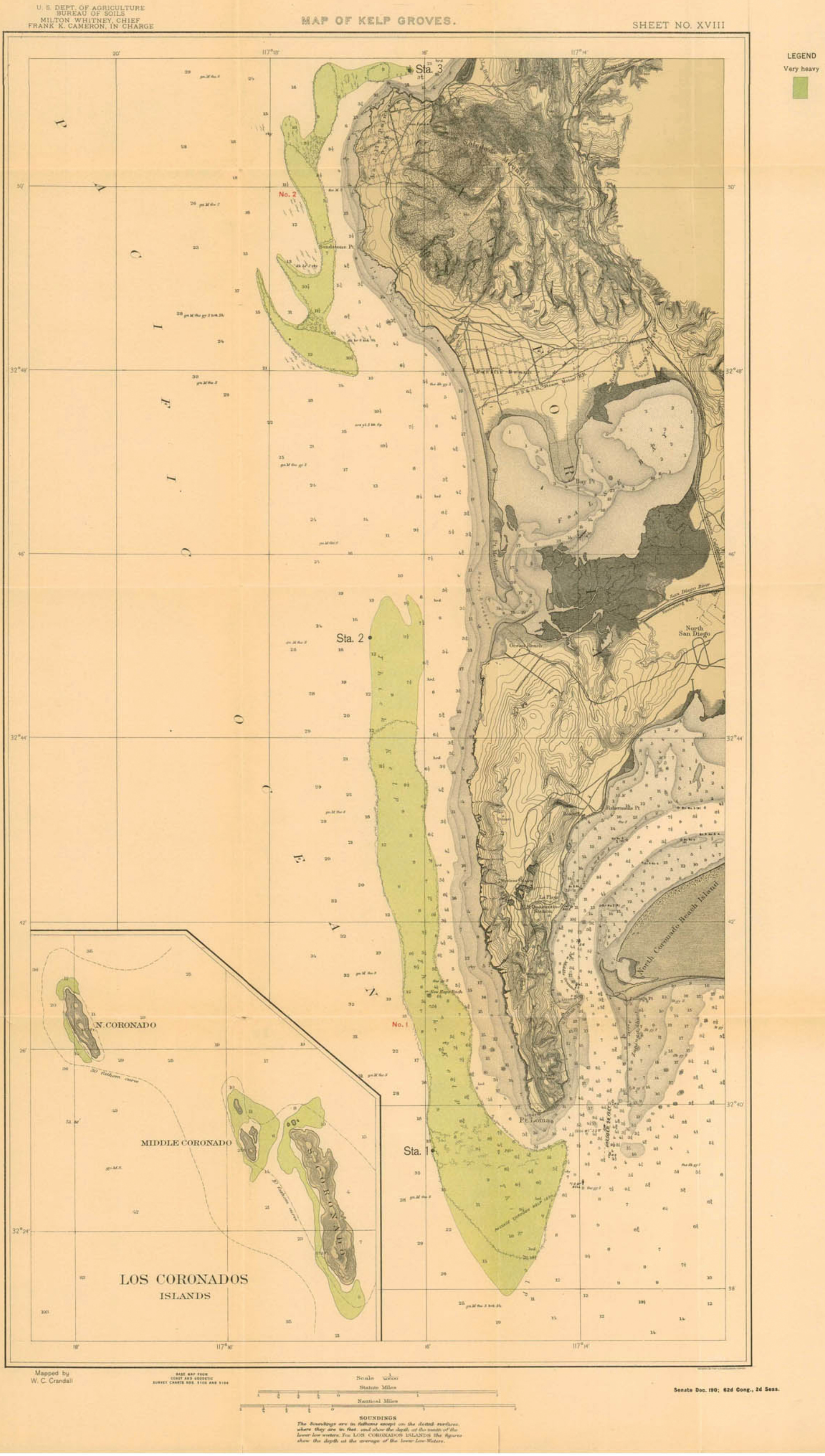
1911 Crandall kelp bed survey, Newport to San Onofre



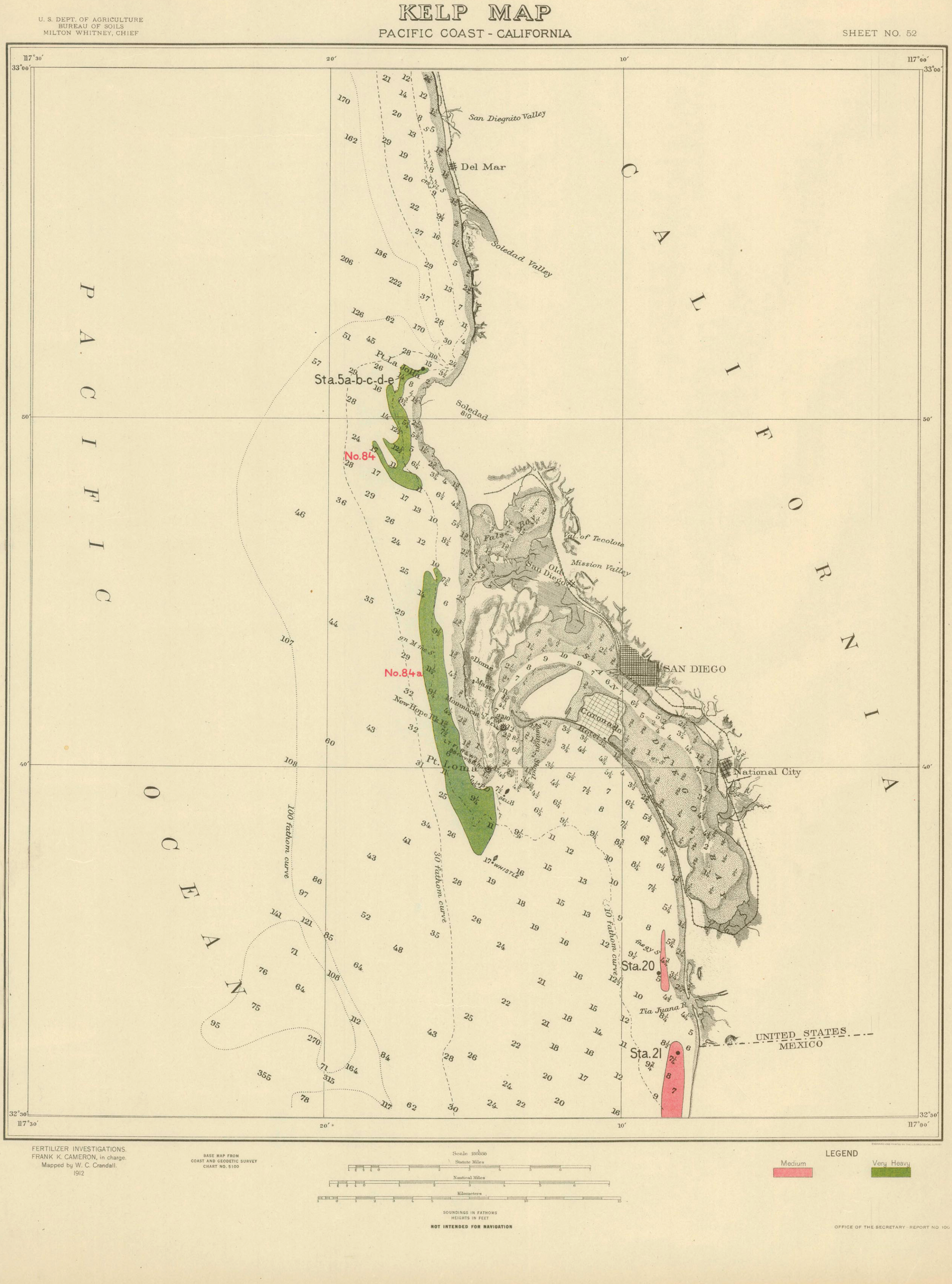
1911 Crandall kelp bed survey, San Onofre to Del Mar



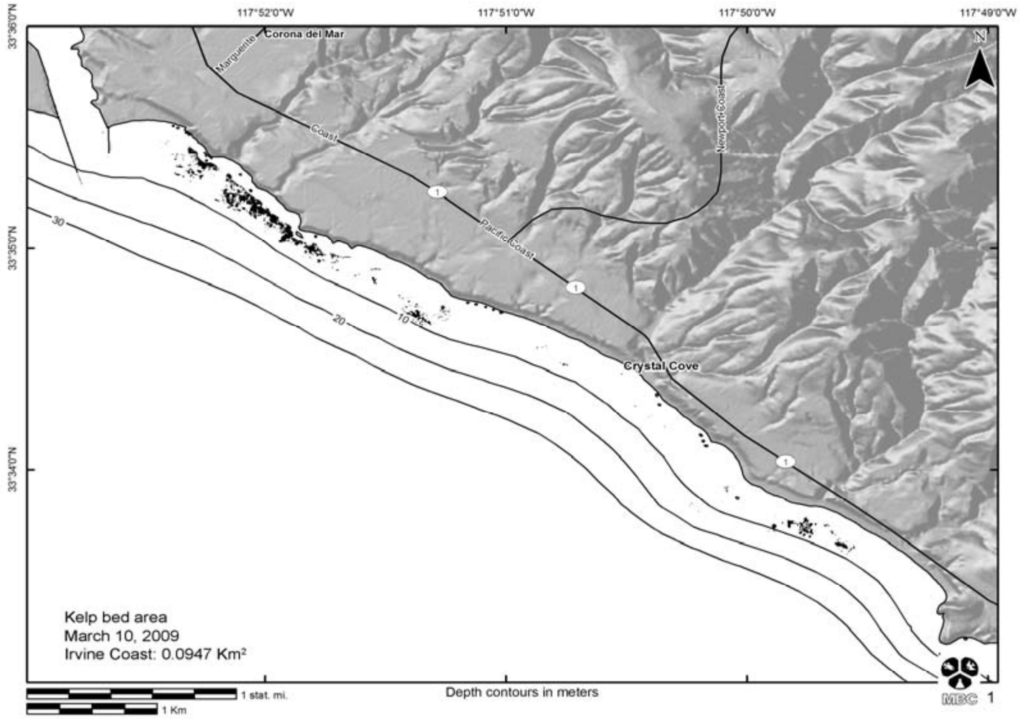
1911 Crandall kelp bed survey, San Juan to Encinitas

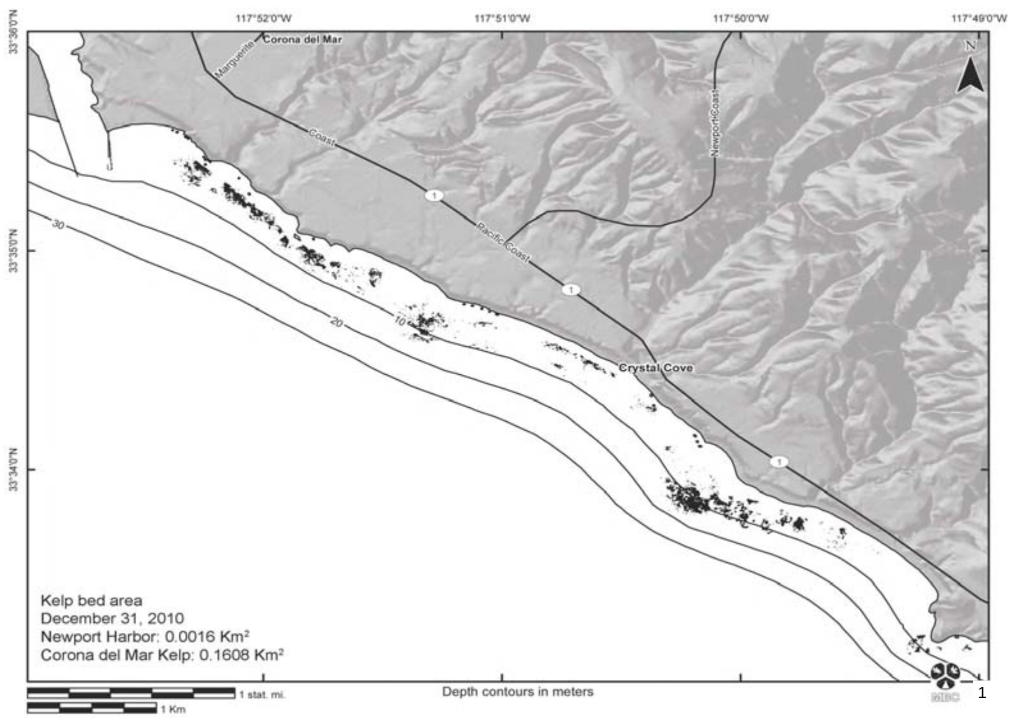


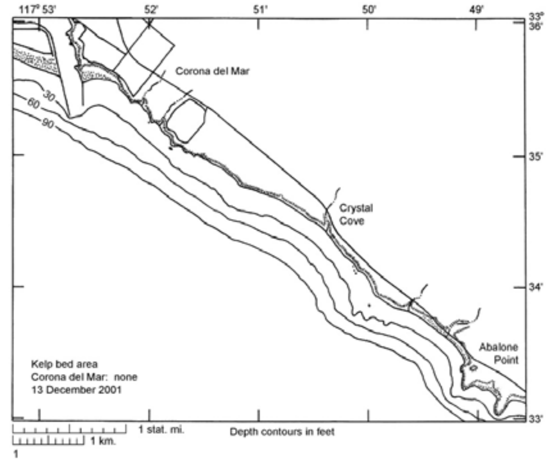
1911 Crandall kelp bed survey, La Jolla to Point Loma

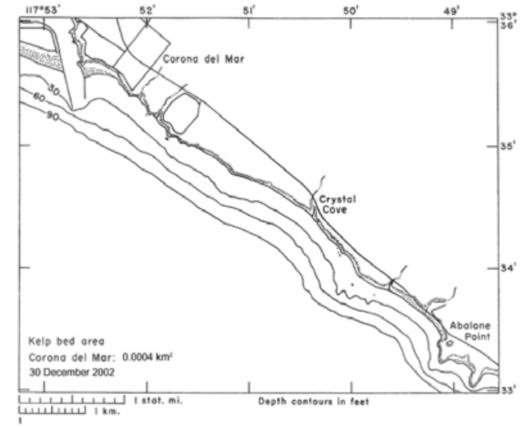


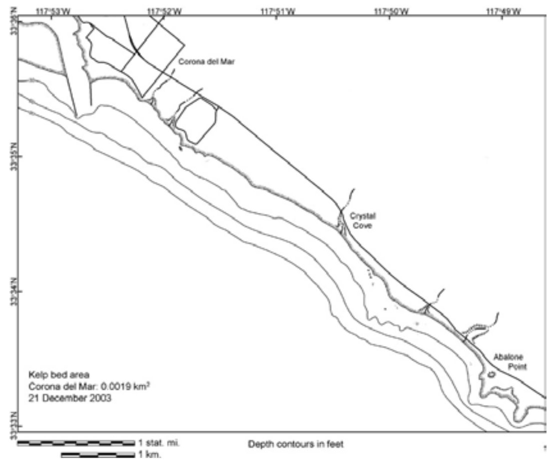
1911 Crandall kelp bed survey, La Jolla to Imperial Beach

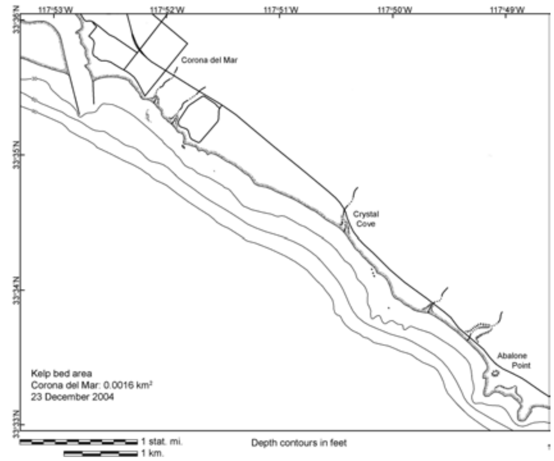

117°52'0"W
117°51'0"W
117°50'0"W
117°49'0"W
33°36'0"N
33°35'0"N
33°34'0"N
Corona del Mar
Marguerite
Coast
Pacific Coast
Newport Coast
Crystal Cove
1
30
20
10
Kelp bed area
March 10, 2009
Irvine Coast: 0.0947 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

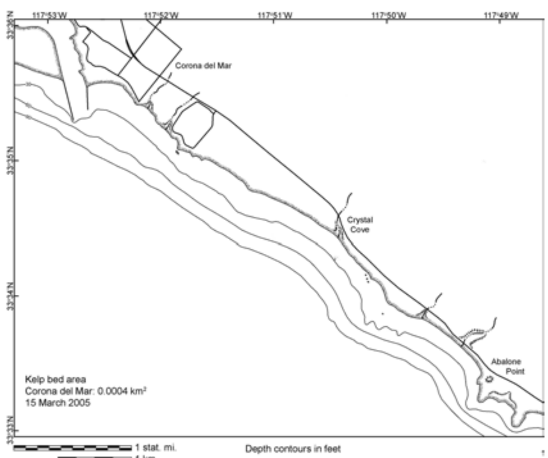

117°52'0"W
117°51'0"W
117°50'0"W
117°49'0"W
33°36'0"N
33°35'0"N
33°34'0"N
Corona del Mar
Marguerite
Coast
Pacific Coast
Newport Coast
Crystal Cove
1
30
20
10
Kelp bed area
December 31, 2010
Newport Harbor: 0.0016 Km²
Corona del Mar Kelp: 0.1608 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC

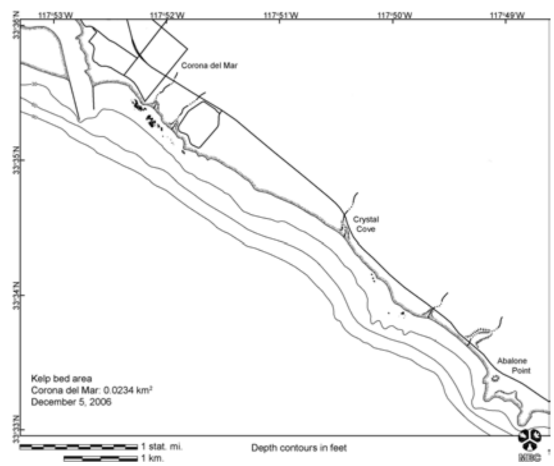

117° 53'
52'
51'
50'
49'
33° 36'
35'
34'
33'
Corona del Mar
Crystal Cove
Abalone Point
30
60
90
Kelp bed area
Corona del Mar: none
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet

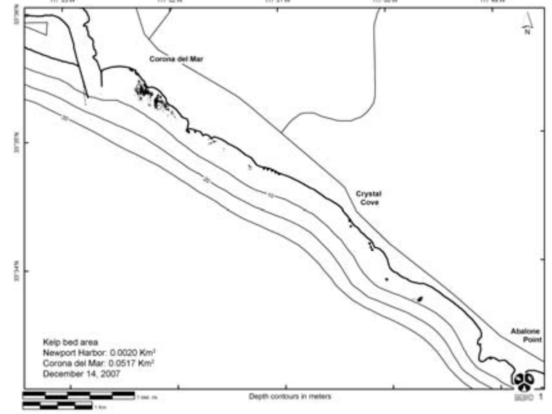

117°53'
52'
51'
50'
49'
33° 36'
35'
34'
33'
Corona del Mar
Crystal Cove
Abalone Point
30
60
90
Kelp bed area
Corona del Mar: 0.0004 km²
30 December 2002
1 stat. mi.
1 km.
Depth contours in feet

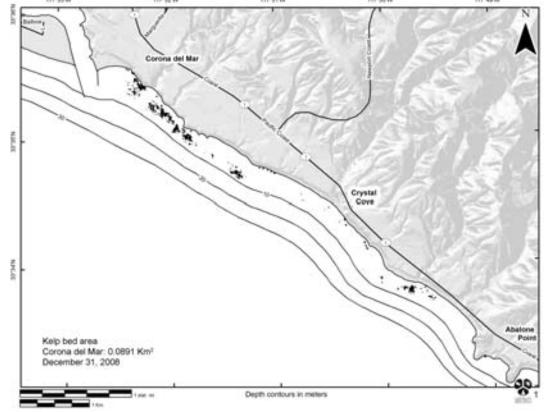

117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Corona del Mar: 0.0019 km²
21 December 2003
1 stat. mi.
1 km.
Depth contours in feet

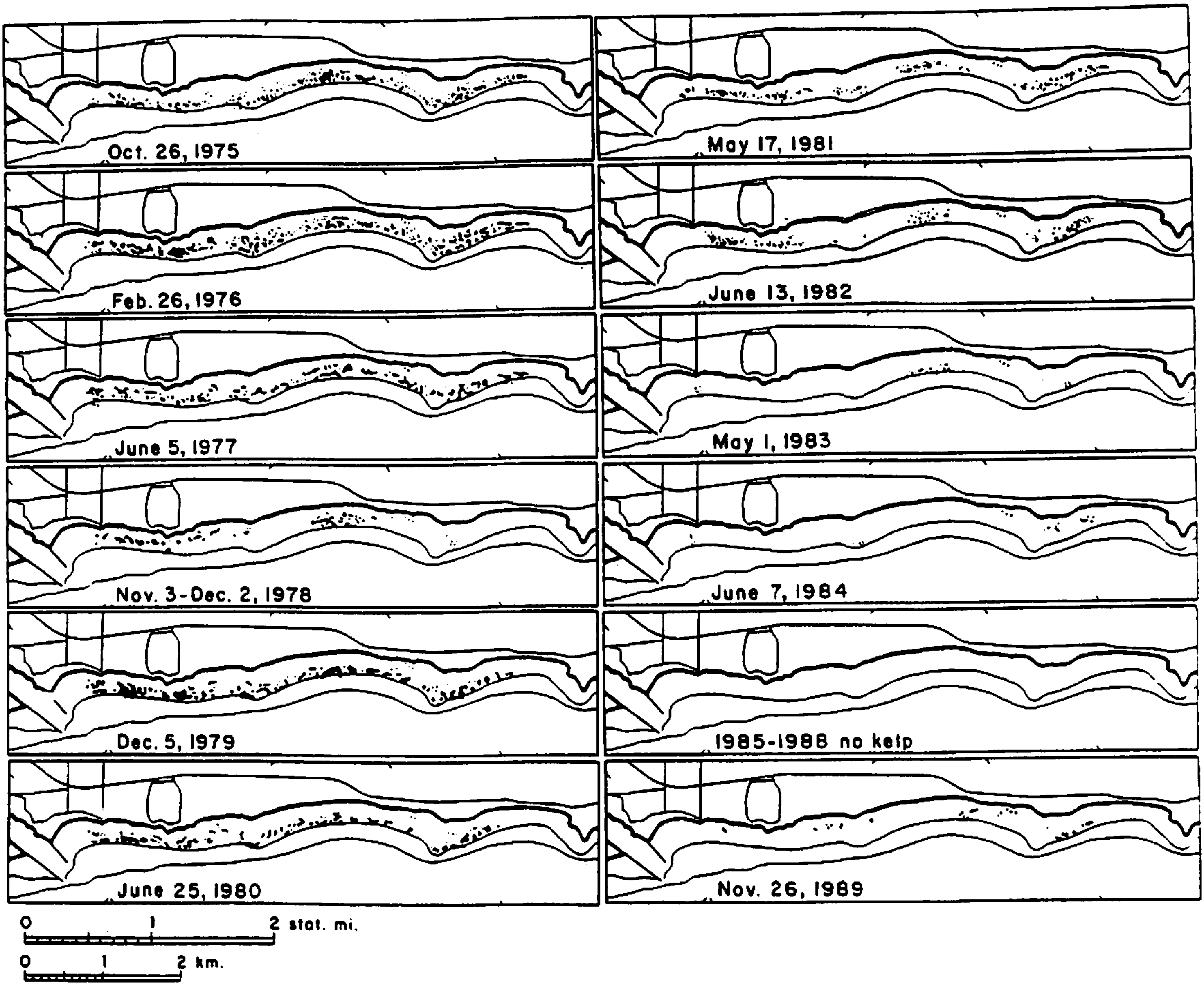

117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Corona del Mar: 0.0016 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet


117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Corona del Mar: 0.0004 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet

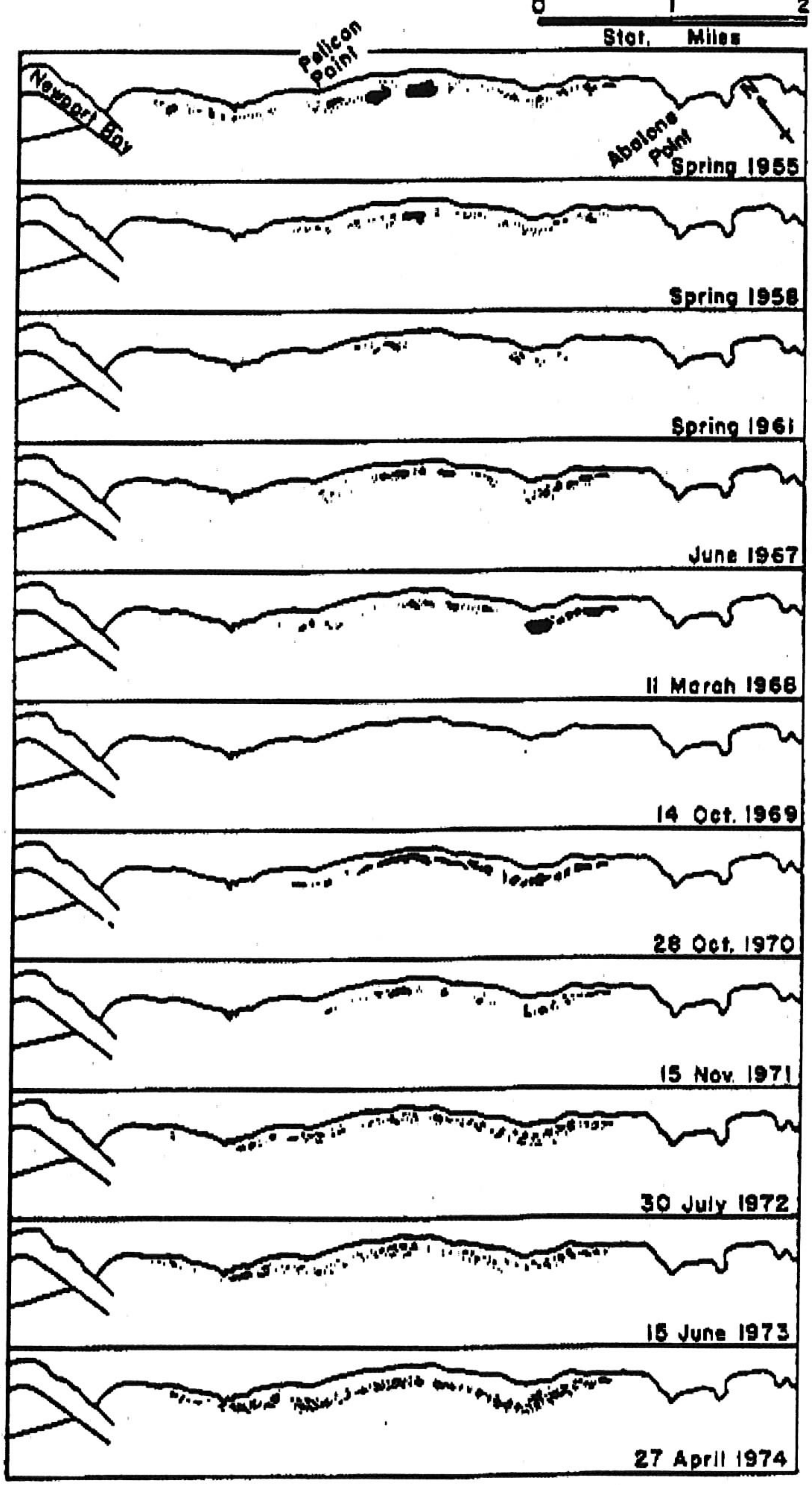

117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Corona del Mar: 0.0234 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet


117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Newport Harbor: 0.0020 Km²
Corona del Mar: 0.0517 Km²
December 14, 2007
Depth contours in meters

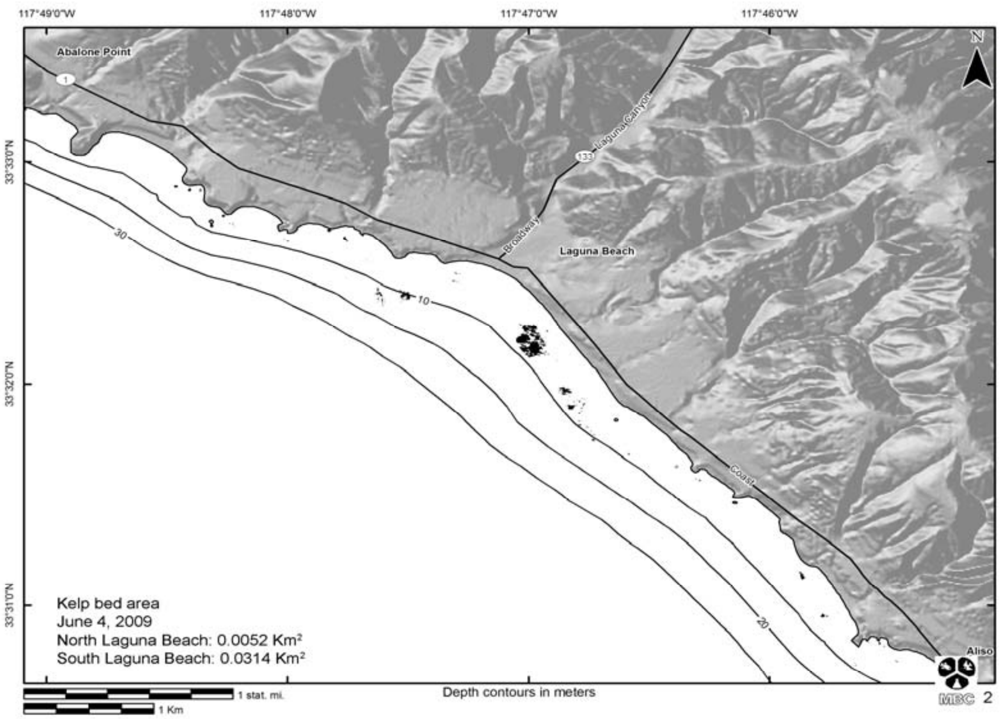

117°53'W
117°52'W
117°51'W
117°50'W
117°49'W
Corona del Mar
Crystal Cove
Abalone Point
Kelp bed area
Corona del Mar: 0.0891 Km²
December 31, 2008
Depth contours in meters

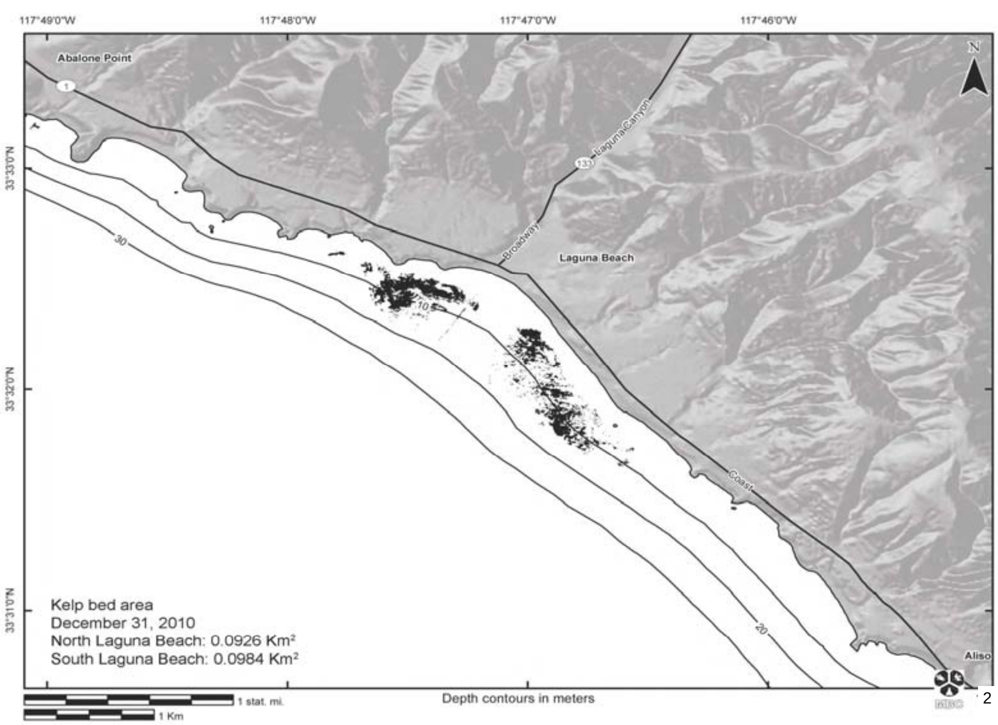


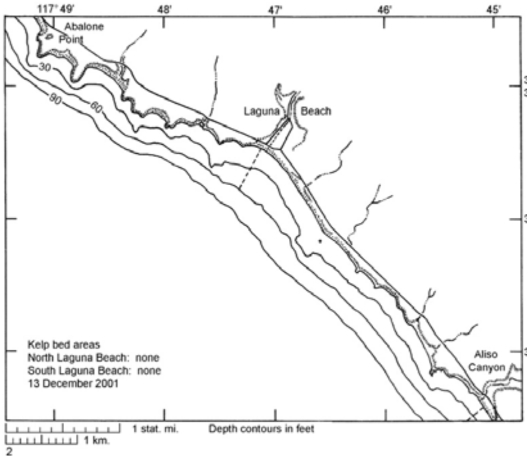
Historical charts of Corona del Mar kelp from 1975 to 1989.

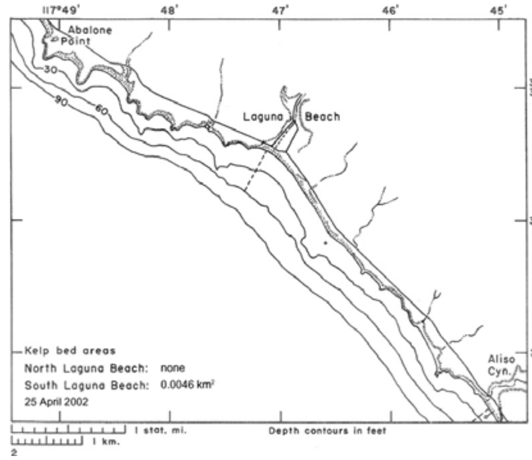


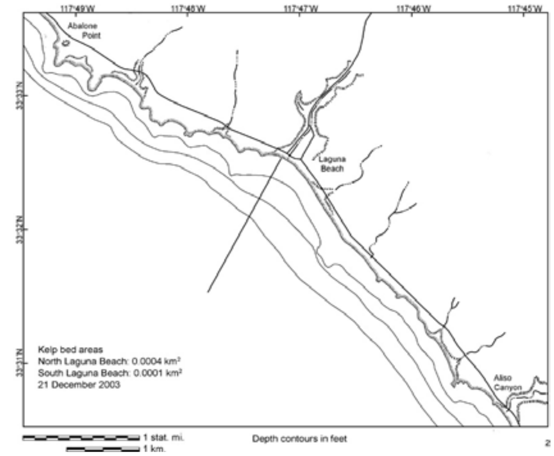
Historical charts of Corona del Mar kelp from 1955 to 1974.

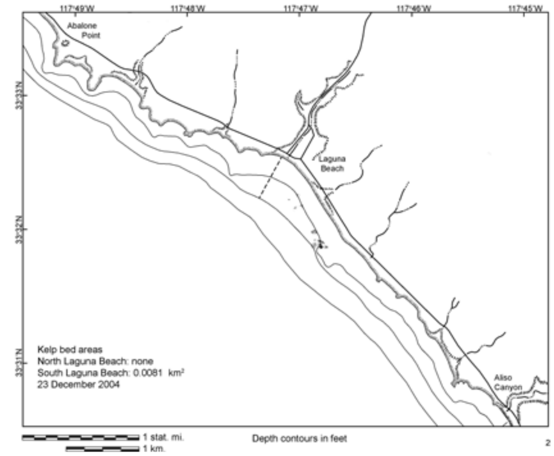

117°49'0"W
117°48'0"W
117°47'0"W
117°46'0"W
33°33'0"N
33°32'0"N
33°31'0"N
Abalone Point
1
133
Laguna Canyon
Broadway
Laguna Beach
Coast
Aliso
N
10
20
30
Kelp bed area
June 4, 2009
North Laguna Beach: 0.0052 Km²
South Laguna Beach: 0.0314 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
2

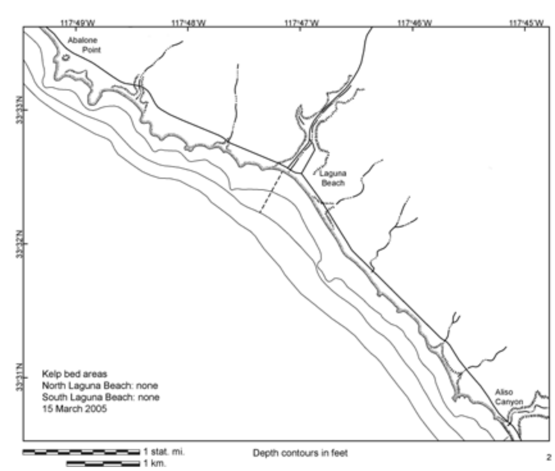

117°49'0"W
117°48'0"W
117°47'0"W
117°46'0"W
33°33'0"N
33°32'0"N
33°31'0"N
Abalone Point
1
133
Laguna Canyon
Broadway
Laguna Beach
Coast
Aliso
N
10
20
30
Kelp bed area
December 31, 2010
North Laguna Beach: 0.0926 Km²
South Laguna Beach: 0.0984 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
2

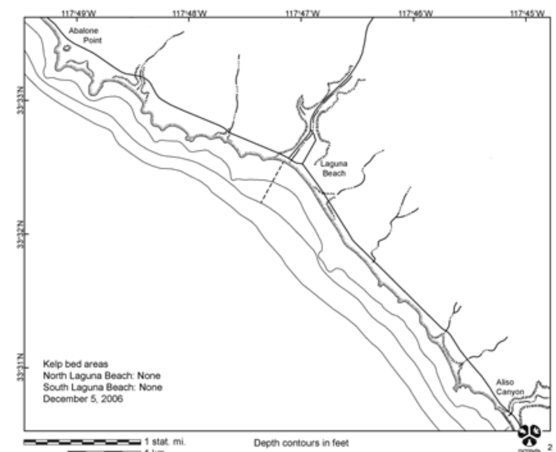

117° 49'
48'
47'
46'
45'
Abalone Point
30
90
60
Laguna Beach
33° 33'
32'
31'
Aliso Canyon
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
2

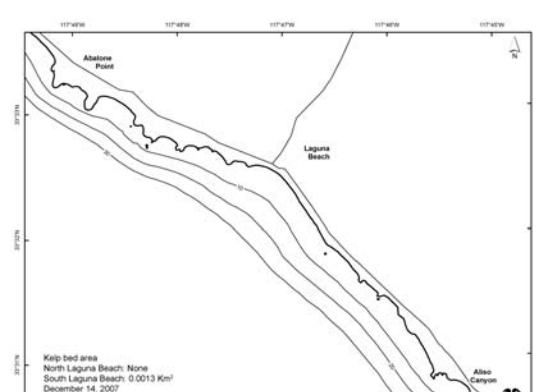

117°49'
48'
47'
46'
45'
Abalone Point
30
90
60
Laguna Beach
33° 33'
32'
31'
Aliso Cyn.
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: 0.0046 km²
25 April 2002
1 stat. mi.
1 km.
Depth contours in feet
2

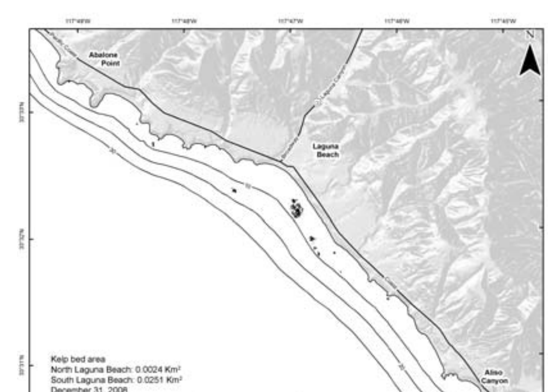

117°49'W
117°48'W
117°47'W
117°46'W
117°45'W
Abalone Point
Laguna Beach
Aliso Canyon
33°33'N
33°32'N
33°31'N
Kelp bed areas
North Laguna Beach: 0.0004 km²
South Laguna Beach: 0.0001 km²
21 December 2003
1 stat. mi.
1 km.
Depth contours in feet
2

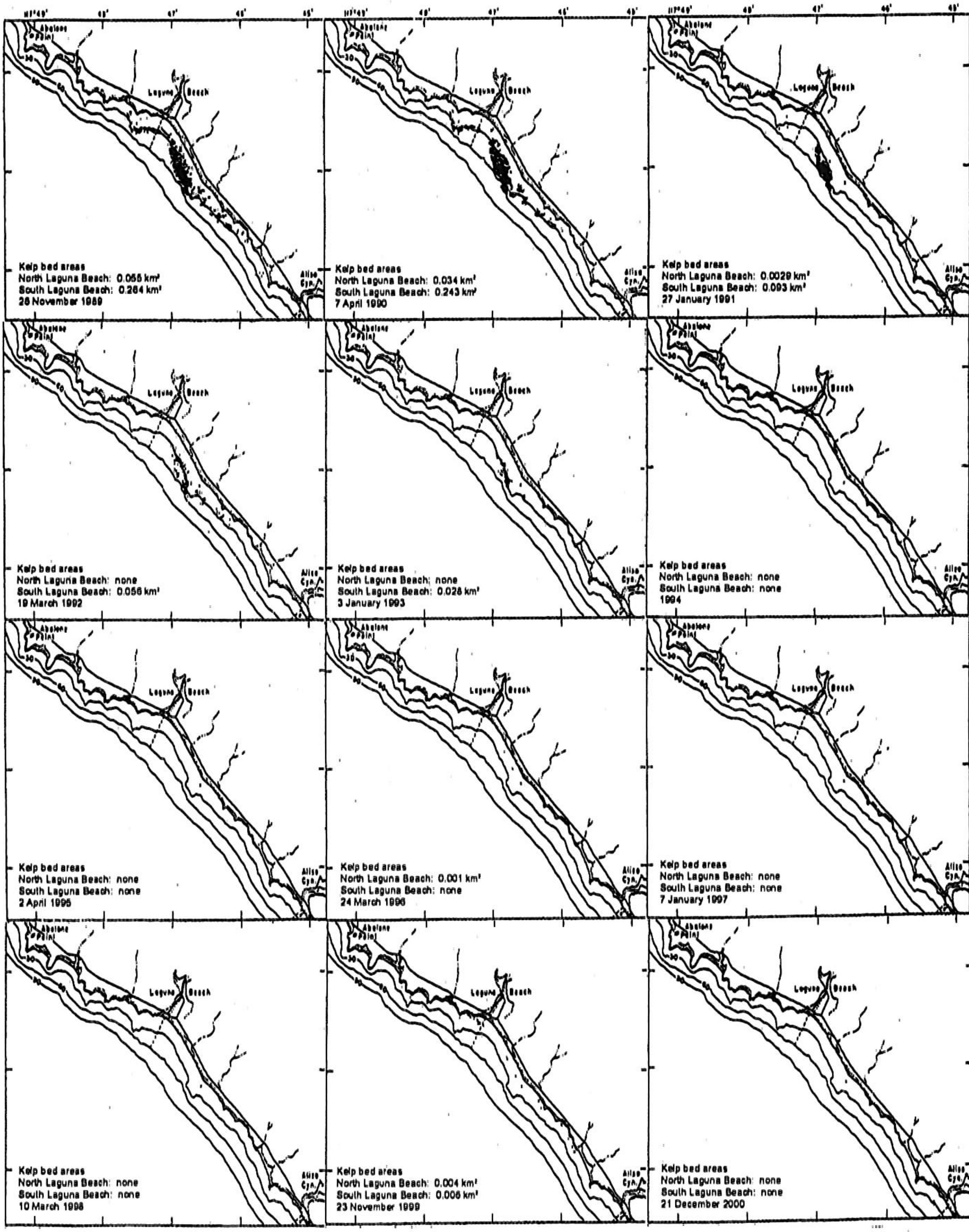

117°49'W
117°48'W
117°47'W
117°46'W
117°45'W
Abalone Point
Laguna Beach
Aliso Canyon
33°33'N
33°32'N
33°31'N
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: 0.0081 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
2

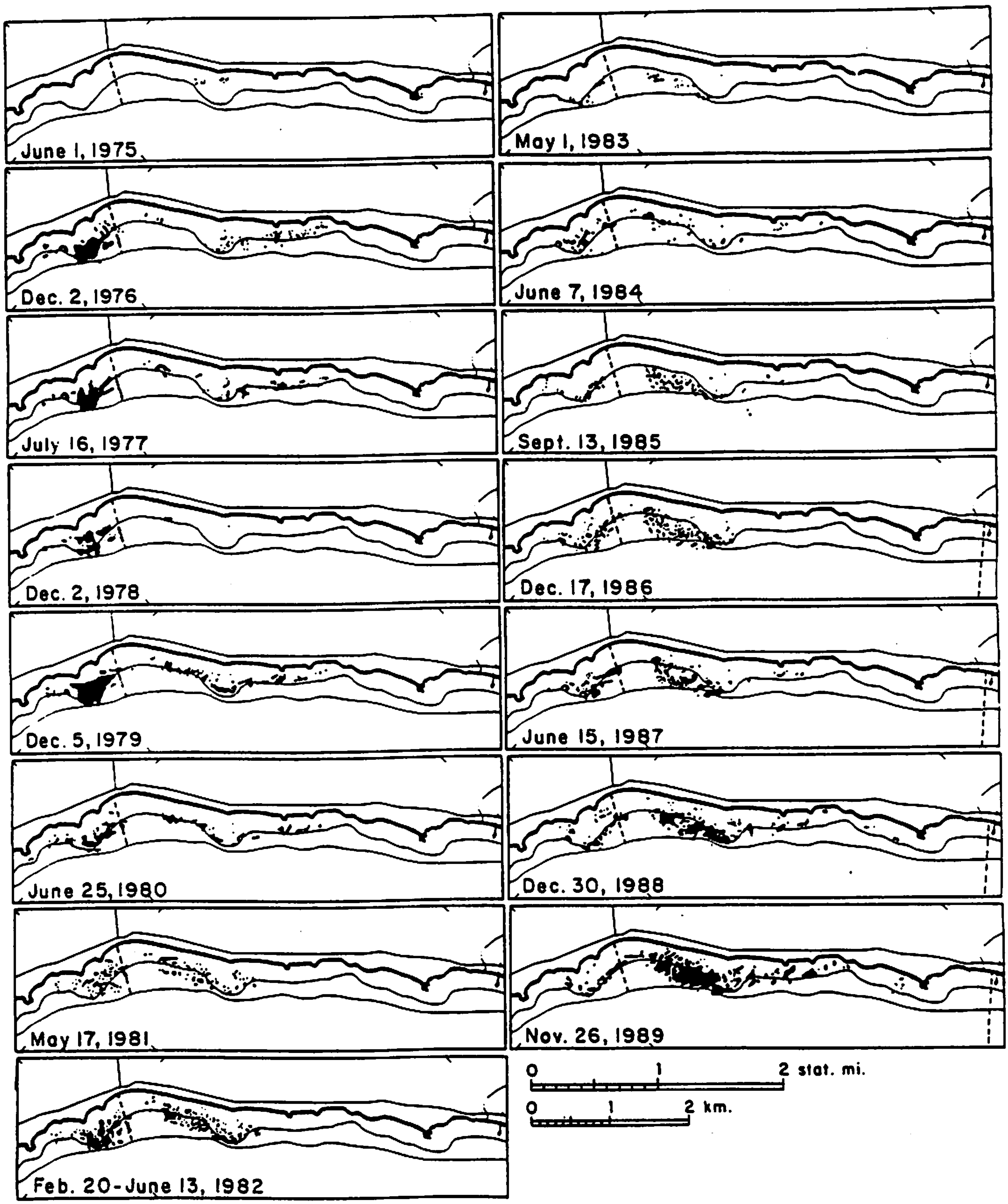

117°49'W
117°48'W
117°47'W
117°46'W
117°45'W
Abalone Point
Laguna Beach
Aliso Canyon
33°33'N
33°32'N
33°31'N
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
2


117°49'W
117°48'W
117°47'W
117°46'W
117°45'W
Abalone Point
Laguna Beach
Aliso Canyon
33°33'N
33°32'N
33°31'N
Kelp bed areas
North Laguna Beach: None
South Laguna Beach: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
2

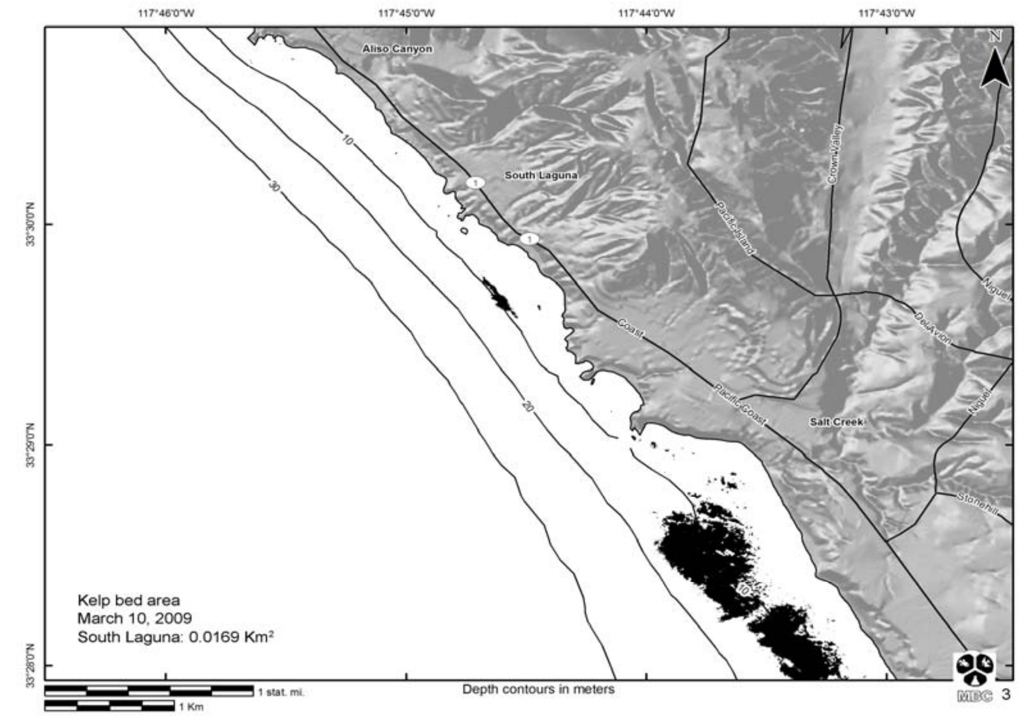

Abalone Point
Laguna Beach
Aliso Canyon
Kelp bed area
North Laguna Beach: None
South Laguna Beach: 0.0013 Km²
December 14, 2007
Depth contours in meters
2

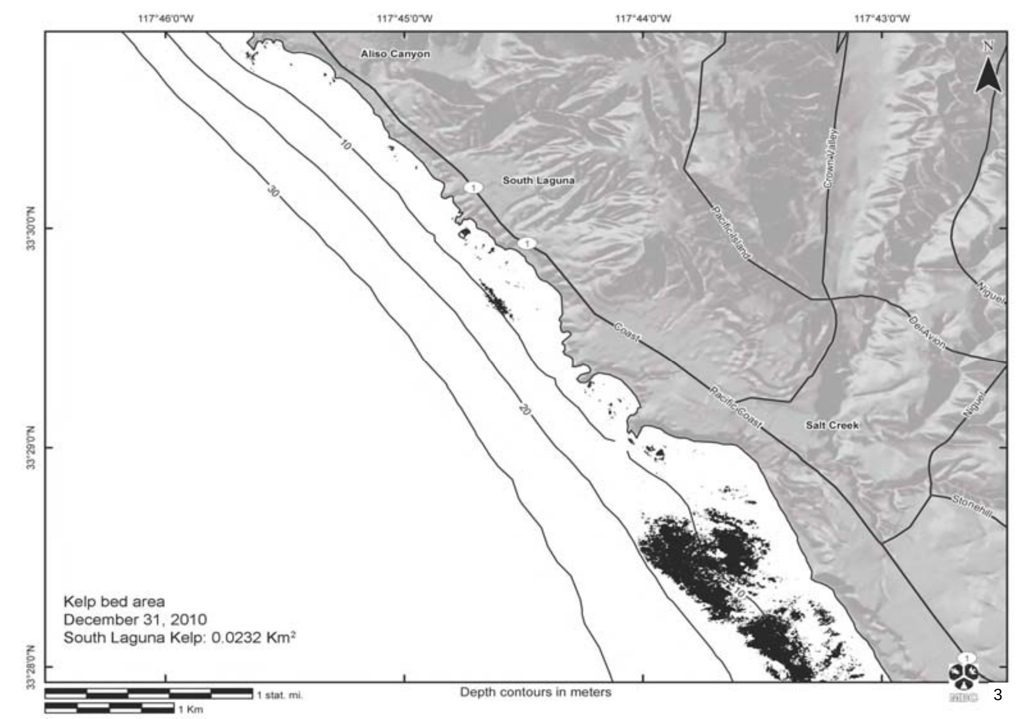

Abalone Point
Laguna Beach
Aliso Canyon
Kelp bed area
North Laguna Beach: 0.0024 Km²
South Laguna Beach: 0.0251 Km²
December 31, 2008
Depth contours in meters
2

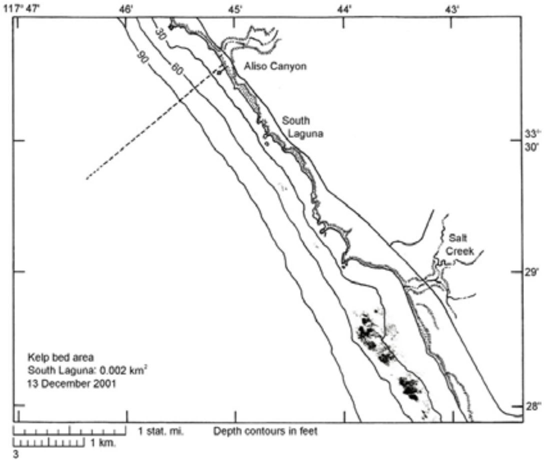

Abalone Point
Laguna Beach
Aliso Cyn.
Kelp bed areas
North Laguna Beach: 0.055 km²
South Laguna Beach: 0.264 km²
26 November 1989
Kelp bed areas
North Laguna Beach: 0.034 km²
South Laguna Beach: 0.243 km²
7 April 1990
Kelp bed areas
North Laguna Beach: 0.0029 km²
South Laguna Beach: 0.093 km²
27 January 1991
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: 0.056 km²
19 March 1992
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: 0.028 km²
3 January 1993
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
1994
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
2 April 1995
Kelp bed areas
North Laguna Beach: 0.001 km²
South Laguna Beach: none
24 March 1996
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
7 January 1997
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
10 March 1998
Kelp bed areas
North Laguna Beach: 0.004 km²
South Laguna Beach: 0.006 km²
23 November 1999
Kelp bed areas
North Laguna Beach: none
South Laguna Beach: none
21 December 2000

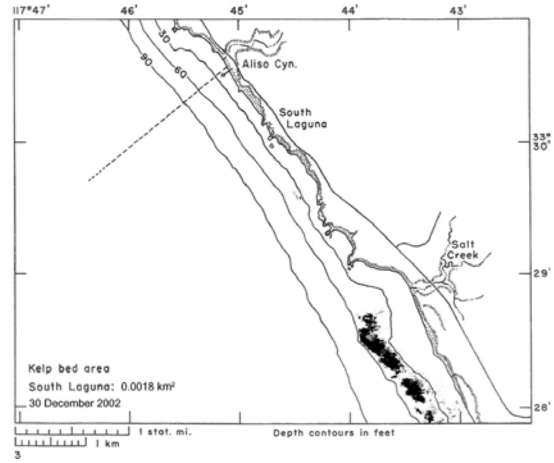


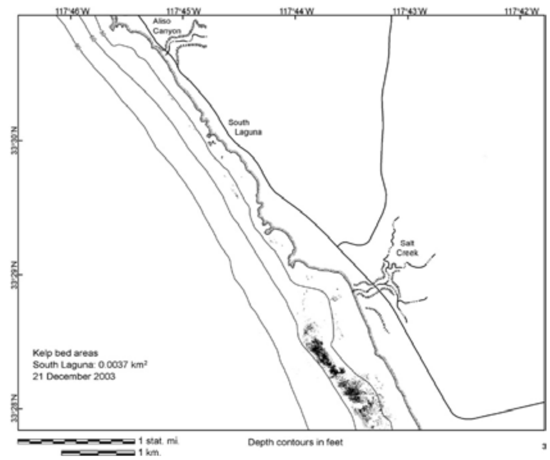
Historical charts of Laguna Beach kelp from 1975 to 1989.

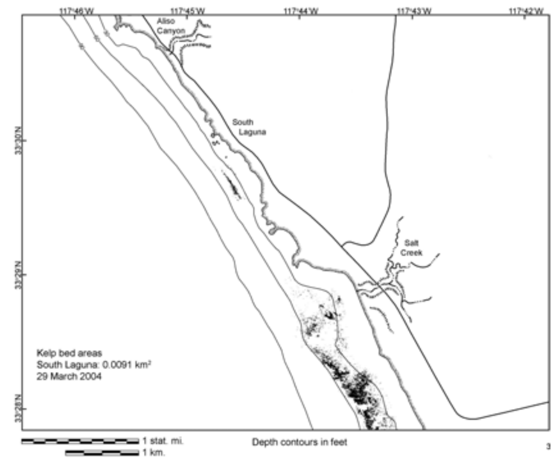

117°46'0"W
117°45'0"W
117°44'0"W
117°43'0"W
33°30'0"N
33°29'0"N
33°28'0"N
N
Aliso Canyon
South Laguna
Salt Creek
Crown Valley
Pacific Island
Del Avion
Niguel
Stonehill
Coast
Pacific Coast
10
20
30
Kelp bed area
March 10, 2009
South Laguna: 0.0169 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
3

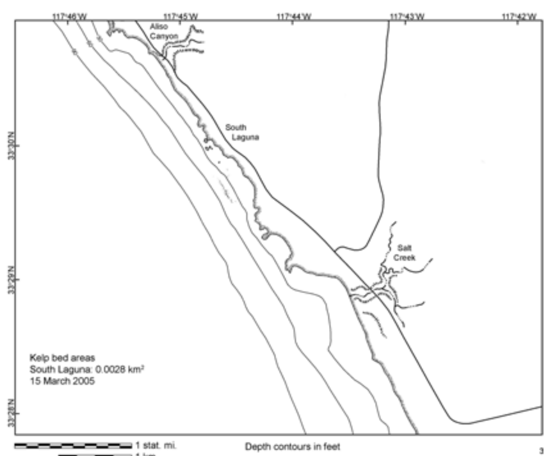

117°46'0"W
117°45'0"W
117°44'0"W
117°43'0"W
33°30'0"N
33°29'0"N
33°28'0"N
N
Aliso Canyon
South Laguna
Salt Creek
Crown Valley
Pacific Island
Del Avion
Niguel
Stonehill
Coast
Pacific Coast
10
20
30
Kelp bed area
December 31, 2010
South Laguna Kelp: 0.0232 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
3

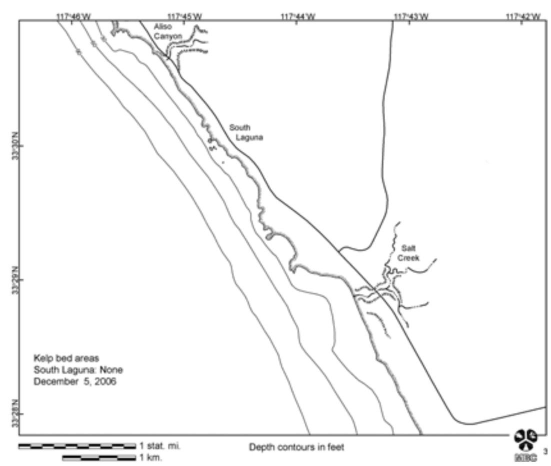

117° 47'
46'
45'
44'
43'
30
60
90
Aliso Canyon
South Laguna
33°
30'
Salt Creek
29'
28'
Kelp bed area
South Laguna: 0.002 km²
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
3

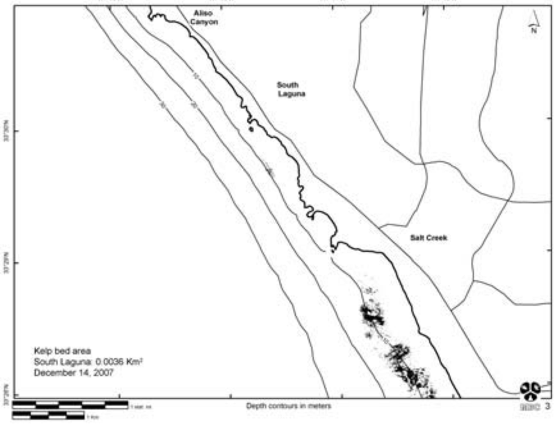

117°47'
46'
45'
44'
43'
30
60
90
Aliso Cyn.
South Laguna
33°
30'
Salt Creek
29'
28'
Kelp bed area
South Laguna: 0.0018 km²
30 December 2002
1 stat. mi.
1 km
Depth contours in feet
3


117°46'W
117°45'W
117°44'W
117°43'W
117°42'W
Aliso Canyon
South Laguna
Salt Creek
33°30'N
33°29'N
33°28'N
Kelp bed areas
South Laguna: 0.0037 km²
21 December 2003
1 stat. mi.
1 km.
Depth contours in feet
3


117°46'W
117°45'W
117°44'W
117°43'W
117°42'W
Aliso Canyon
South Laguna
Salt Creek
33°30'N
33°29'N
33°28'N
Kelp bed areas
South Laguna: 0.0091 km²
29 March 2004
1 stat. mi.
1 km.
Depth contours in feet
3


117°46'W
117°45'W
117°44'W
117°43'W
117°42'W
Aliso Canyon
South Laguna
Salt Creek
33°30'N
33°29'N
33°28'N
Kelp bed areas
South Laguna: 0.0028 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
3


117°46'W
117°45'W
117°44'W
117°43'W
117°42'W
Aliso Canyon
South Laguna
Salt Creek
33°30'N
33°29'N
33°28'N
Kelp bed areas
South Laguna: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
3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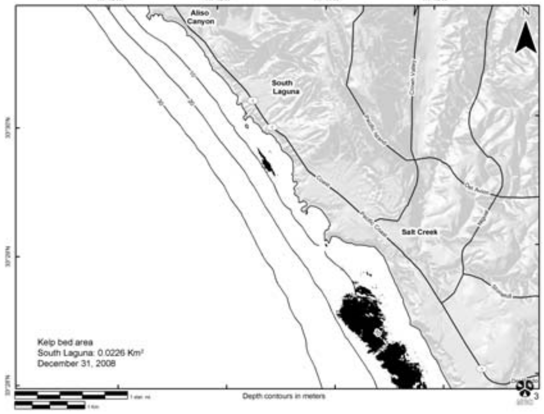
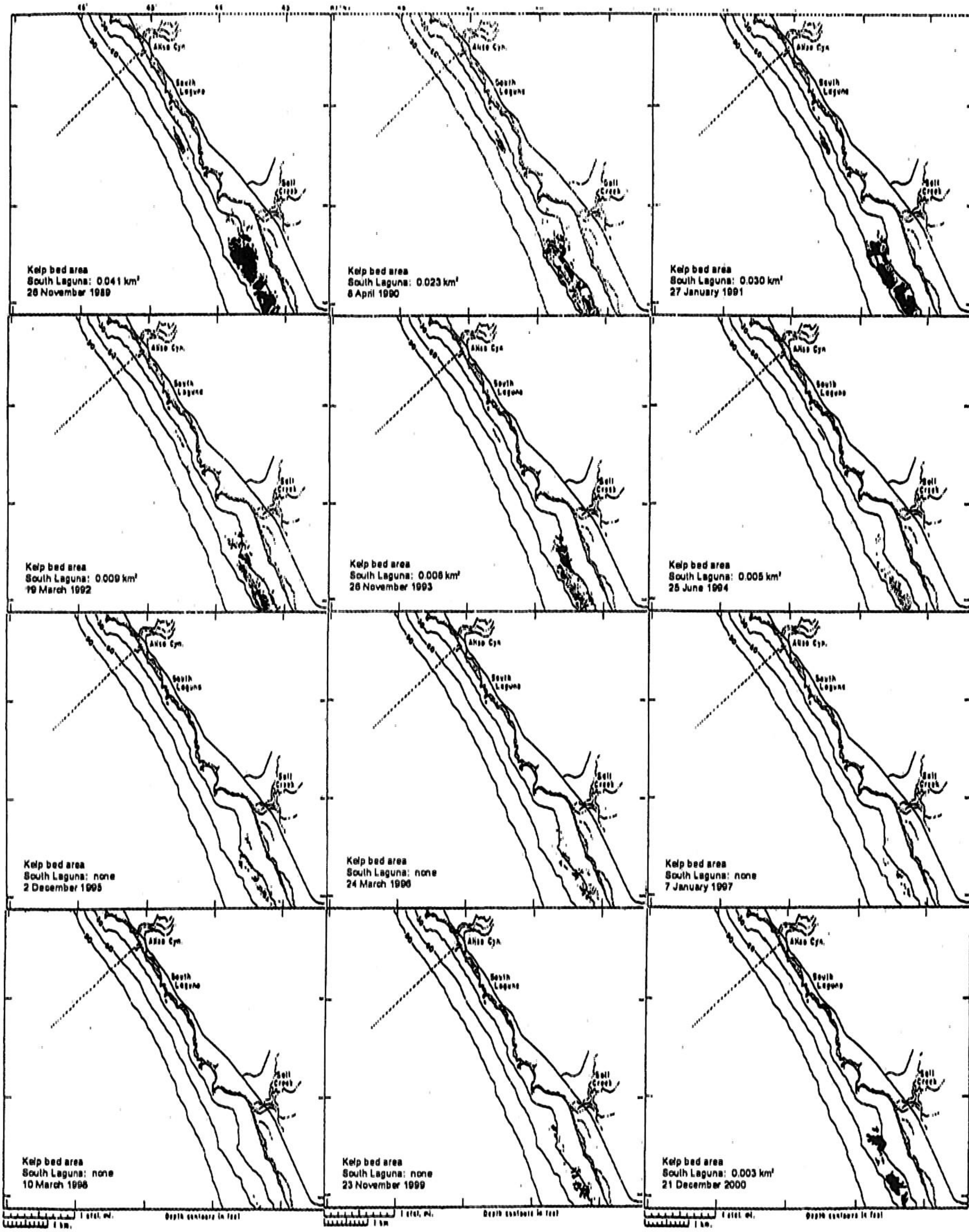
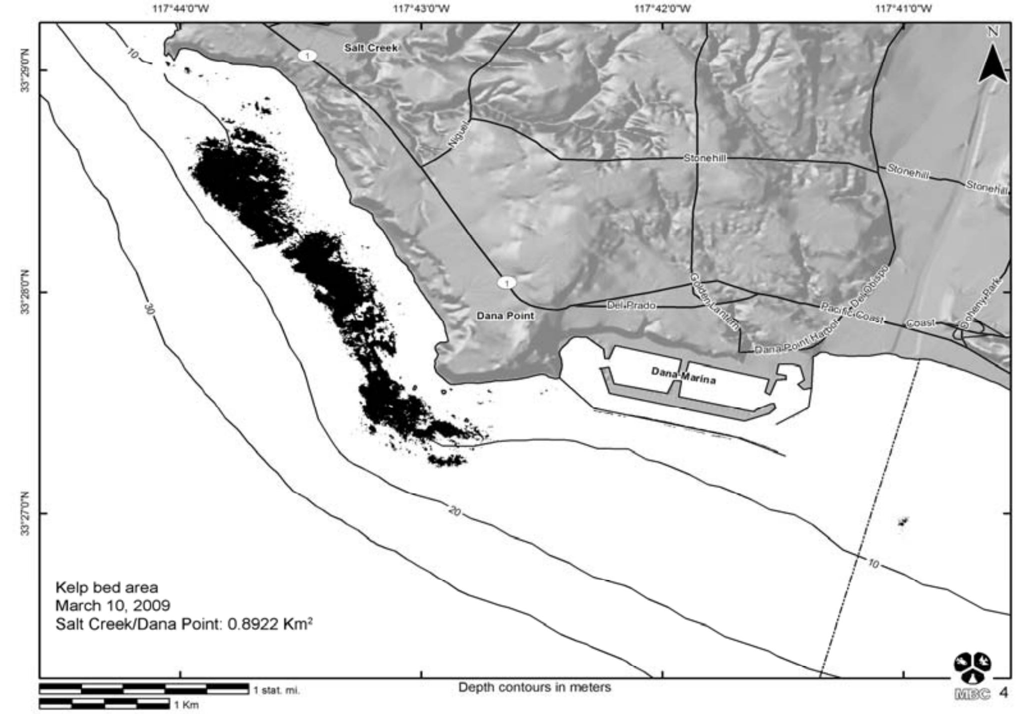
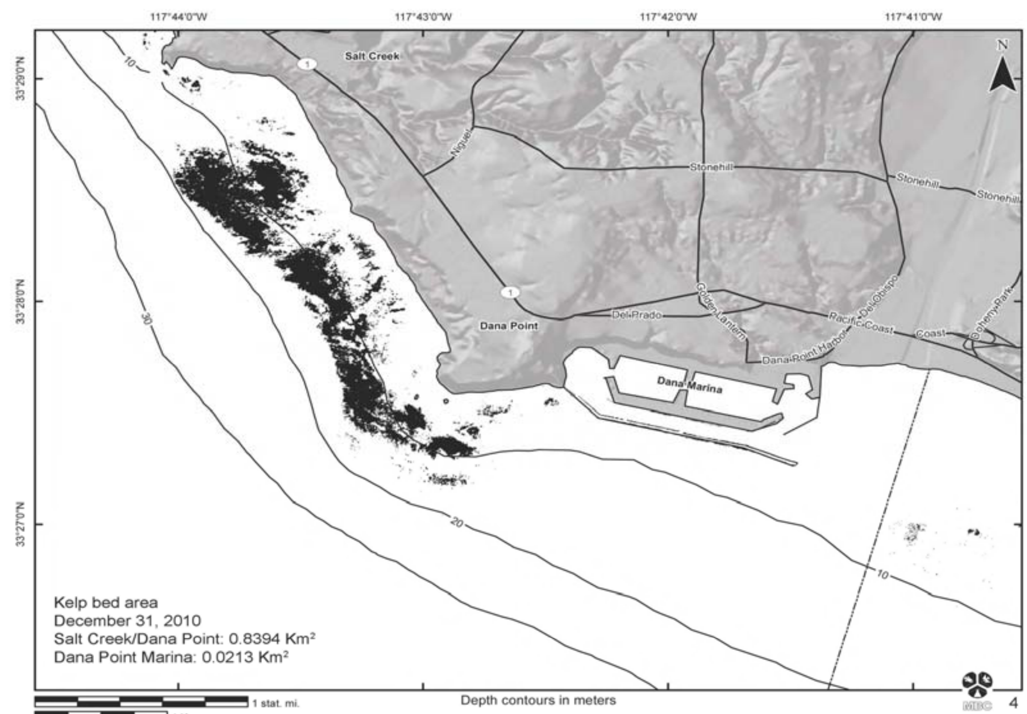
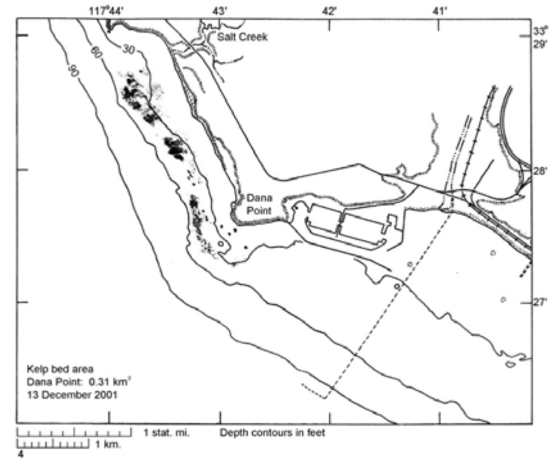
117°44'W
117°43'W
Aliso Canyon
South Laguna
Salt Creek
Kelp bed area
South Laguna: 0.0036 Km²
December 14, 2007
Depth contours in meters
3


117°46'W
117°45'W
117°44'W
117°43'W
N
Aliso Canyon
South Laguna
Salt Creek
Kelp bed area
South Laguna: 0.0226 Km²
December 31, 2008
Depth contours in meters
3

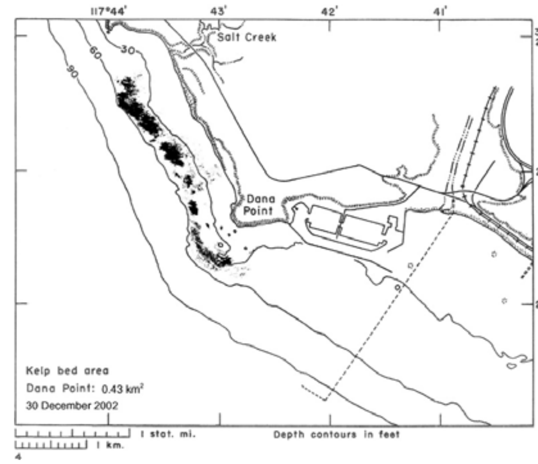

Aliso Cyn.
South Laguna
Salt Creek
Kelp bed area
South Laguna: 0.041 km²
26 November 1989
Kelp bed area
South Laguna: 0.023 km²
8 April 1990
Kelp bed area
South Laguna: 0.030 km²
27 January 1991
Kelp bed area
South Laguna: 0.009 km²
19 March 1992
Kelp bed area
South Laguna: 0.006 km²
26 November 1993
Kelp bed area
South Laguna: 0.005 km²
25 June 1994
Kelp bed area
South Laguna: none
2 December 1995
Kelp bed area
South Laguna: none
24 March 1996
Kelp bed area
South Laguna: none
7 January 1997
Kelp bed area
South Laguna: none
10 March 1998
Kelp bed area
South Laguna: none
23 November 1999
Kelp bed area
South Laguna: 0.003 km²
21 December 2000
1 stat. mi.
1 km.
Depth contours in feet


117°44'0"W
117°43'0"W
117°42'0"W
117°41'0"W
33°29'0"N
33°28'0"N
33°27'0"N
N
Salt Creek
Niguel
Stonehill
Dana Point
Del Prado
Golden Lantern
Pacific Coast
Del Obispo
Dana Point Harbor
Doheny Park
Dana Marina
10
20
30
Kelp bed area
March 10, 2009
Salt Creek/Dana Point: 0.8922 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
4

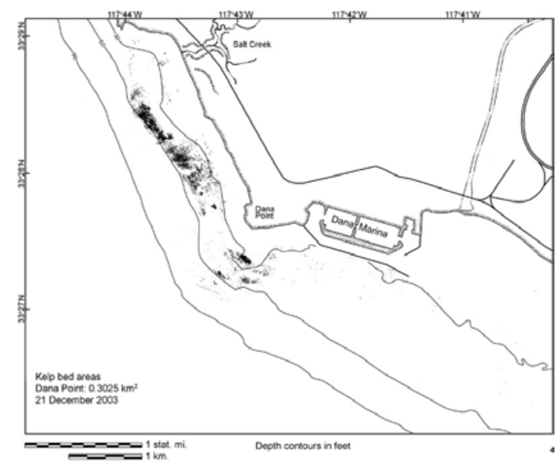

117°44'0"W
117°43'0"W
117°42'0"W
117°41'0"W
33°29'0"N
33°28'0"N
33°27'0"N
N
Salt Creek
Niguel
Stonehill
Dana Point
Del Prado
Golden Lantern
Pacific Coast
Del Obispo
Dana Point Harbor
Doheny Park
Dana Marina
10
20
30
Kelp bed area
December 31, 2010
Salt Creek/Dana Point: 0.8394 Km²
Dana Point Marina: 0.0213 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
4



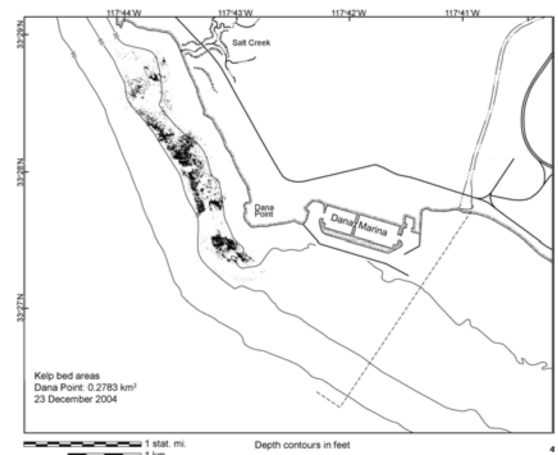
117°44'
43'
42'
41'
33°
29'
28'
27'
Salt Creek
Dana Point
30
60
90
Kelp bed area
Dana Point: 0.31 km²
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
4



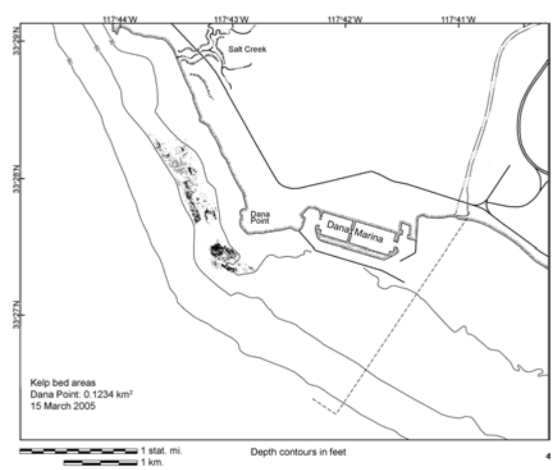
117°44'
43'
42'
41'
33°
29'
28'
27'
Salt Creek
Dana Point
30
60
90
Kelp bed area
Dana Point: 0.43 km²
30 December 2002
1 stat. mi.
1 km.
Depth contours in feet
4



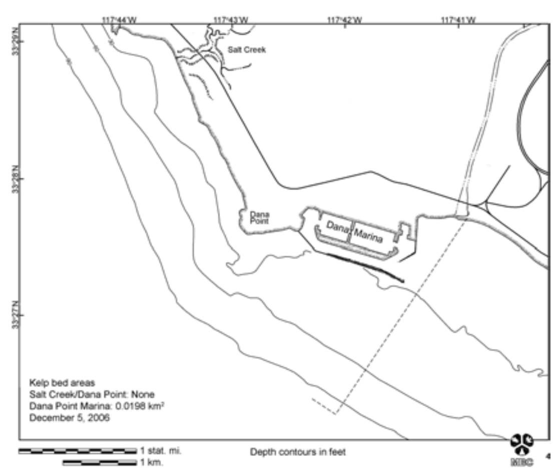
117°44'W
117°43'W
117°42'W
117°41'W
33°29'N
33°28'N
33°27'N
Salt Creek
Dana Point
Dana Marina
Kelp bed areas
Dana Point: 0.3025 km²
21 December 2003
1 stat. mi.
1 km.
Depth contours in feet
4



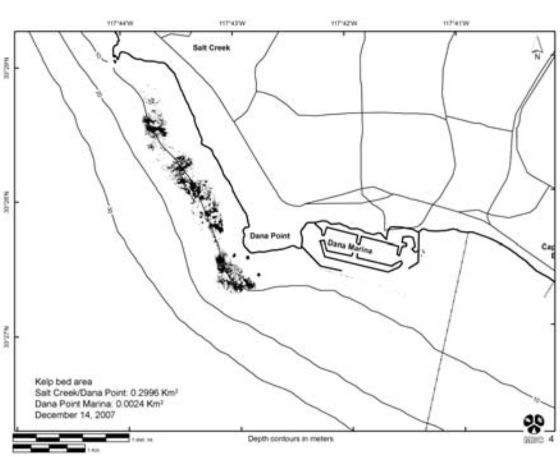
117°44'W
117°43'W
117°42'W
117°41'W
33°29'N
33°28'N
33°27'N
Salt Creek
Dana Point
Dana Marina
Kelp bed areas
Dana Point: 0.2783 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
4



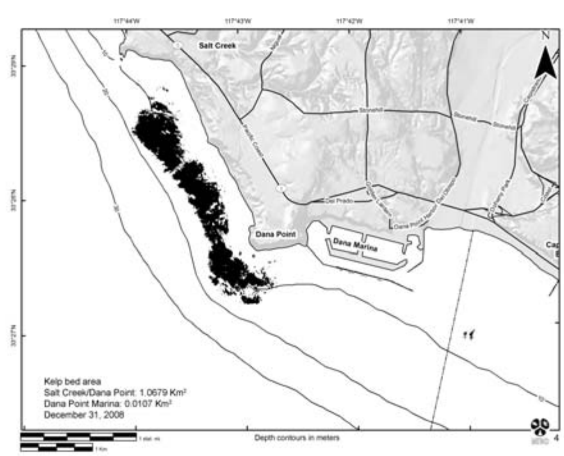
117°44'W
117°43'W
117°42'W
117°41'W
33°29'N
33°28'N
33°27'N
Salt Creek
Dana Point
Dana Marina
Kelp bed areas
Dana Point: 0.1234 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
4



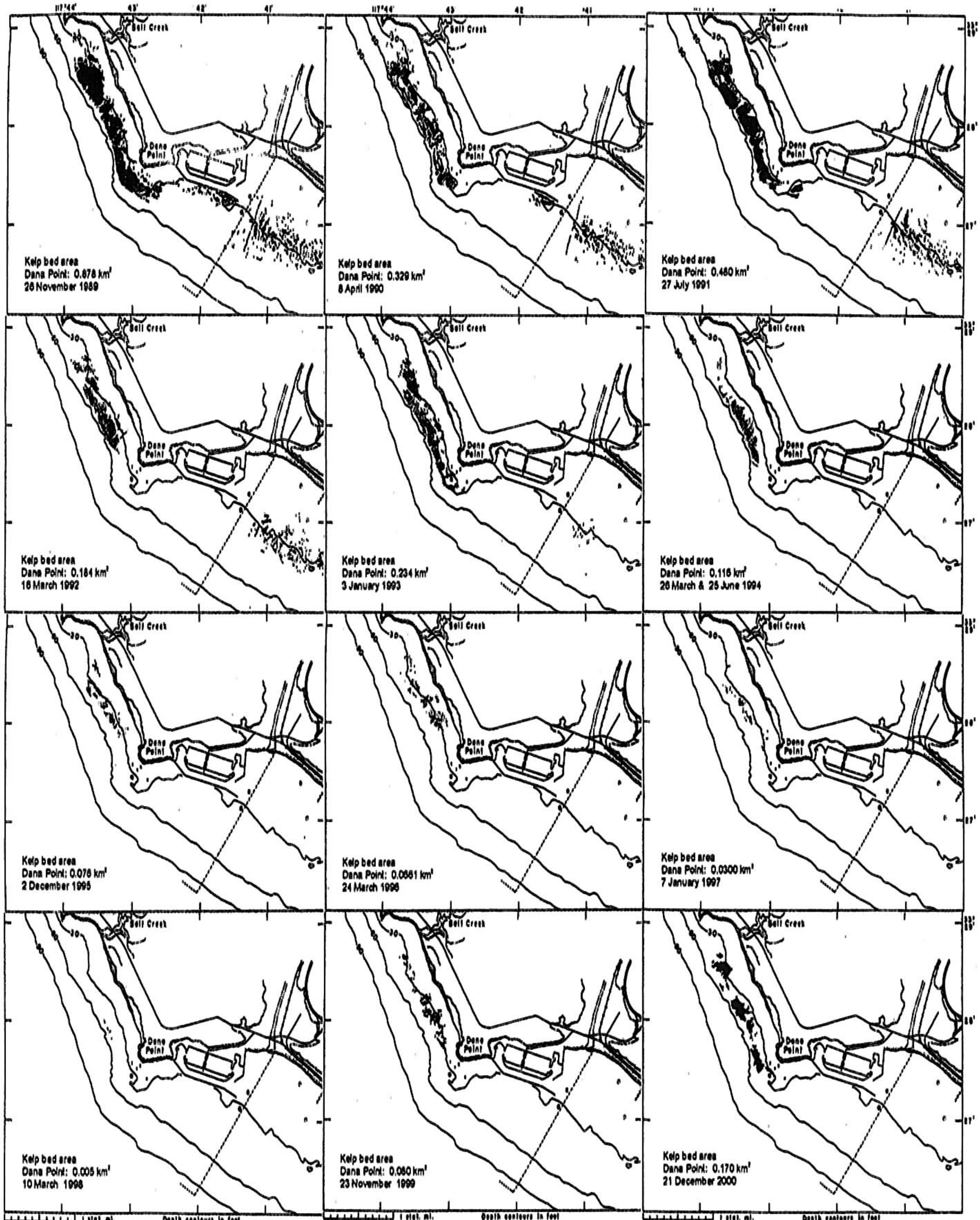
117°44'W
117°43'W
117°42'W
117°41'W
33°29'N
33°28'N
33°27'N
Salt Creek
Dana Point
Dana Marina
Kelp bed areas
Salt Creek/Dana Point: None
Dana Point Marina: 0.0198 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
4

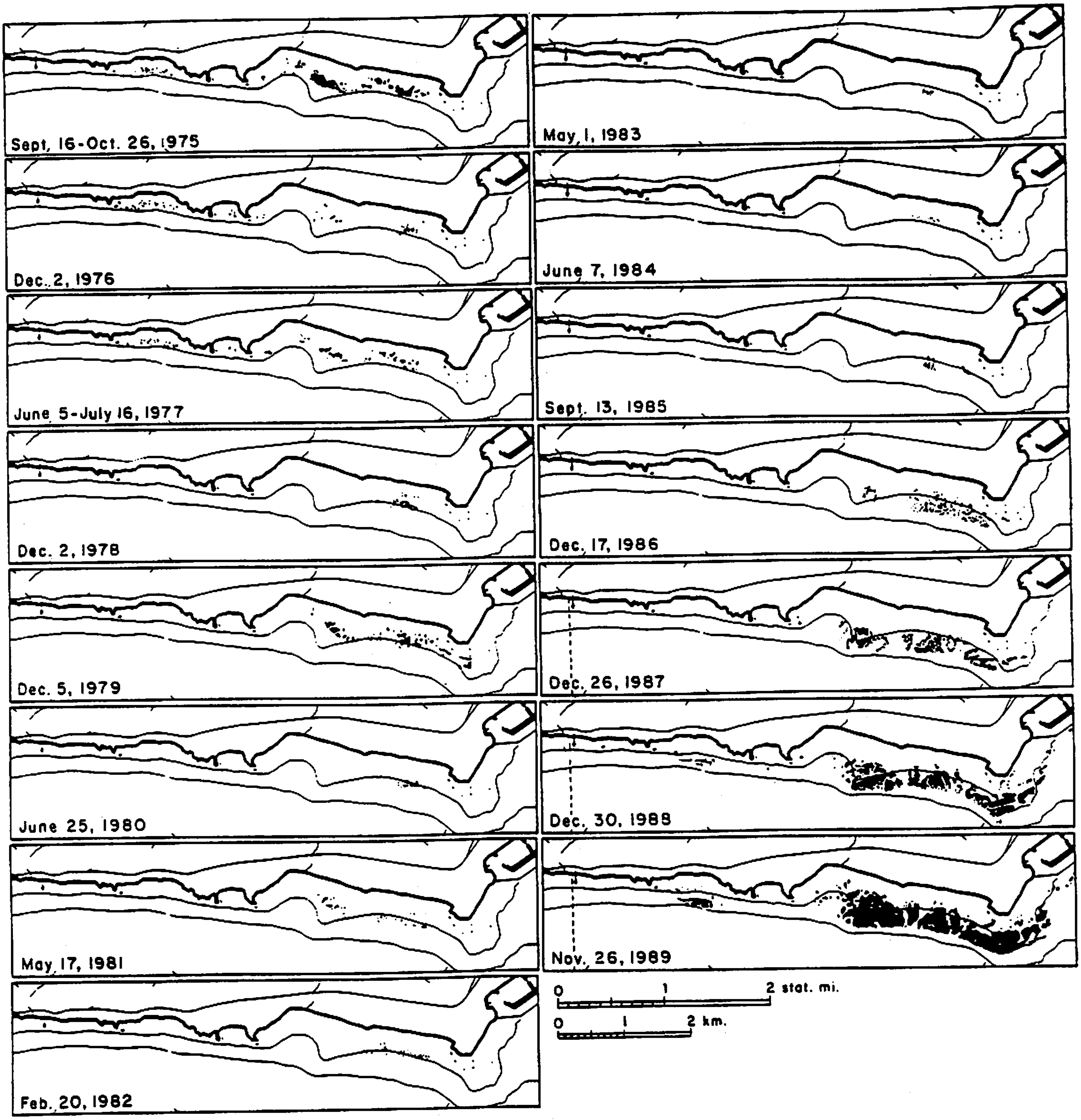


117°44'W
117°43'W
117°42'W
117°41'W
Salt Creek
Dana Point
Dana Marina
Kelp bed area
Salt Creek/Dana Point: 0.2996 Km²
Dana Point Marina: 0.0024 Km²
December 14, 2007
Depth contours in meters
MBC
4

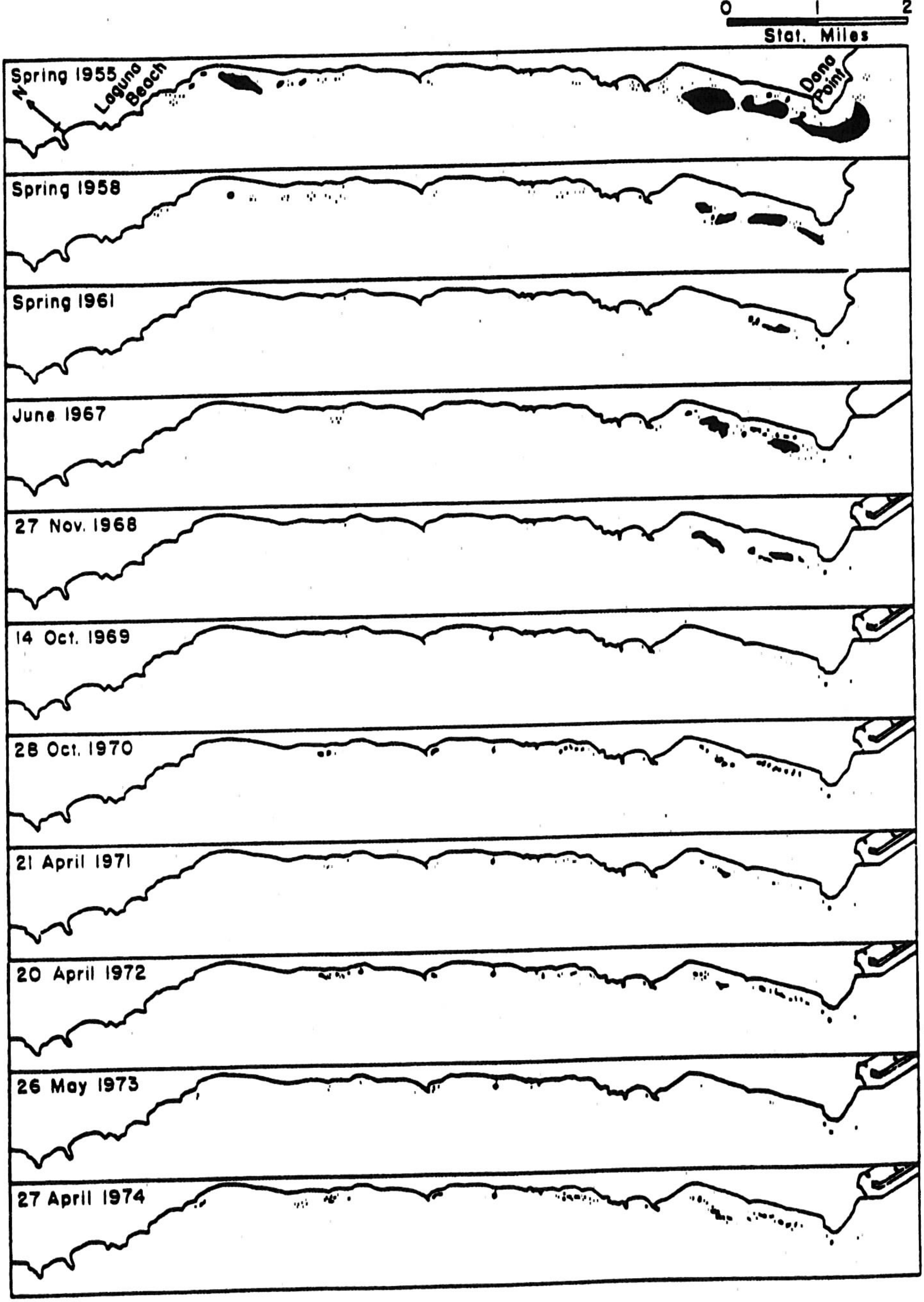


117°44'W
117°43'W
117°42'W
117°41'W
Salt Creek
Dana Point
Dana Marina
Del Prado
N
Kelp bed area
Salt Creek/Dana Point: 1.0679 Km²
Dana Point Marina: 0.0107 Km²
December 31, 2008
Depth contours in meters
MBC
4

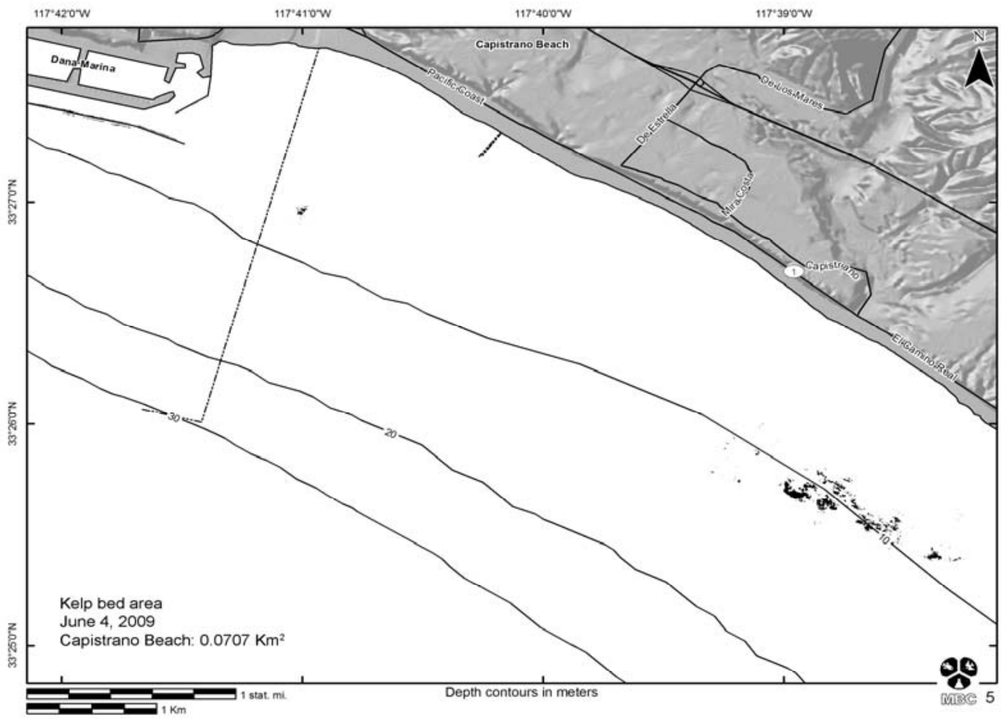

117°44'
43'
42'
41'
Bell Creek
Dana Point
30
Kelp bed area
Dana Point: 0.678 km²
26 November 1989
Kelp bed area
Dana Point: 0.329 km²
8 April 1990
Kelp bed area
Dana Point: 0.460 km²
27 July 1991
Kelp bed area
Dana Point: 0.184 km²
16 March 1992
Kelp bed area
Dana Point: 0.234 km²
3 January 1993
Kelp bed area
Dana Point: 0.116 km²
26 March & 25 June 1994
Kelp bed area
Dana Point: 0.076 km²
2 December 1995
Kelp bed area
Dana Point: 0.0661 km²
24 March 1996
Kelp bed area
Dana Point: 0.0300 km²
7 January 1997
Kelp bed area
Dana Point: 0.005 km²
10 March 1998
Kelp bed area
Dana Point: 0.060 km²
23 November 1999
Kelp bed area
Dana Point: 0.170 km²
21 December 2000
1 stat. mi.
1 km.
Depth contours in feet
28'
27'



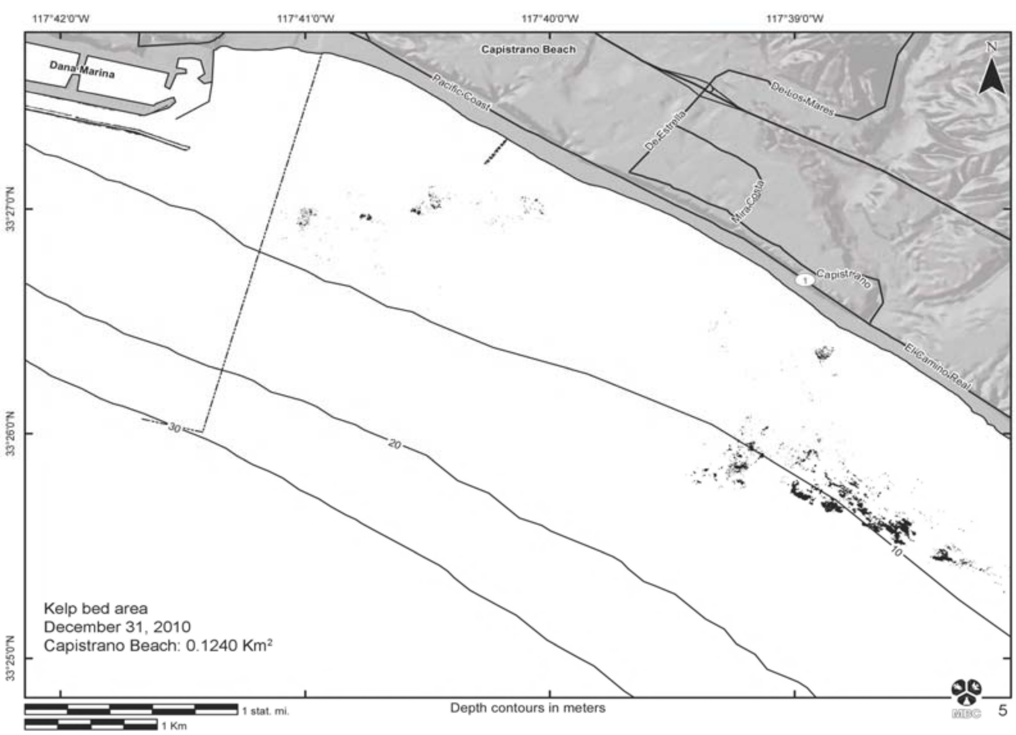
Historical charts of South Laguna kelp and Dana Pt kelp from 1975 to 1989.



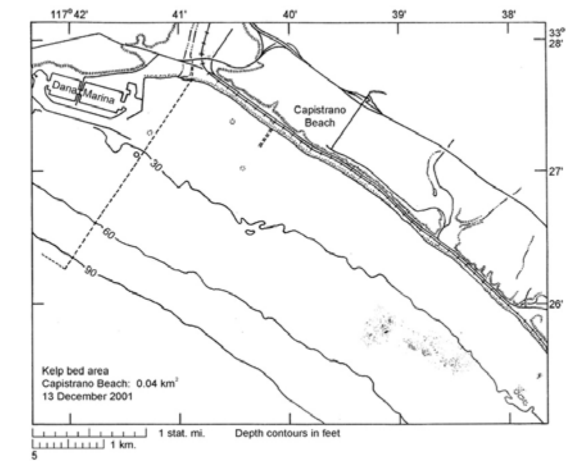
Historical charts of kelp beds from Laguna Beach to Dana Point, 1955 to 1974.

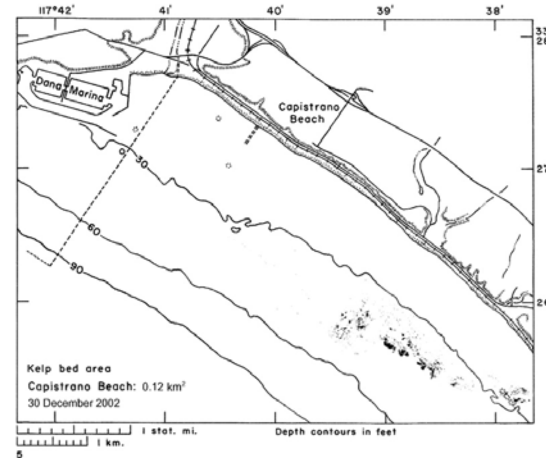


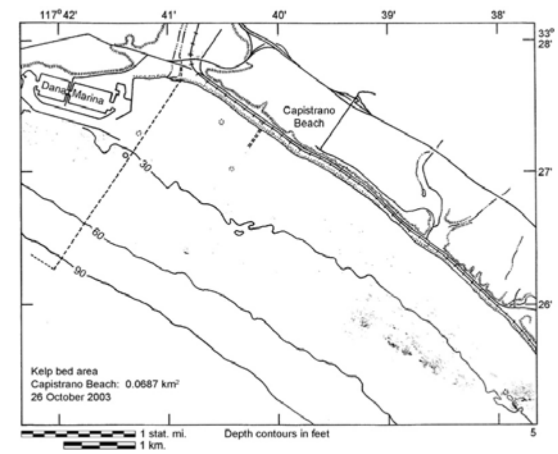
117°42'0"W
117°41'0"W
117°40'0"W
117°39'0"W
33°27'0"N
33°26'0"N
33°25'0"N
Capistrano Beach
Dana Marina
Pacific Coast
De Los Mares
De Estrella
Mira Costa
Capistrano
1
El Camino Real
N
30
20
10
Kelp bed area
June 4, 2009
Capistrano Beach: 0.0707 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
5

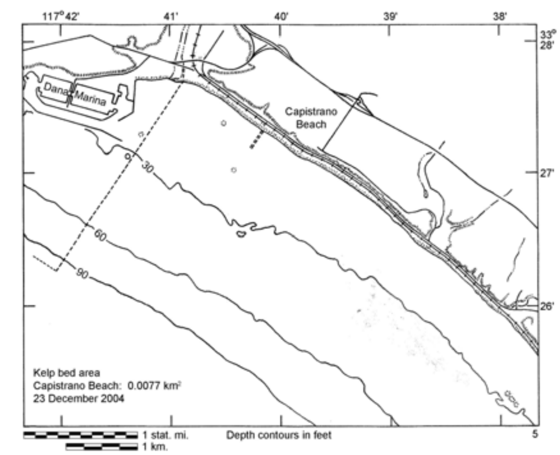


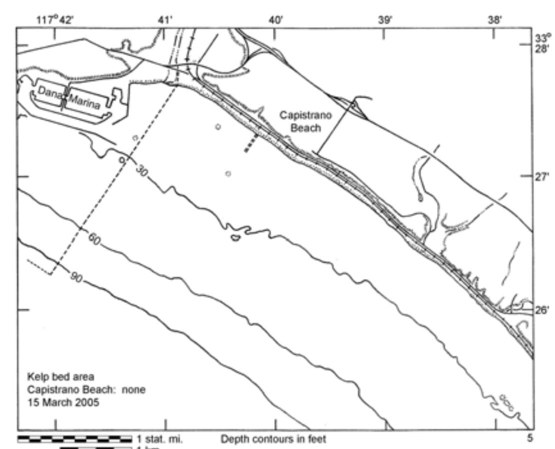
117°42'0"W
117°41'0"W
117°40'0"W
117°39'0"W
33°27'0"N
33°26'0"N
33°25'0"N
Capistrano Beach
Dana Marina
Pacific Coast
De Los Mares
De Estrella
Mira Costa
Capistrano
1
El Camino Real
N
30
20
10
Kelp bed area
December 31, 2010
Capistrano Beach: 0.1240 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
5

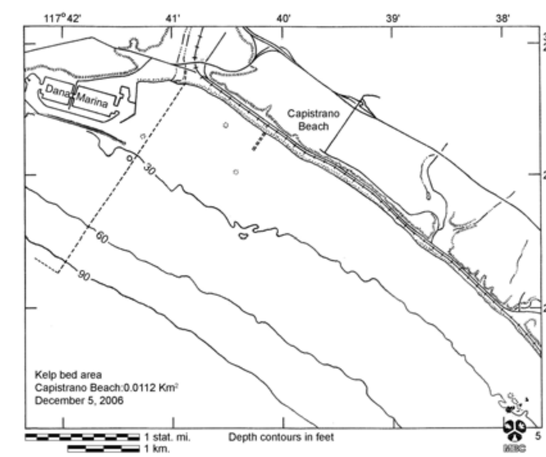

117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach: 0.04 km²
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
5

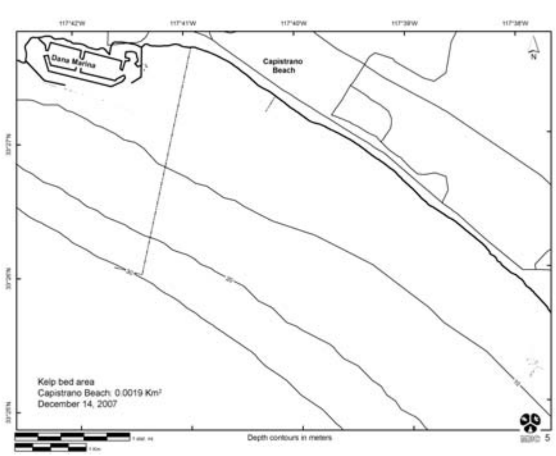

117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach: 0.12 km²
30 December 2002
1 stat. mi.
1 km.
Depth contours in feet
5

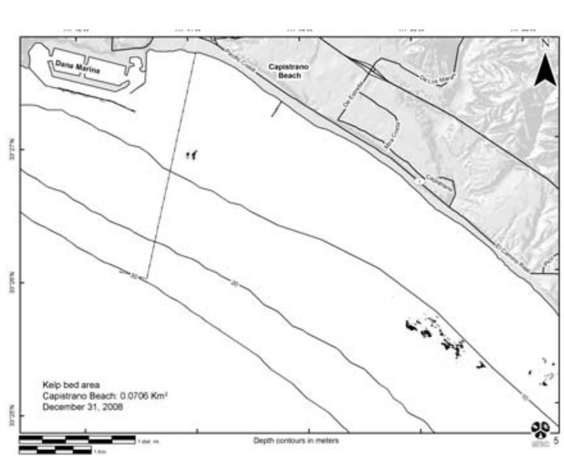

117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach: 0.0687 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
5

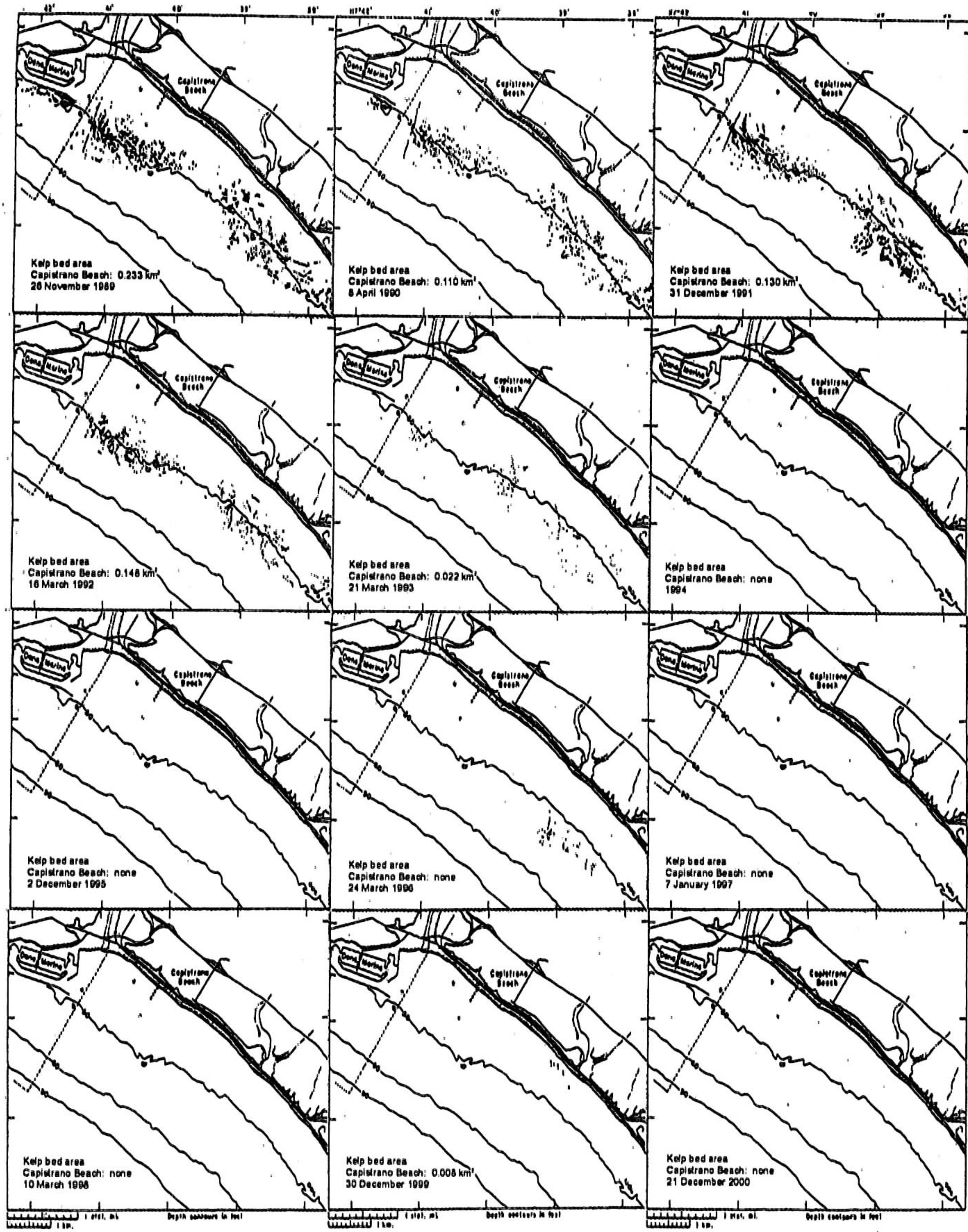

117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach: 0.0077 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
5

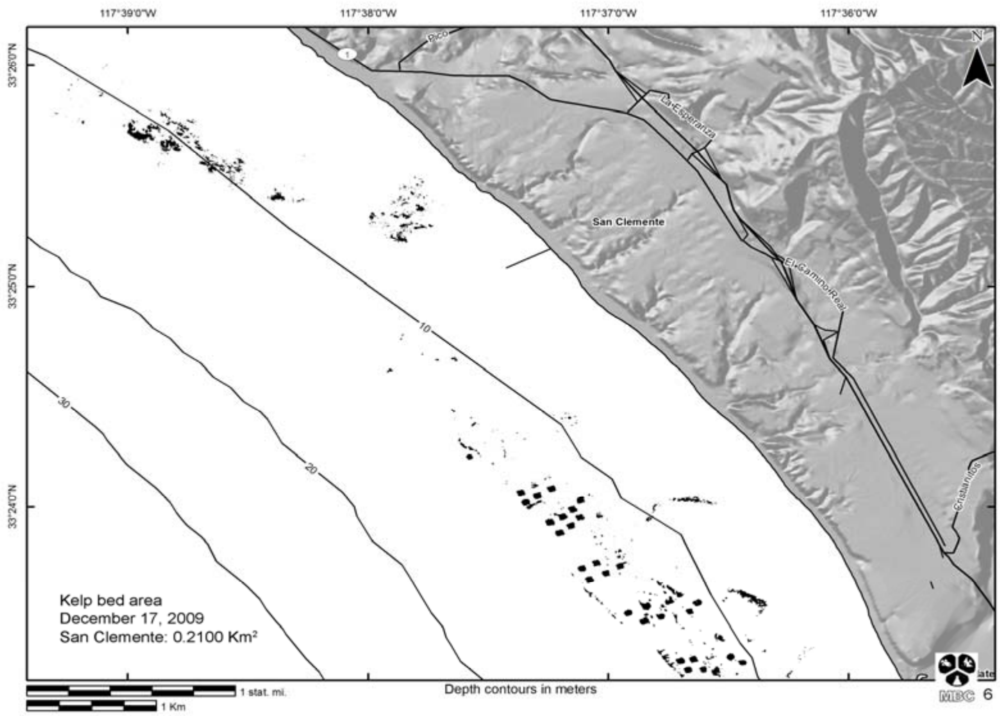

117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
5


117°42'
41'
40'
39'
38'
33°
28'
27'
26'
Dana Marina
Capistrano
Beach
30
60
90
Kelp bed area
Capistrano Beach:0.0112 Km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
5

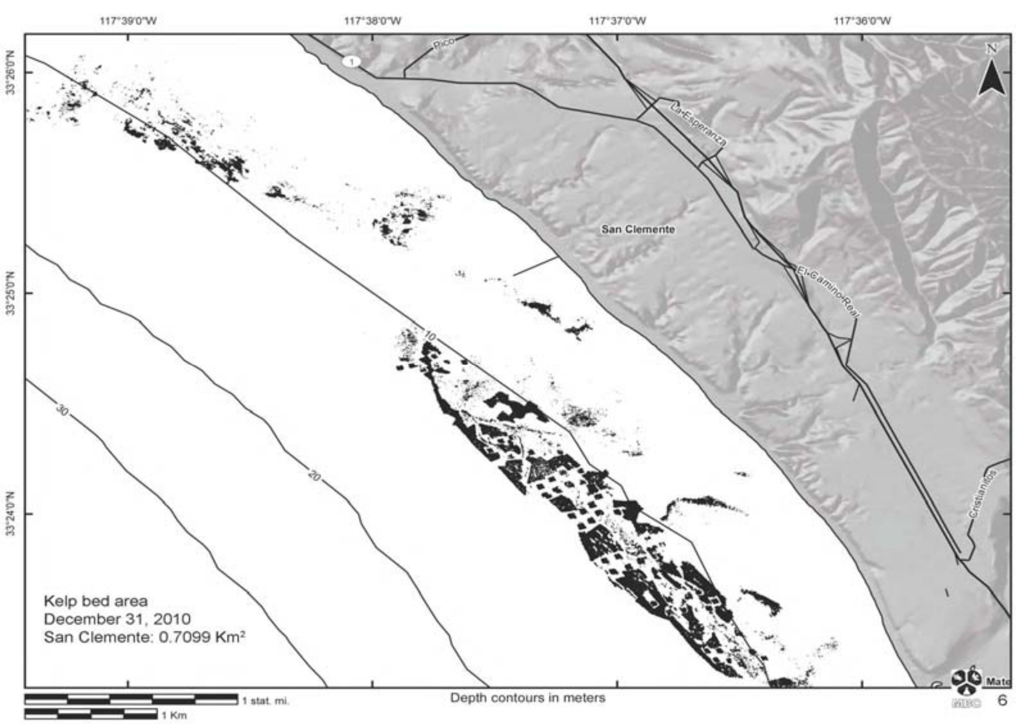

117°42'W
117°41'W
117°40'W
117°39'W
117°38'W
Dana Marina
Capistrano
Beach
Kelp bed area
Capistrano Beach: 0.0019 Km²
December 14, 2007
Depth contours in meters
5


Dana Marina
Capistrano
Beach
Kelp bed area
Capistrano Beach: 0.0706 Km²
December 31, 2008
Depth contours in meters
5

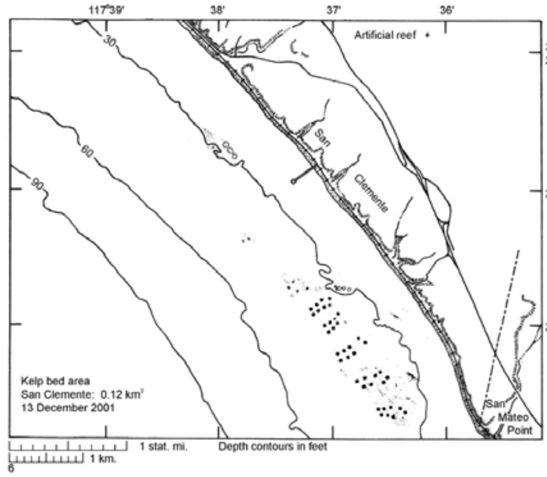

Kelp bed area
Capistrano Beach: 0.233 km²
28 November 1989
Kelp bed area
Capistrano Beach: 0.110 km²
8 April 1990
Kelp bed area
Capistrano Beach: 0.130 km²
31 December 1991
Kelp bed area
Capistrano Beach: 0.148 km²
16 March 1992
Kelp bed area
Capistrano Beach: 0.022 km²
21 March 1993
Kelp bed area
Capistrano Beach: none
1994
Kelp bed area
Capistrano Beach: none
2 December 1995
Kelp bed area
Capistrano Beach: none
24 March 1996
Kelp bed area
Capistrano Beach: none
7 January 1997
Kelp bed area
Capistrano Beach: none
10 March 1998
Kelp bed area
Capistrano Beach: 0.008 km²
30 December 1999
Kelp bed area
Capistrano Beach: none
21 December 2000
Dana Marina
Capistrano Beach
1 km.
Depth contours in feet

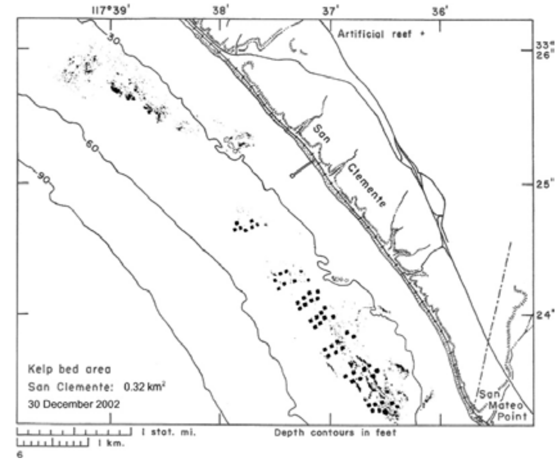


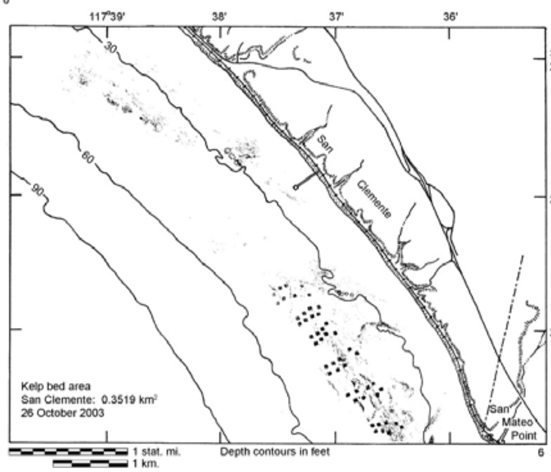
117°39'0"W
117°38'0"W
117°37'0"W
117°36'0"W
33°26'0"N
33°25'0"N
33°24'0"N
Pico
La Esperanza
San Clemente
El Camino Real
Cristianitos
10
20
30
Kelp bed area
December 17, 2009
San Clemente: 0.2100 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
6

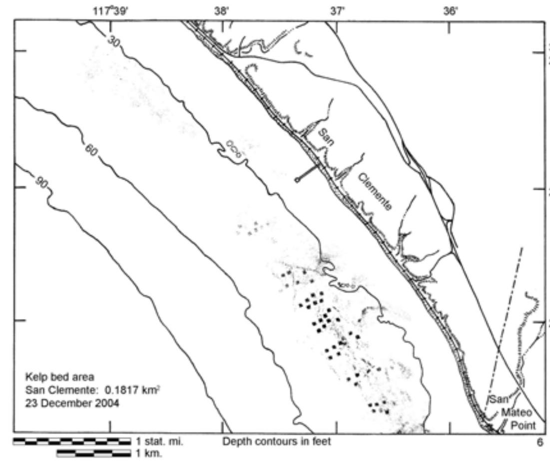


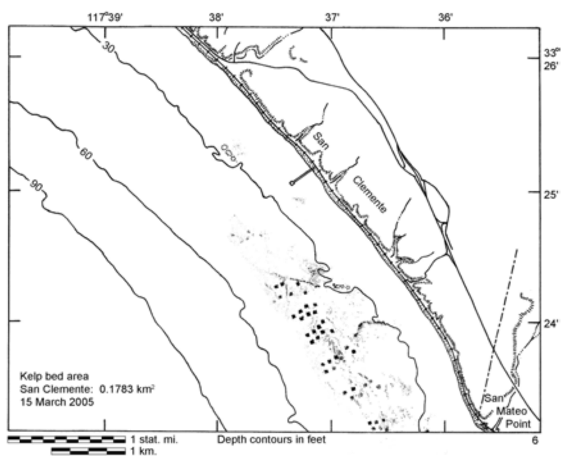
117°39'0"W
117°38'0"W
117°37'0"W
117°36'0"W
33°26'0"N
33°25'0"N
33°24'0"N
Pico
La Esperanza
San Clemente
El Camino Real
Cristianitos
10
20
30
Kelp bed area
December 31, 2010
San Clemente: 0.7099 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
6

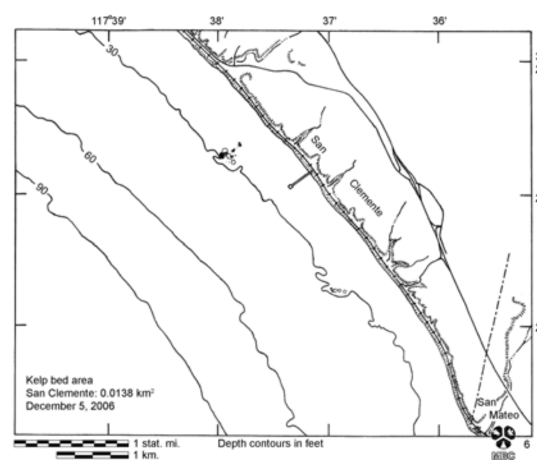

117°39'
38'
37'
36'
Artificial reef +
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Point
Kelp bed area
San Clemente: 0.12 km²
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
6

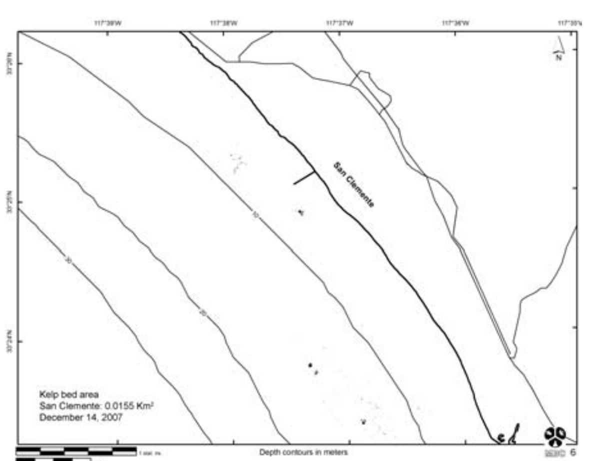

117°39'
38'
37'
36'
Artificial reef +
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Point
Kelp bed area
San Clemente: 0.32 km²
30 December 2002
1 stat. mi.
1 km.
Depth contours in feet
6

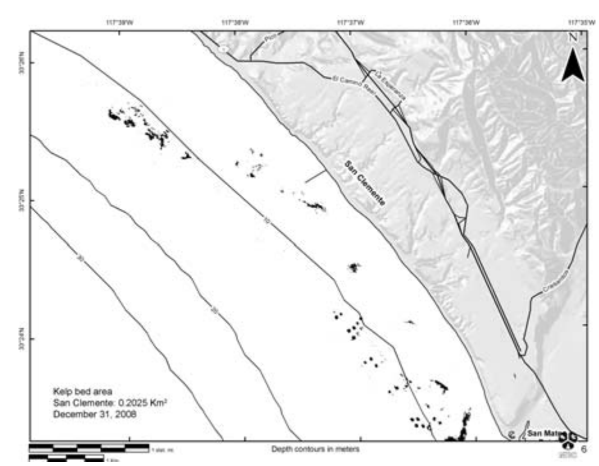

117°39'
38'
37'
36'
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Point
Kelp bed area
San Clemente: 0.3519 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
6

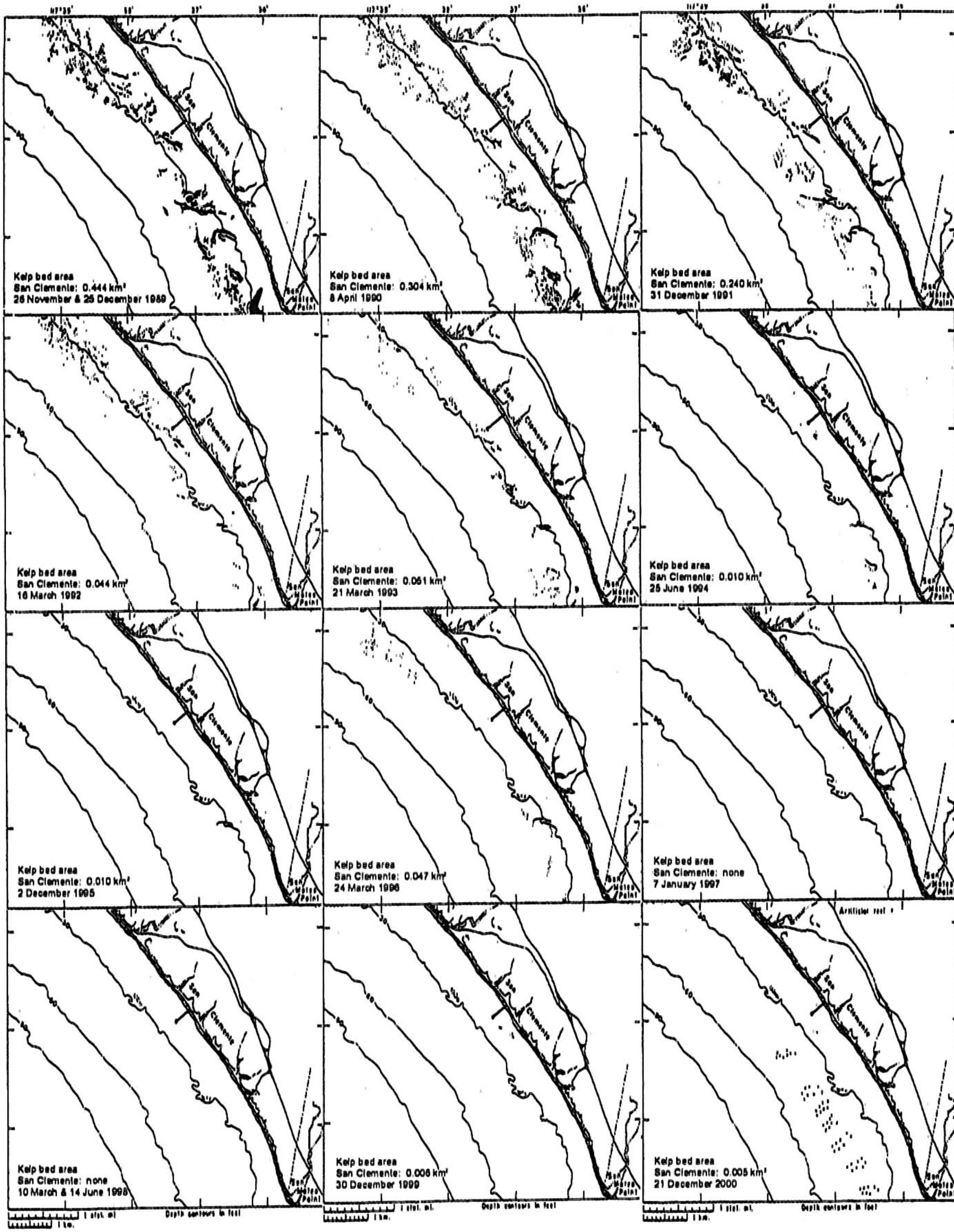

117°39'
38'
37'
36'
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Point
Kelp bed area
San Clemente: 0.1817 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
6


117°39'
38'
37'
36'
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Point
Kelp bed area
San Clemente: 0.1783 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
6

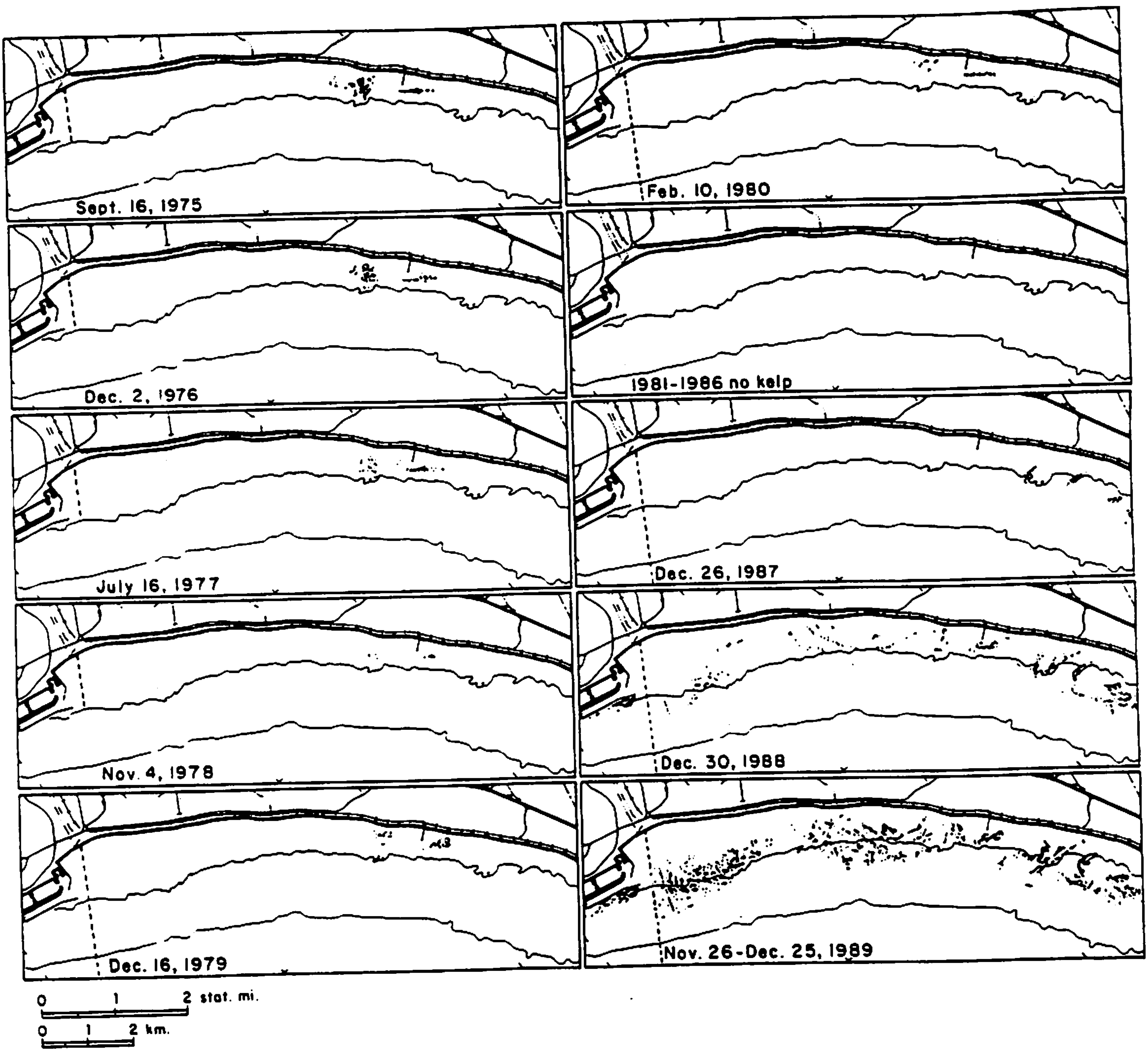

117°39'
38'
37'
36'
33°
26'
25'
24'
30
60
90
San
Clemente
San
Mateo
Kelp bed area
San Clemente: 0.0138 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
6


San Clemente
Kelp bed area
San Clemente: 0.0155 Km²
December 14, 2007
Depth contours in meters
6

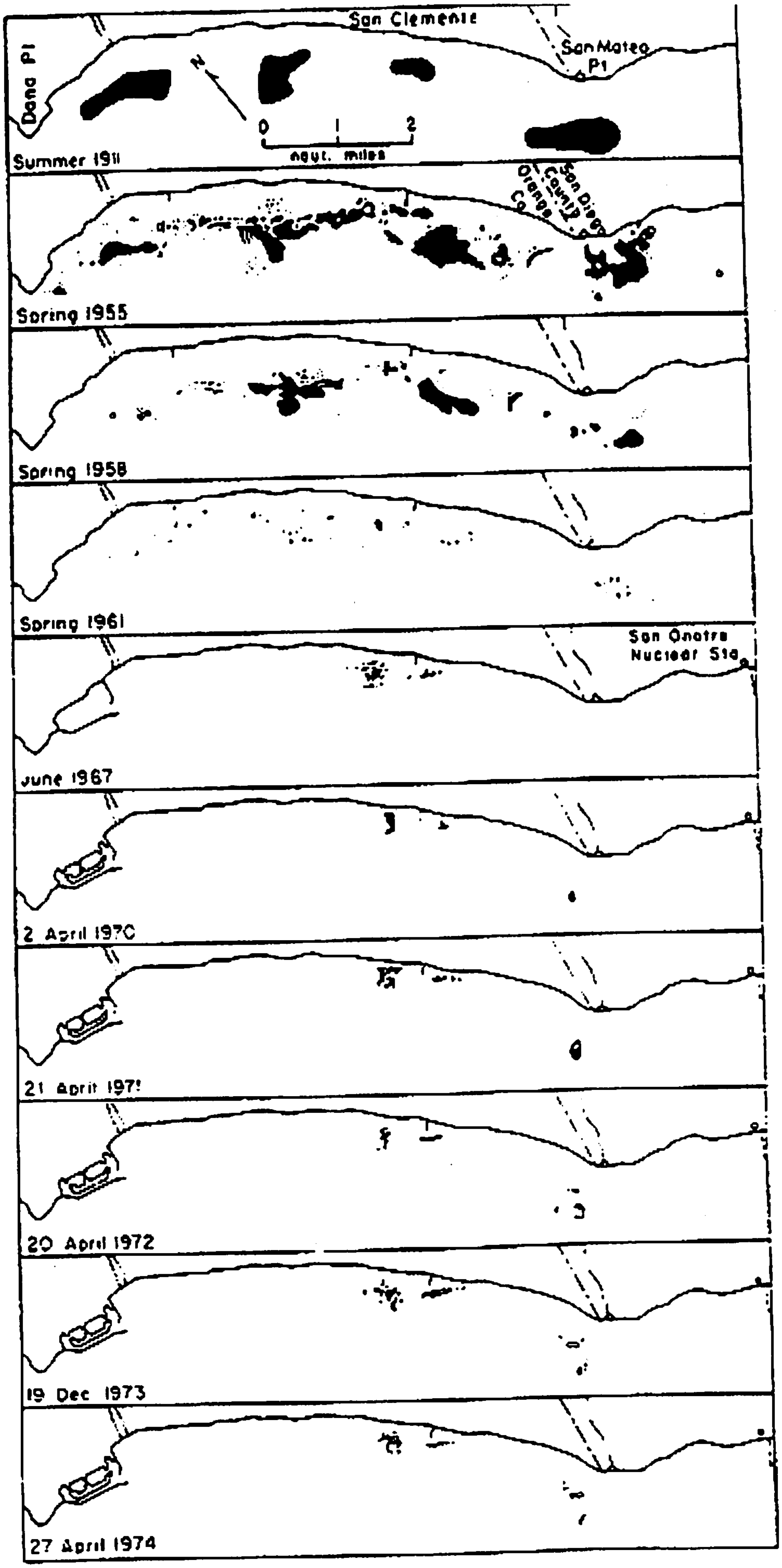

San Clemente
San Mateo
Kelp bed area
San Clemente: 0.2025 Km²
December 31, 2008
Depth contours in meters
6



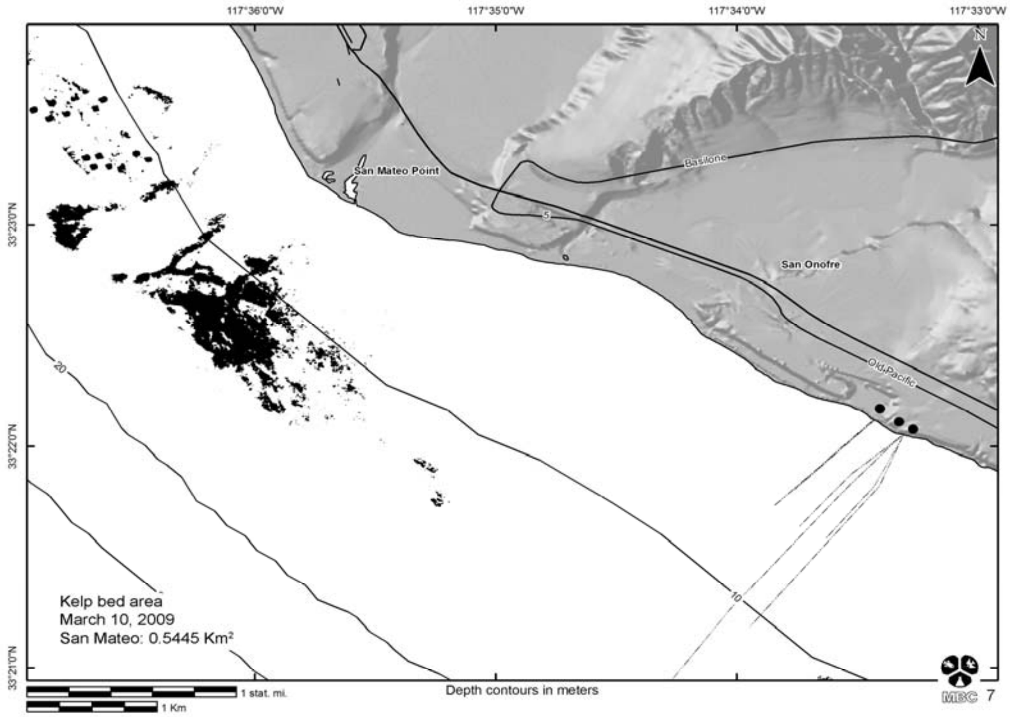
Kelp bed area
San Clemente: 0.444 km²
26 November & 25 December 1989
Kelp bed area
San Clemente: 0.304 km²
8 April 1990
Kelp bed area
San Clemente: 0.240 km²
31 December 1991
Kelp bed area
San Clemente: 0.044 km²
16 March 1992
Kelp bed area
San Clemente: 0.051 km²
21 March 1993
Kelp bed area
San Clemente: 0.010 km²
25 June 1994
Kelp bed area
San Clemente: 0.010 km²
2 December 1995
Kelp bed area
San Clemente: 0.047 km²
24 March 1996
Kelp bed area
San Clemente: none
7 January 1997
Artificial reef
Kelp bed area
San Clemente: none
10 March & 14 June 1998
Kelp bed area
San Clemente: 0.006 km²
30 December 1999
Kelp bed area
San Clemente: 0.005 km²
21 December 2000
San Clemente
San Mateo Point
1 stat. mi.
1 km.
Depth contours in feet

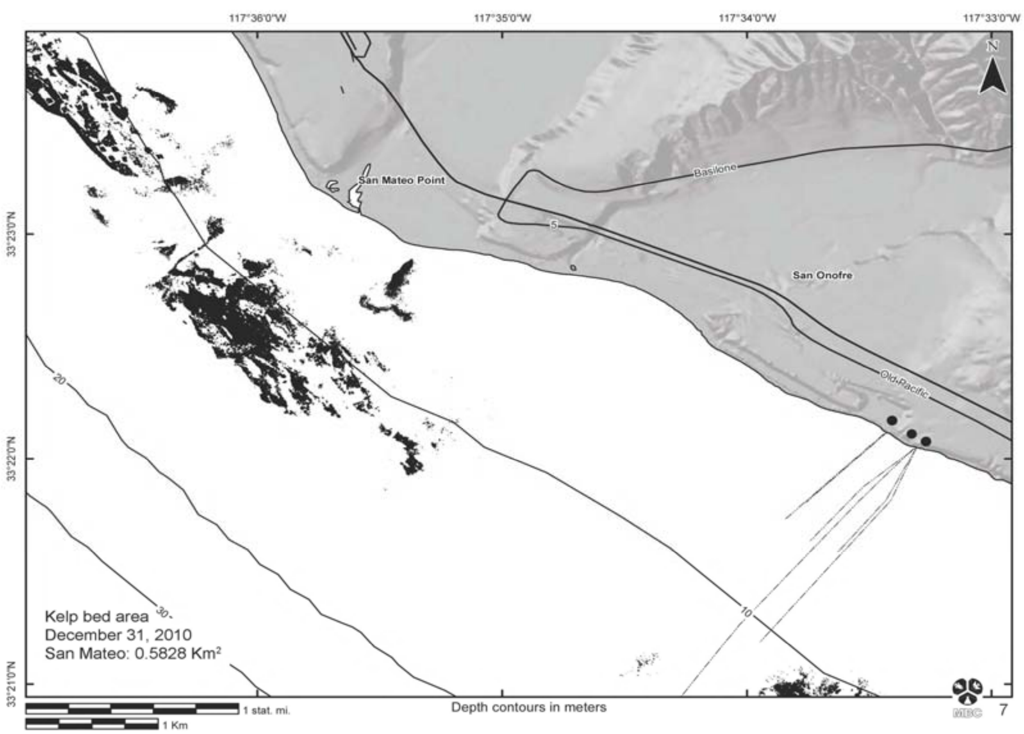


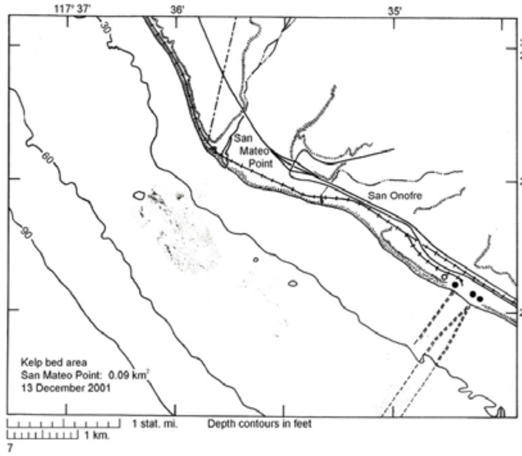
Historical charts of San Clemente kelp from 1975 to 1989.

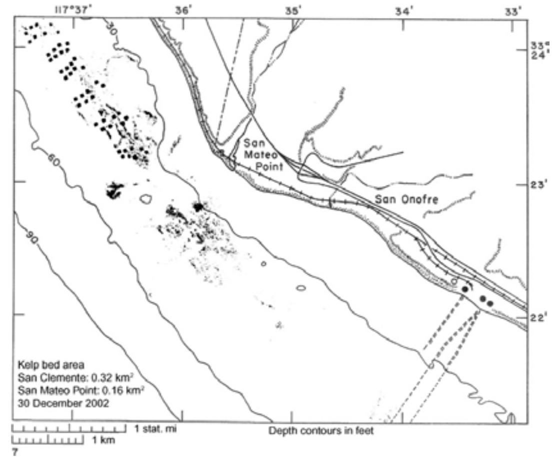


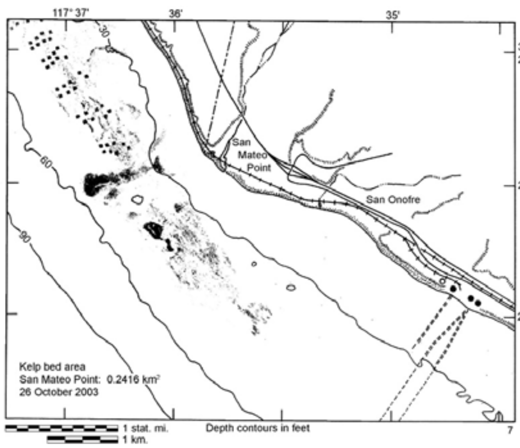
Historical charts of kelp beds from Doheny Beach to San Mateo Point from 1911 to 1974.

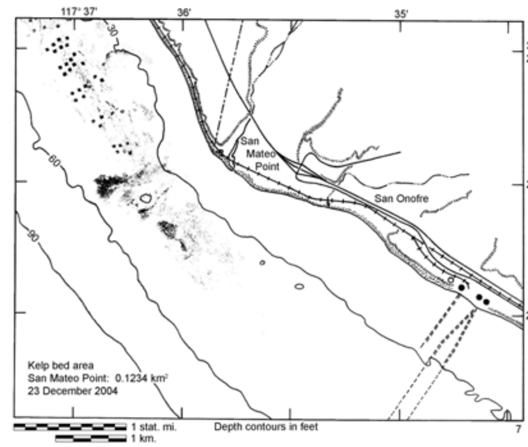

117°36'0"W
117°35'0"W
117°34'0"W
117°33'0"W
33°23'0"N
33°22'0"N
33°21'0"N
N
San Mateo Point
Basilone
5
San Onofre
Old Pacific
20
10
Kelp bed area
March 10, 2009
San Mateo: 0.5445 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
7

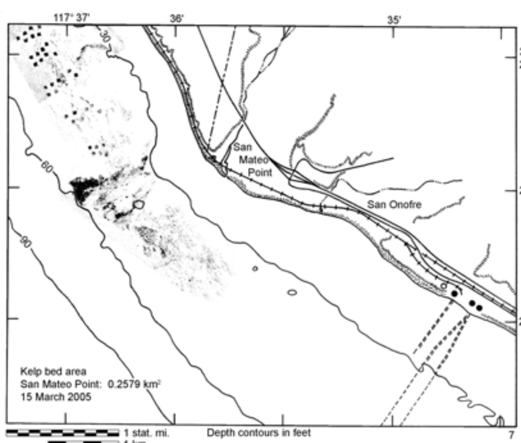

117°36'0"W
117°35'0"W
117°34'0"W
117°33'0"W
33°23'0"N
33°22'0"N
33°21'0"N
N
San Mateo Point
Basilone
5
San Onofre
Old Pacific
20
30
10
Kelp bed area
December 31, 2010
San Mateo: 0.5828 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
7

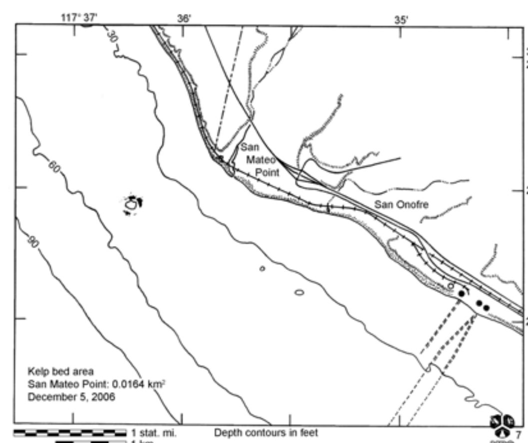

117° 37'
36'
35'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.09 km²
13 December 2001
1 stat. mi.
1 km.
Depth contours in feet
7

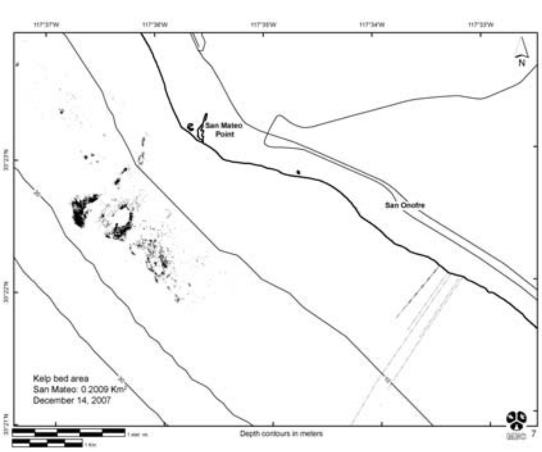

117°37'
36'
35'
34'
33'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Clemente: 0.32 km²
San Mateo Point: 0.16 km²
30 December 2002
1 stat. mi
1 km
Depth contours in feet
7

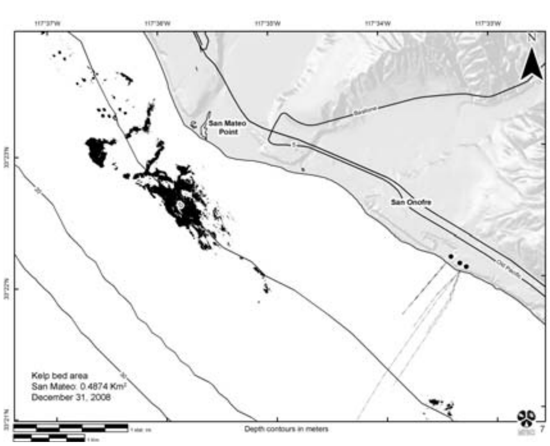

117° 37'
36'
35'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.2416 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
7

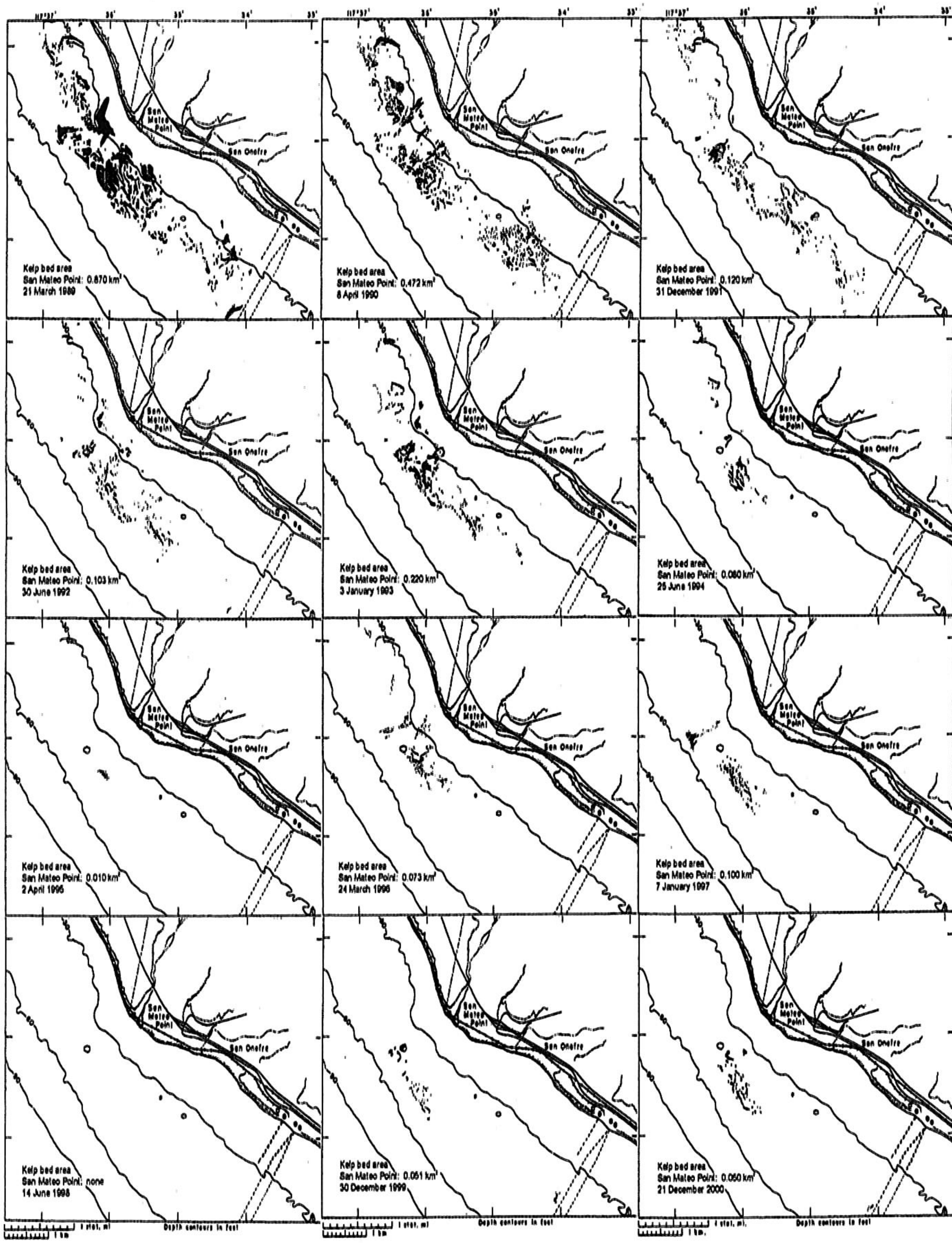

117° 37'
36'
35'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.1234 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
7


117° 37'
36'
35'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.2579 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
7

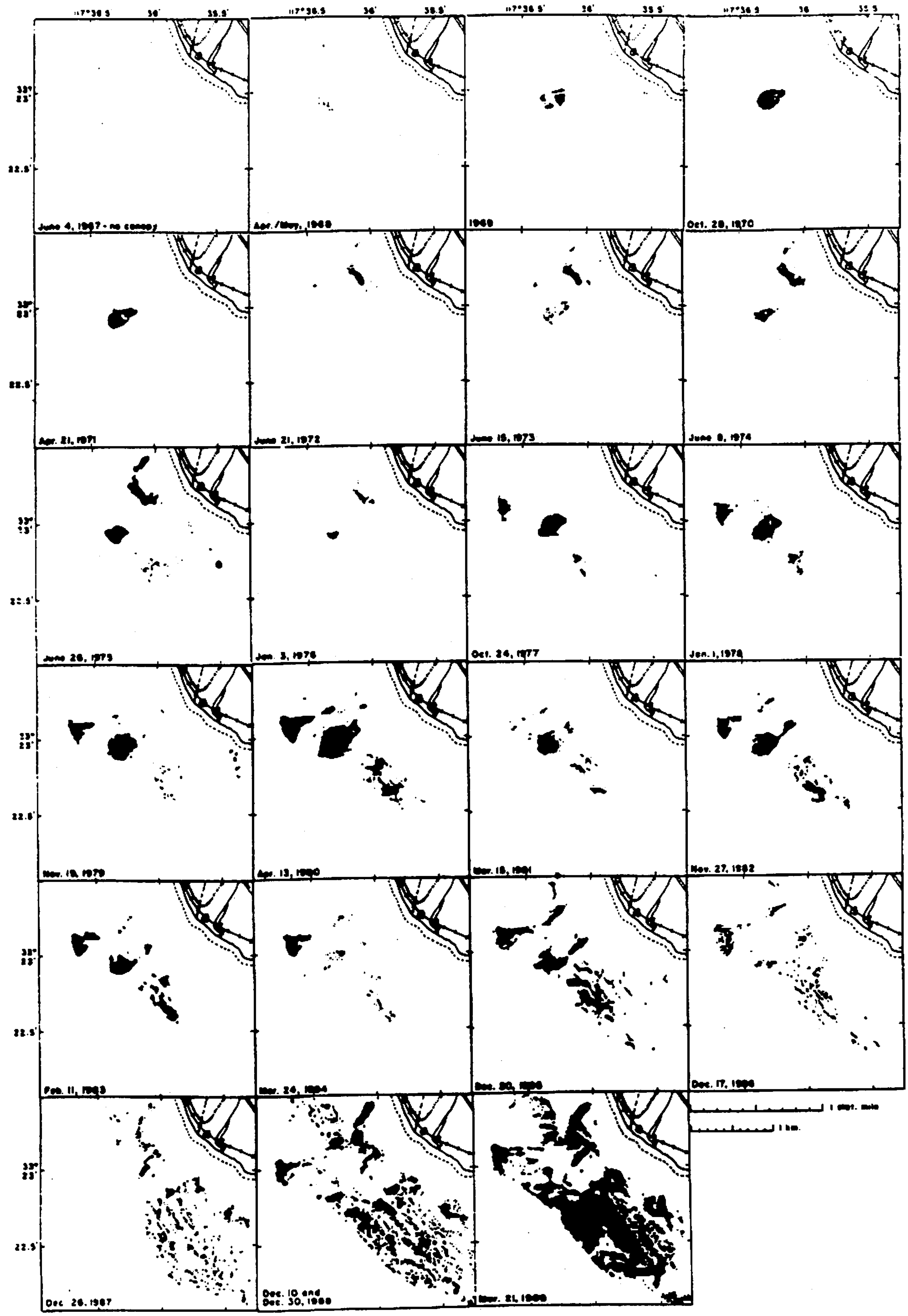

117° 37'
36'
35'
33° 24'
23'
22'
30
60
90
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.0164 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
7


N
San Mateo Point
San Onofre
Kelp bed area
San Mateo: 0.2009 Km²
December 14, 2007
Depth contours in meters
7

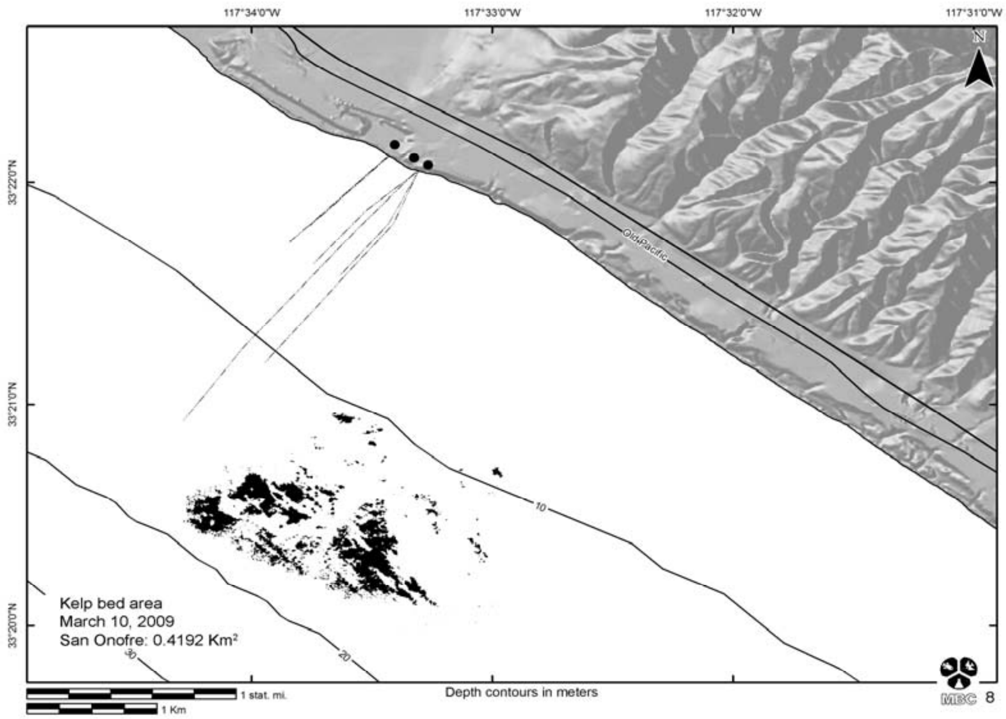

N
San Mateo Point
San Onofre
Kelp bed area
San Mateo: 0.4874 Km²
December 31, 2008
Depth contours in meters
7

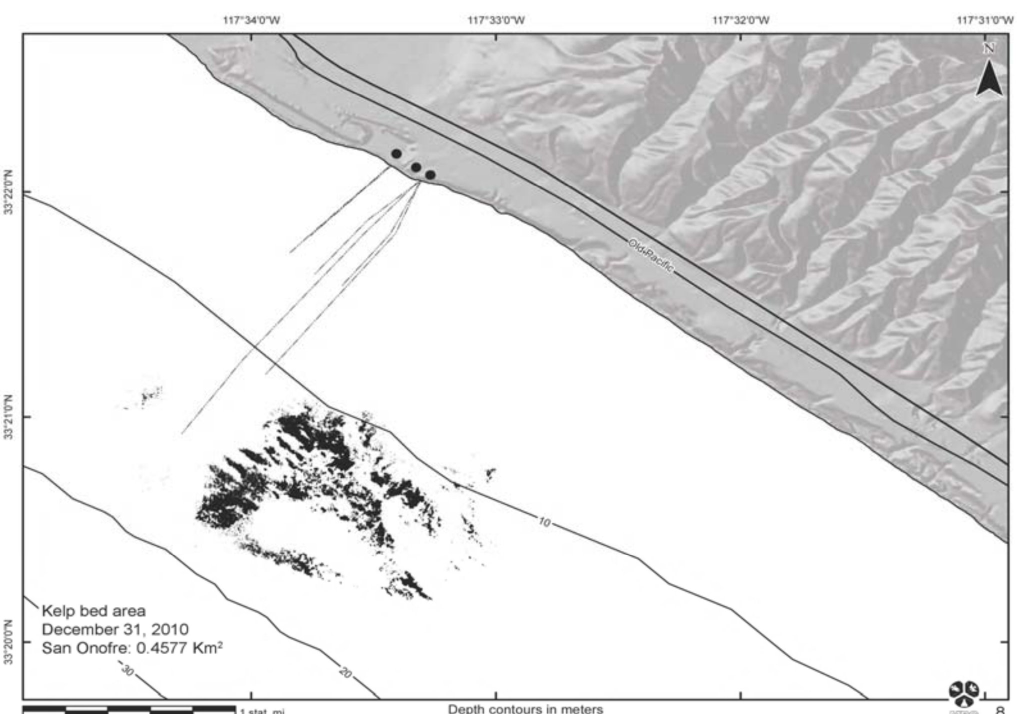


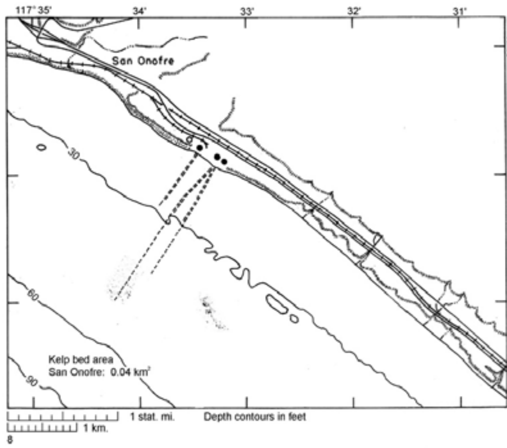
117°37'
36'
35'
34'
33'
San Mateo Point
San Onofre
Kelp bed area
San Mateo Point: 0.670 km²
21 March 1989
Kelp bed area
San Mateo Point: 0.472 km²
6 April 1990
Kelp bed area
San Mateo Point: 0.120 km²
31 December 1991
Kelp bed area
San Mateo Point: 0.103 km²
30 June 1992
Kelp bed area
San Mateo Point: 0.220 km²
3 January 1993
Kelp bed area
San Mateo Point: 0.080 km²
25 June 1994
Kelp bed area
San Mateo Point: 0.010 km²
2 April 1995
Kelp bed area
San Mateo Point: 0.073 km²
24 March 1996
Kelp bed area
San Mateo Point: 0.100 km²
7 January 1997
Kelp bed area
San Mateo Point: none
14 June 1998
Kelp bed area
San Mateo Point: 0.051 km²
30 December 1999
Kelp bed area
San Mateo Point: 0.050 km²
21 December 2000
1 stat. mi
1 km
Depth contours in feet

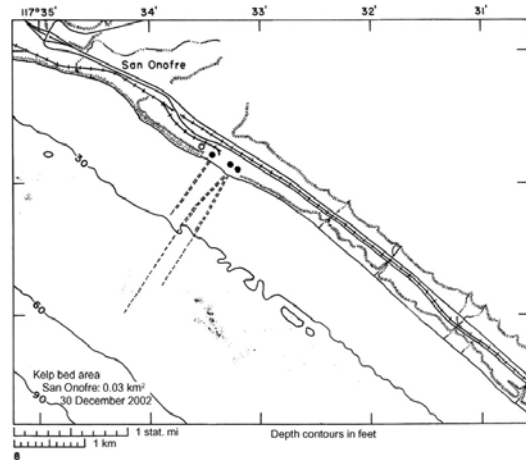


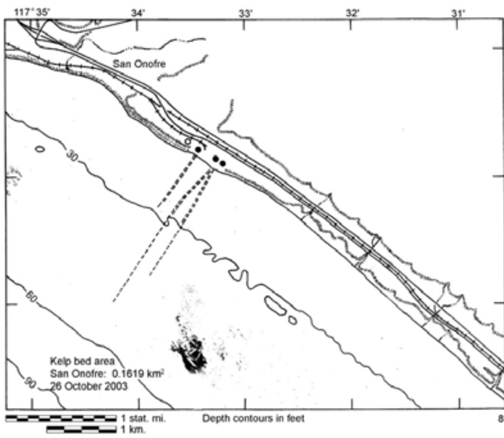
Historical charts of San Mateo kelp from 1967 to 1989.

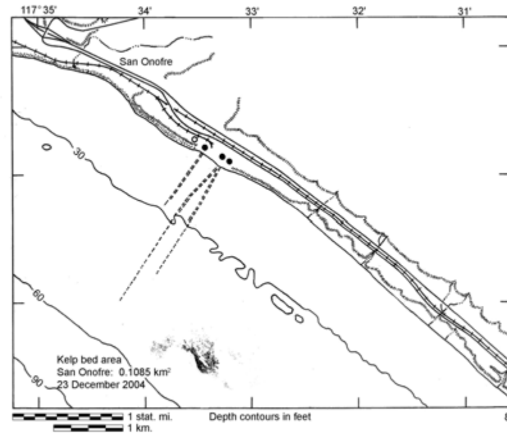

117°34'0"W
117°33'0"W
117°32'0"W
117°31'0"W
N
33°22'0"N
33°21'0"N
33°20'0"N
Old Pacific
10
20
30
Kelp bed area
March 10, 2009
San Onofre: 0.4192 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
8

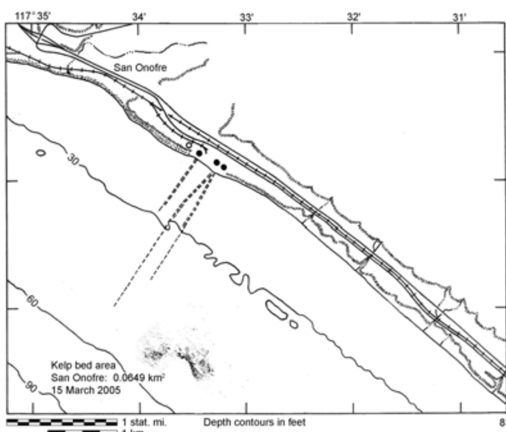

117°34'0"W
117°33'0"W
117°32'0"W
117°31'0"W
N
33°22'0"N
33°21'0"N
33°20'0"N
Old Pacific
10
20
30
Kelp bed area
December 31, 2010
San Onofre: 0.4577 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
8

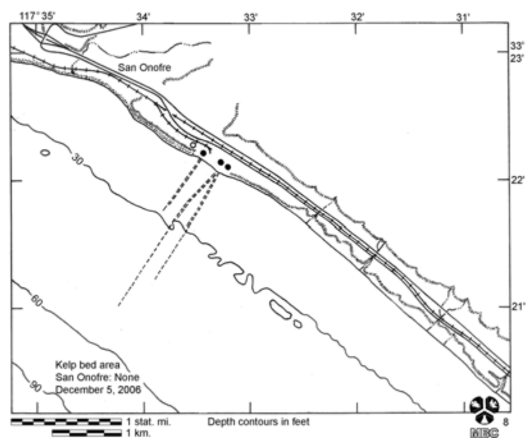

117° 35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: 0.04 km²
1 stat. mi.
1 km.
Depth contours in feet
8

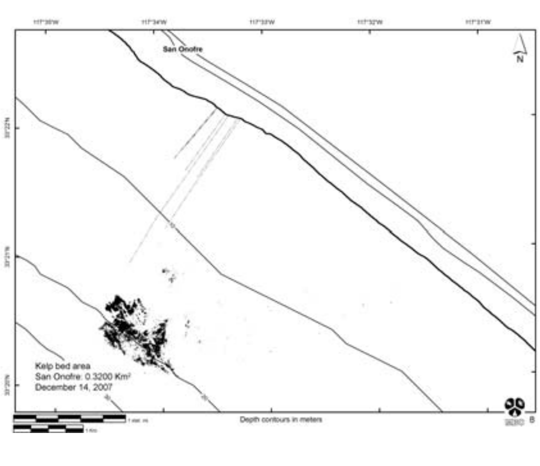

117°35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: 0.03 km²
30 December 2002
1 stat. mi
1 km
Depth contours in feet
8

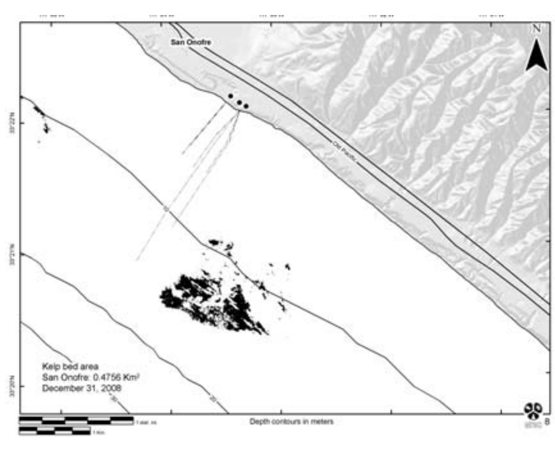

117° 35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: 0.1619 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
8

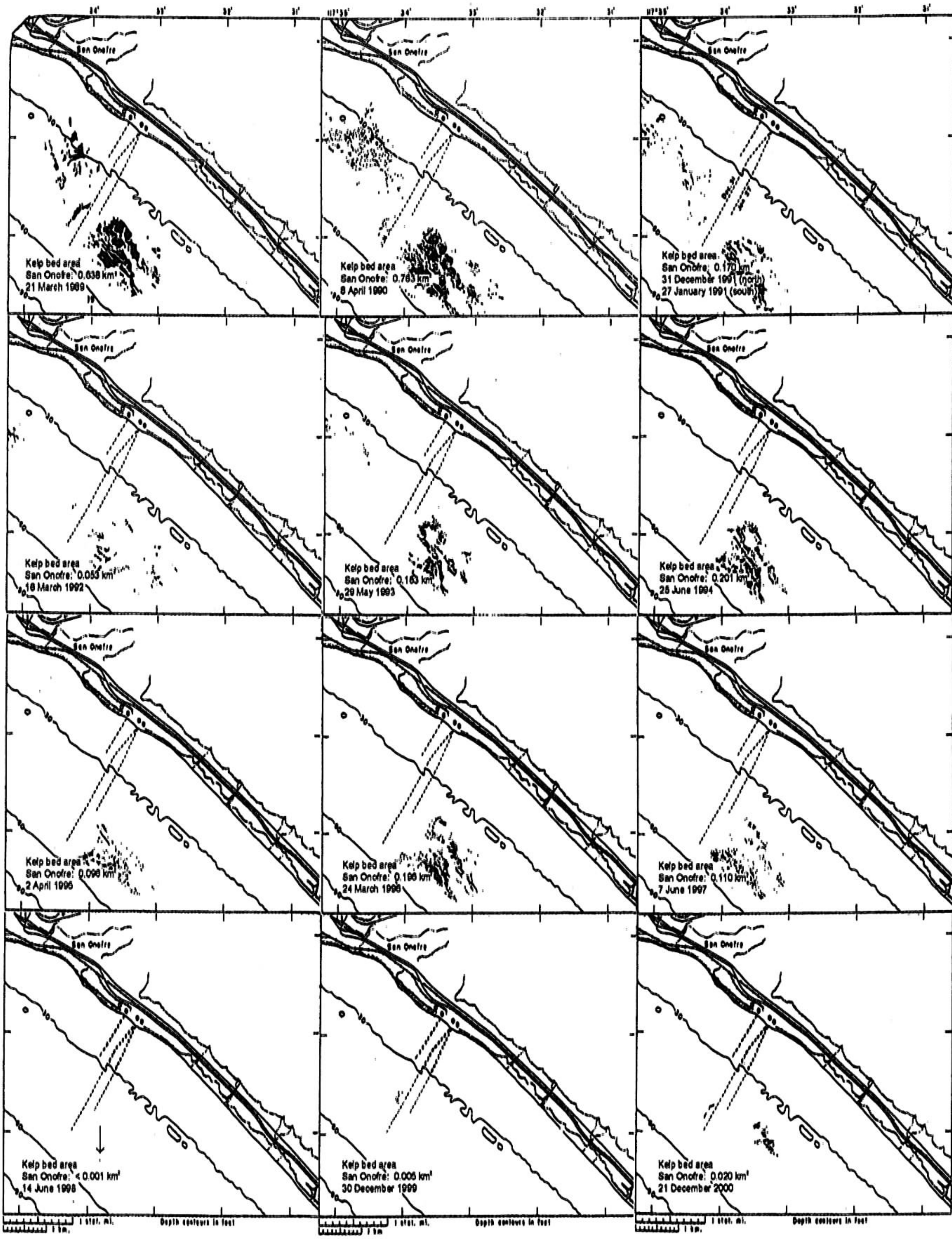

117° 35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: 0.1085 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
8


117° 35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: 0.0649 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
8

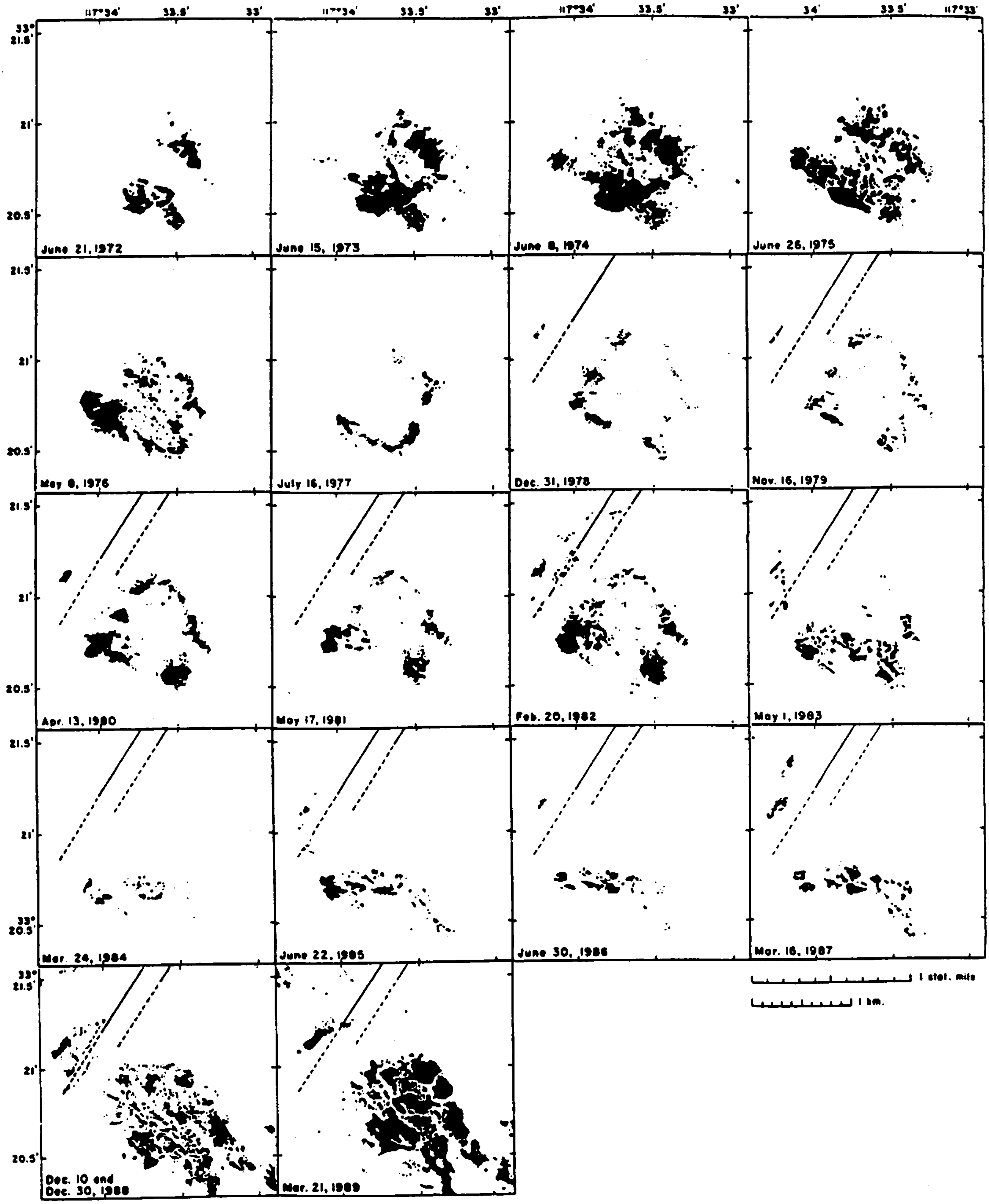

117° 35'
34'
33'
32'
31'
33°
23'
22'
21'
San Onofre
30
60
90
Kelp bed area
San Onofre: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
8


San Onofre
N
Kelp bed area
San Onofre: 0.3200 Km²
December 14, 2007
Depth contours in meters
8

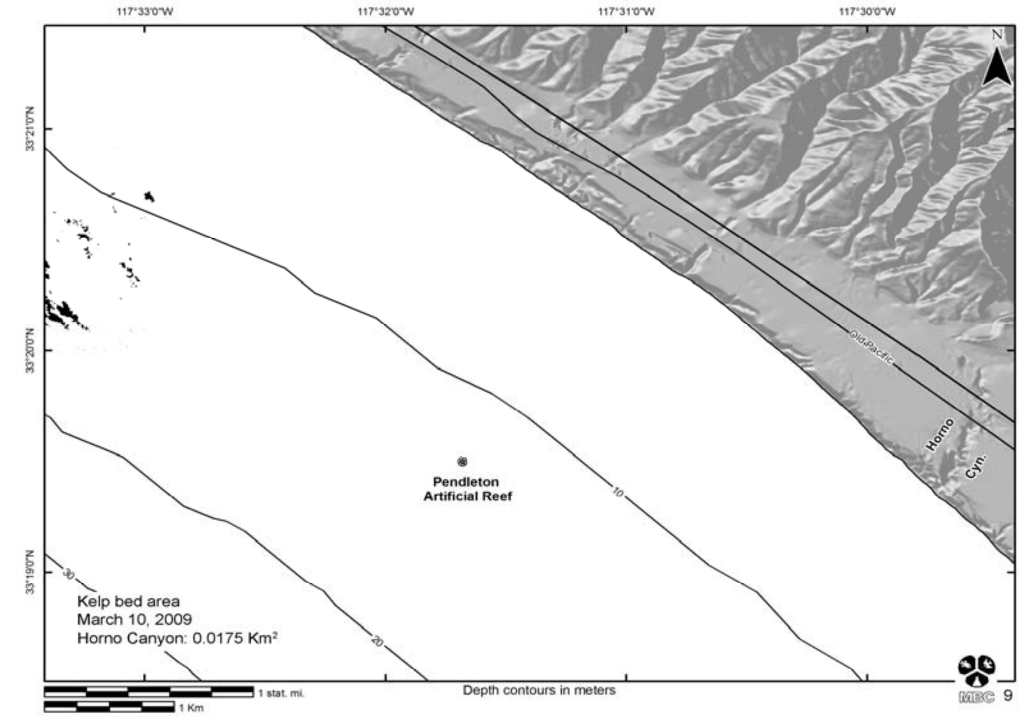

San Onofre
N
Kelp bed area
San Onofre: 0.4756 Km²
December 31, 2008
Depth contours in meters
8



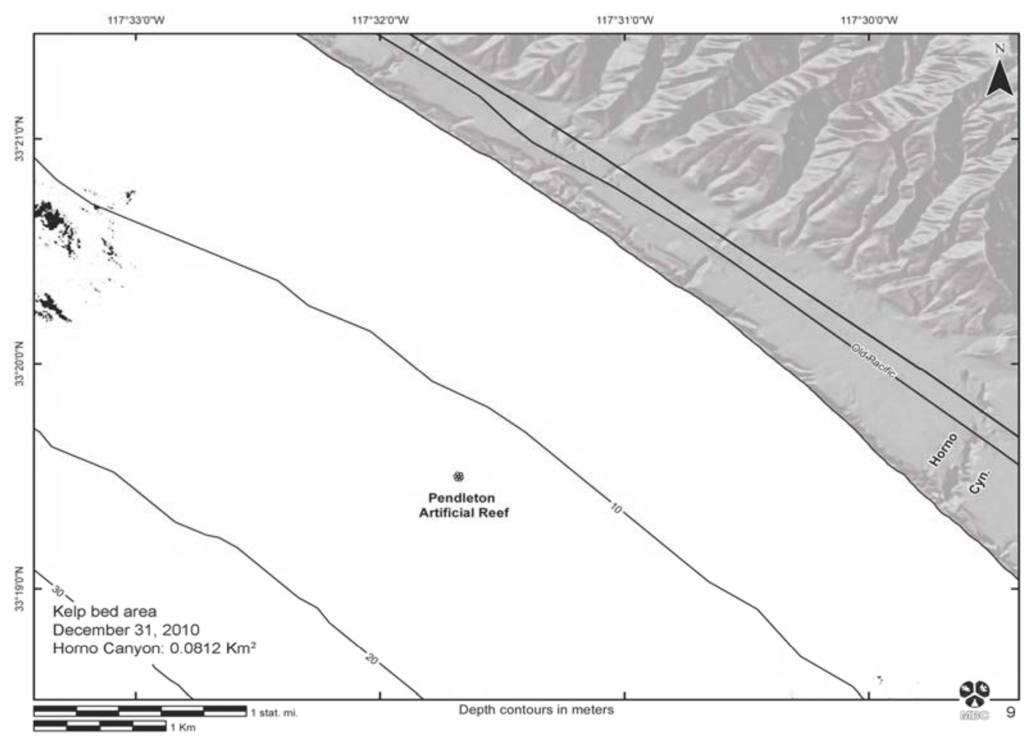
San Onofre
Kelp bed area
San Onofre: 0.638 km²
21 March 1989
Kelp bed area
San Onofre: 0.763 km²
8 April 1990
Kelp bed area
San Onofre: 0.170 km²
31 December 1991 (north)
27 January 1991 (south)
Kelp bed area
San Onofre: 0.053 km²
16 March 1992
Kelp bed area
San Onofre: 0.183 km²
29 May 1993
Kelp bed area
San Onofre: 0.201 km²
25 June 1994
Kelp bed area
San Onofre: 0.096 km²
2 April 1995
Kelp bed area
San Onofre: 0.196 km²
24 March 1996
Kelp bed area
San Onofre: 0.110 km²
7 June 1997
Kelp bed area
San Onofre: < 0.001 km²
14 June 1998
Kelp bed area
San Onofre: 0.006 km²
30 December 1999
Kelp bed area
San Onofre: 0.020 km²
21 December 2000
1 stat. mi.
1 km.
Depth contours in feet



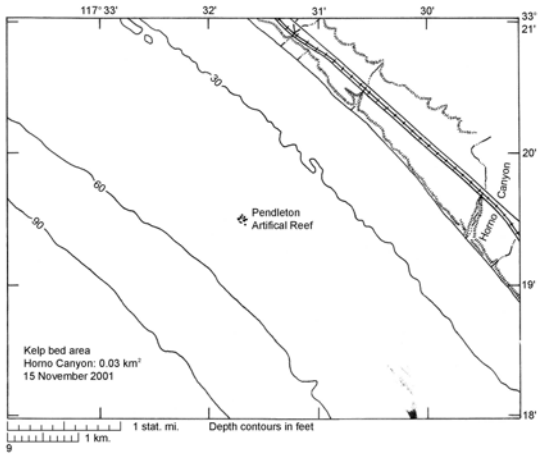
Historical charts of San Onofre kelp from 1972 to 1989.

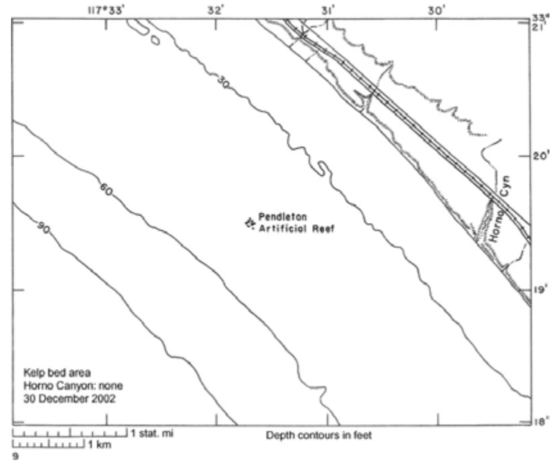


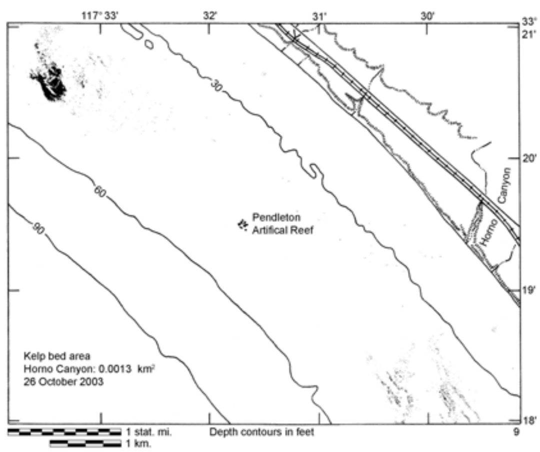
117°33'0"W
117°32'0"W
117°31'0"W
117°30'0"W
33°21'0"N
33°20'0"N
33°19'0"N
N
Old Pacific
Horno
Cyn.
Pendleton
Artificial Reef
10
20
30
Kelp bed area
March 10, 2009
Horno Canyon: 0.0175 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
9

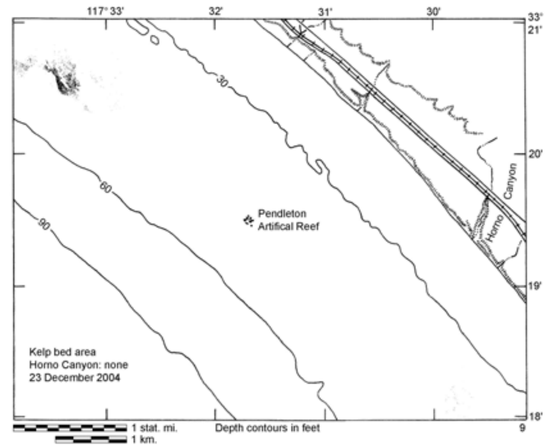


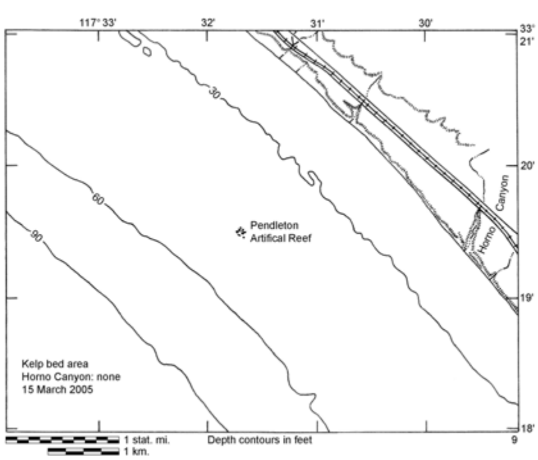
117°33'0"W
117°32'0"W
117°31'0"W
117°30'0"W
33°21'0"N
33°20'0"N
33°19'0"N
N
Old Pacific
Horno
Cyn.
Pendleton
Artificial Reef
10
20
30
Kelp bed area
December 31, 2010
Horno Canyon: 0.0812 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
9

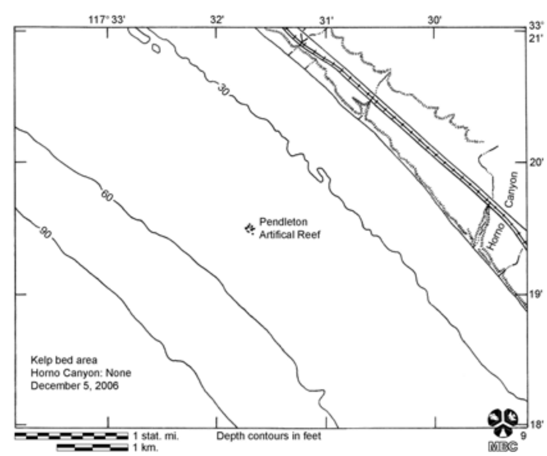

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artifical Reef
Horno Canyon
Kelp bed area
Horno Canyon: 0.03 km²
15 November 2001
1 stat. mi.
1 km.
Depth contours in feet
9

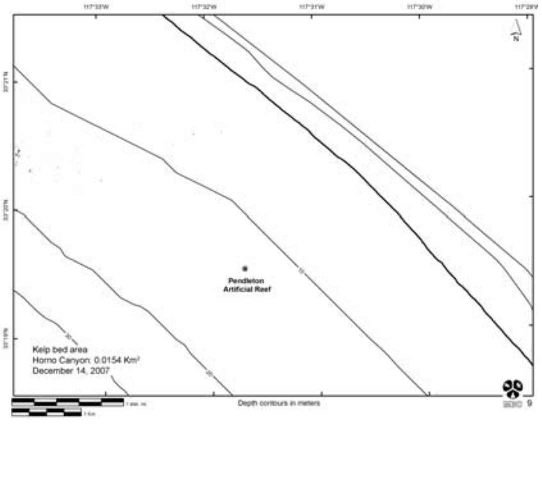

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artificial Reef
Horno Cyn
Kelp bed area
Horno Canyon: none
30 December 2002
1 stat. mi
1 km
Depth contours in feet
9

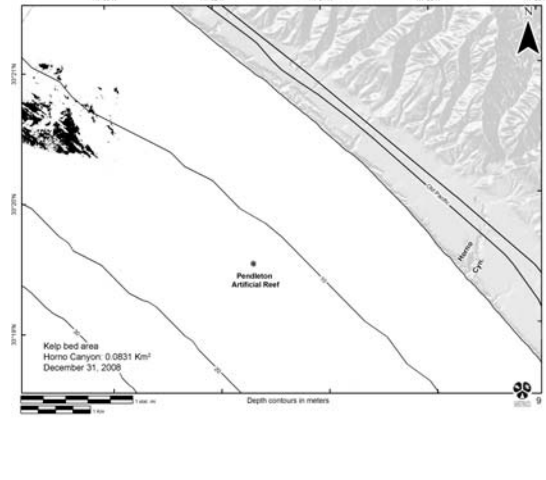

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artifical Reef
Horno Canyon
Kelp bed area
Horno Canyon: 0.0013 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
9

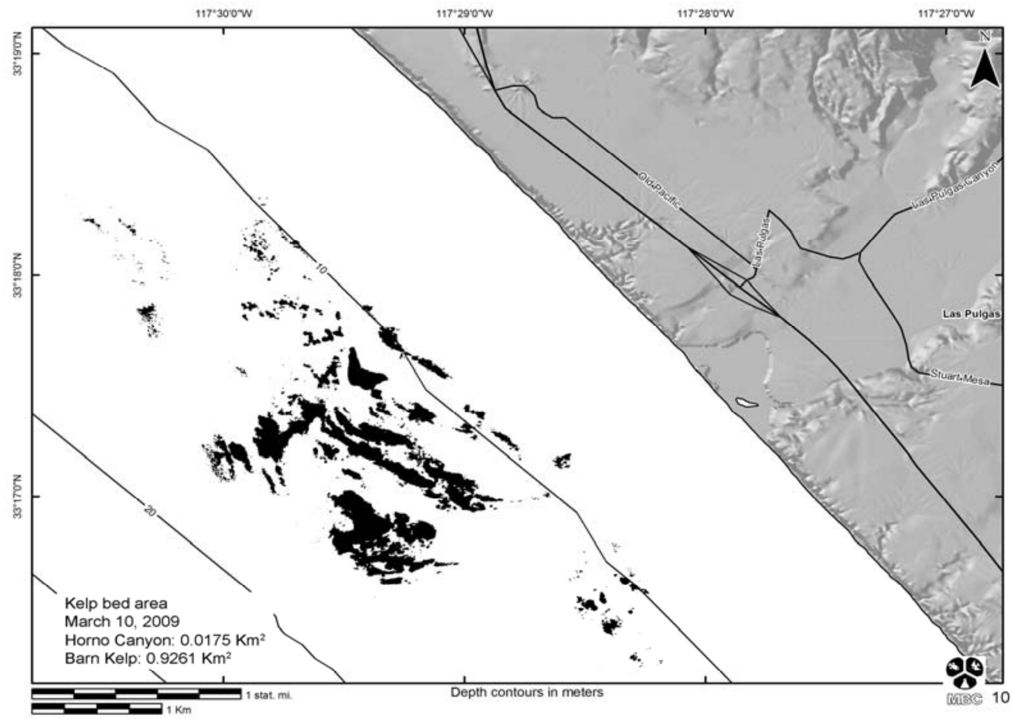

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artifical Reef
Horno Canyon
Kelp bed area
Horno Canyon: none
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
9

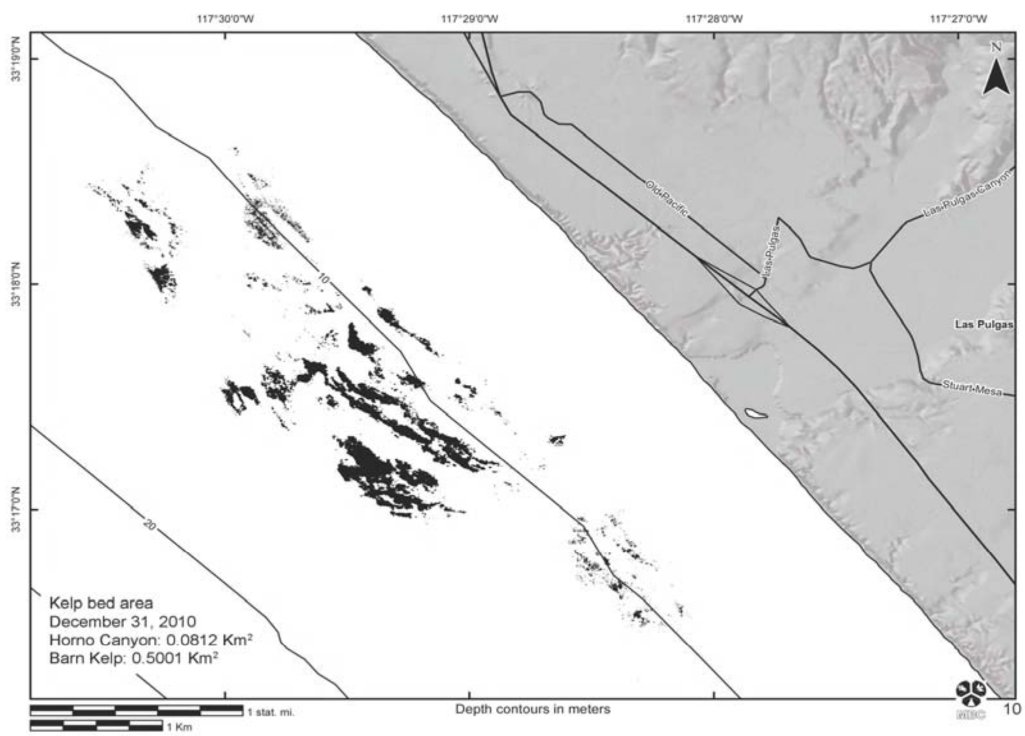

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artifical Reef
Horno Canyon
Kelp bed area
Horno Canyon: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
9

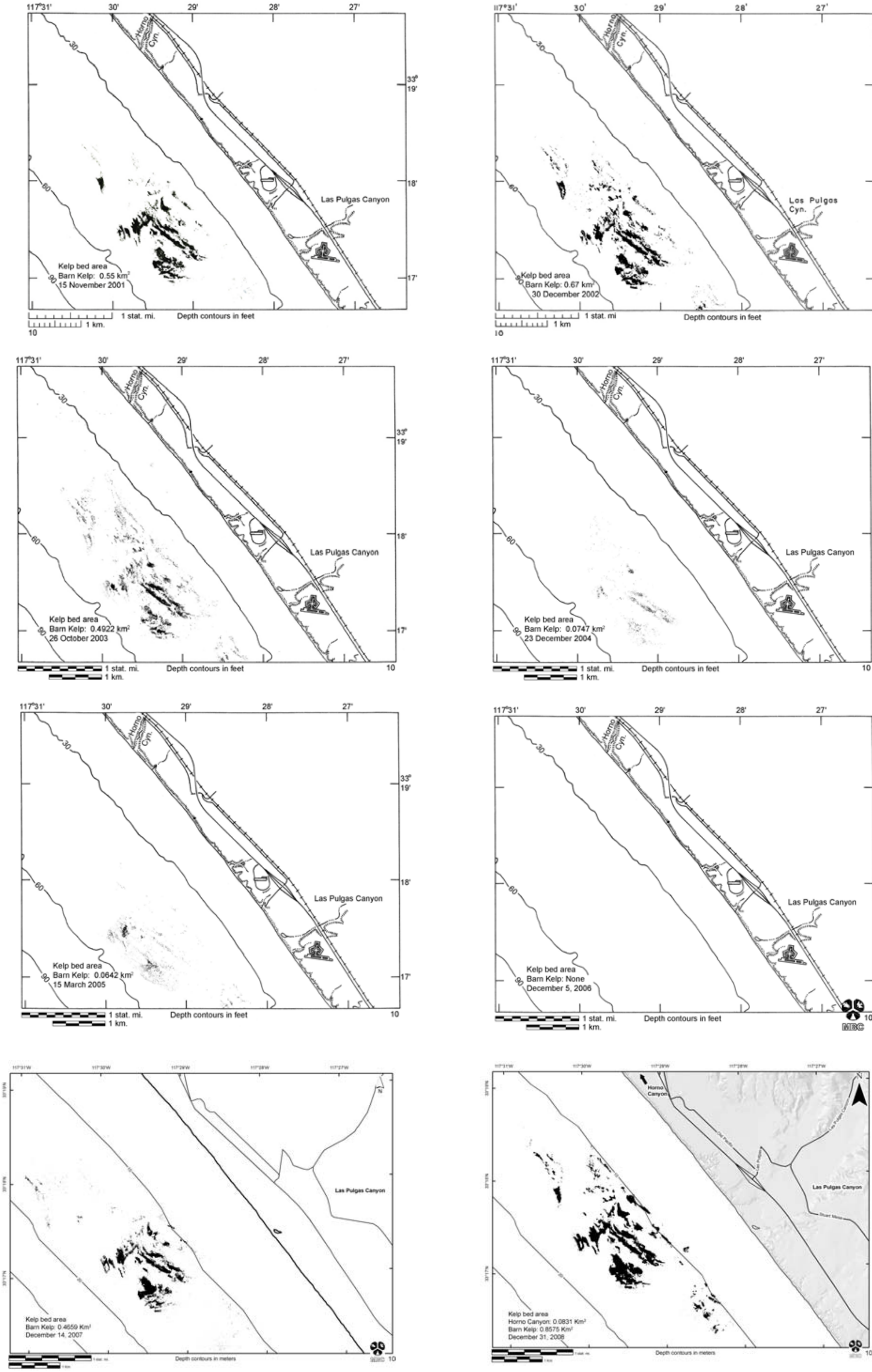

117° 33'
32'
31'
30'
33° 21'
20'
19'
18'
30
60
90
Pendleton Artifical Reef
Horno Canyon
Kelp bed area
Horno Canyon: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
9


117°33'W
117°32'W
117°31'W
117°30'W
117°29'W
Pendleton Artificial Reef
Kelp bed area
Horno Canyon: 0.0154 Km²
December 14, 2007
Depth contours in meters
9

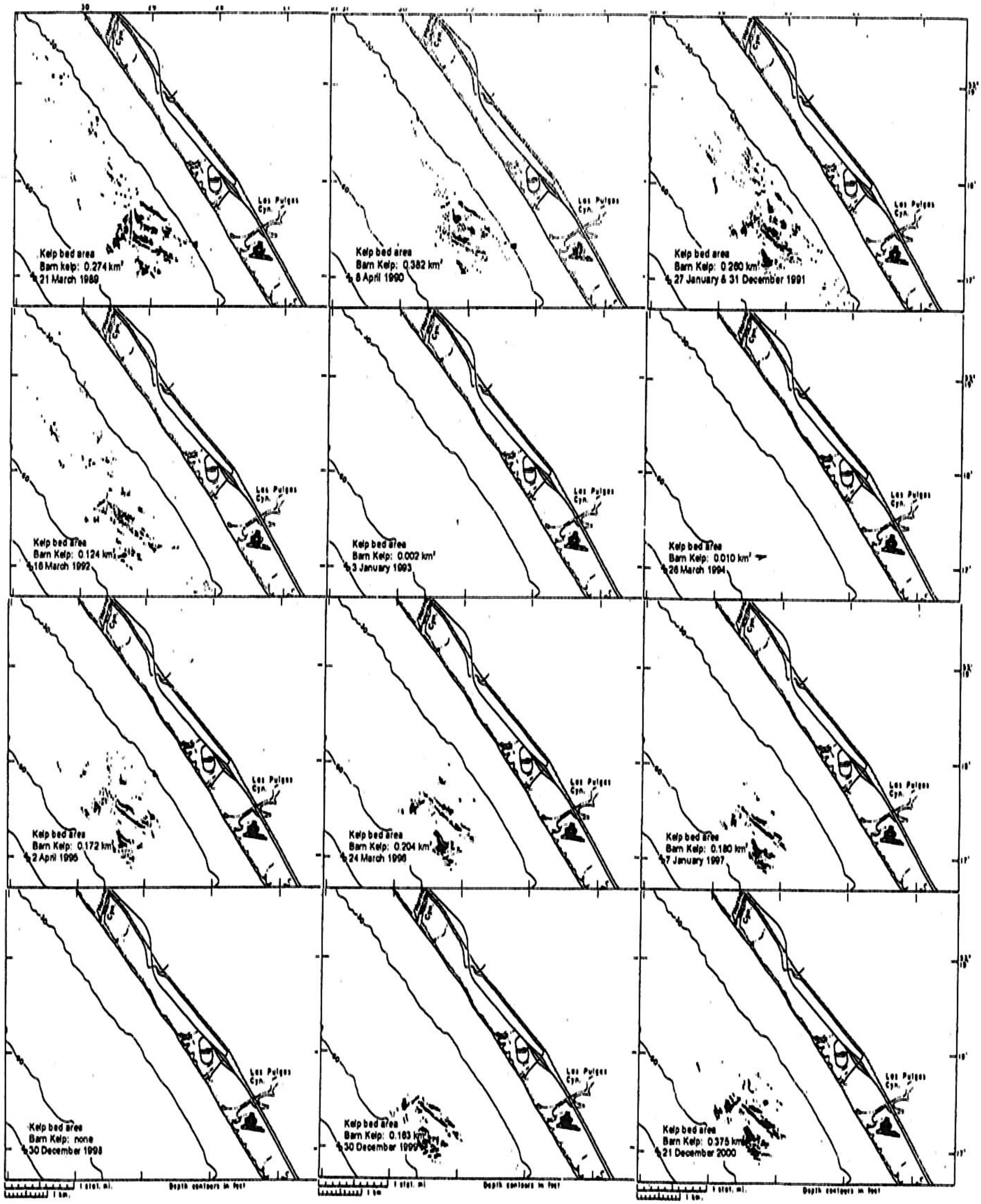

117°33'W
117°32'W
117°31'W
117°30'W
117°29'W
N
Pendleton Artificial Reef
Horno Cyn.
Kelp bed area
Horno Canyon: 0.0831 Km²
December 31, 2008
Depth contours in meters
9

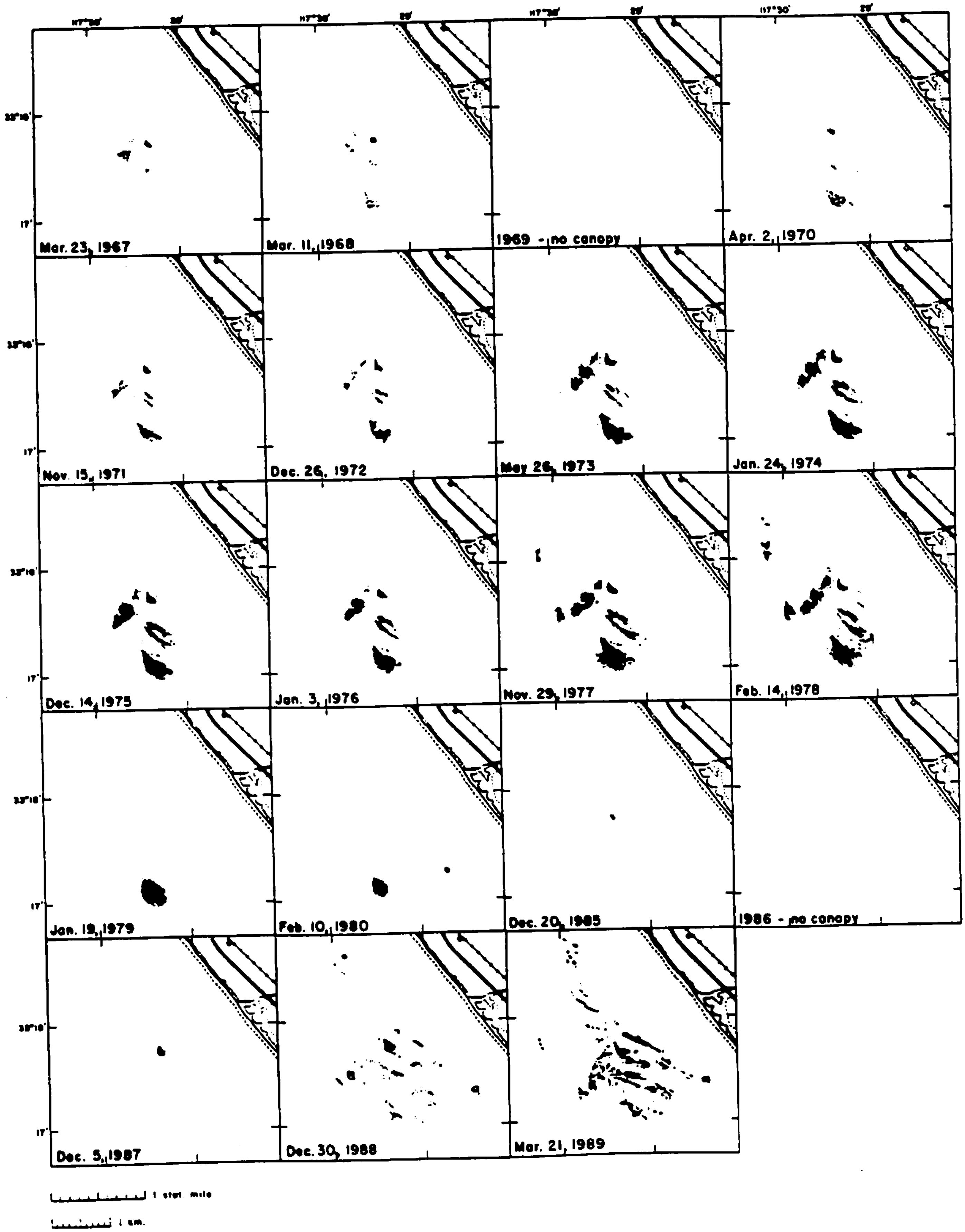

117°30'0"W
117°29'0"W
117°28'0"W
117°27'0"W
33°19'0"N
33°18'0"N
33°17'0"N
N
Old Pacific
Las Pulgas Canyon
Las Pulgas
Las Pulgas
Stuart Mesa
10
20
Kelp bed area
March 10, 2009
Horno Canyon: 0.0175 Km²
Barn Kelp: 0.9261 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
10


117°30'0"W
117°29'0"W
117°28'0"W
117°27'0"W
33°19'0"N
33°18'0"N
33°17'0"N
N
Old Pacific
Las Pulgas Canyon
Las Pulgas
Las Pulgas
Stuart Mesa
10
20
Kelp bed area
December 31, 2010
Horno Canyon: 0.0812 Km²
Barn Kelp: 0.5001 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
10

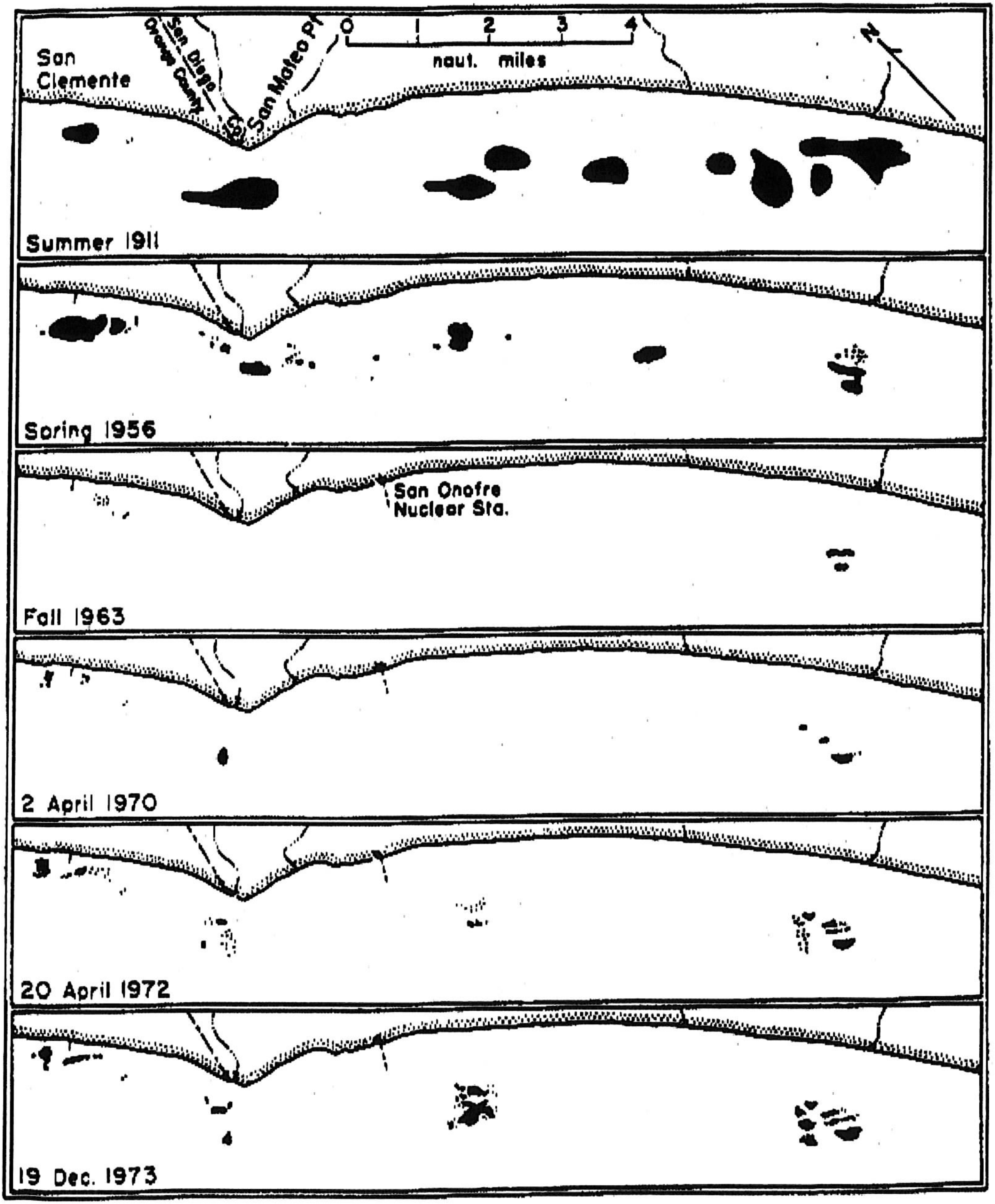


117°31'
30'
29'
28'
27'
Horno Cyn.
33° 19'
18'
17'
Las Pulgas Canyon
Kelp bed area
Barn Kelp: 0.55 km^2
15 November 2001
1 stat. mi.
1 km.
Depth contours in feet
Las Pulgas Cyn.
Kelp bed area
Barn Kelp: 0.67 km^2
30 December 2002
Kelp bed area
Barn Kelp: 0.4922 km^2
26 October 2003
Kelp bed area
Barn Kelp: 0.0747 km^2
23 December 2004
Kelp bed area
Barn Kelp: 0.0642 km^2
15 March 2005
Kelp bed area
Barn Kelp: None
December 5, 2006
Las Pulgas Canyon
Kelp bed area
Barn Kelp: 0.4659 Km^2
December 14, 2007
Depth contours in meters
Horno Canyon
Las Pulgas Canyon
Kelp bed area
Horno Canyon: 0.0831 Km^2
Barn Kelp: 0.8575 Km^2
December 31, 2008
Depth contours in meters

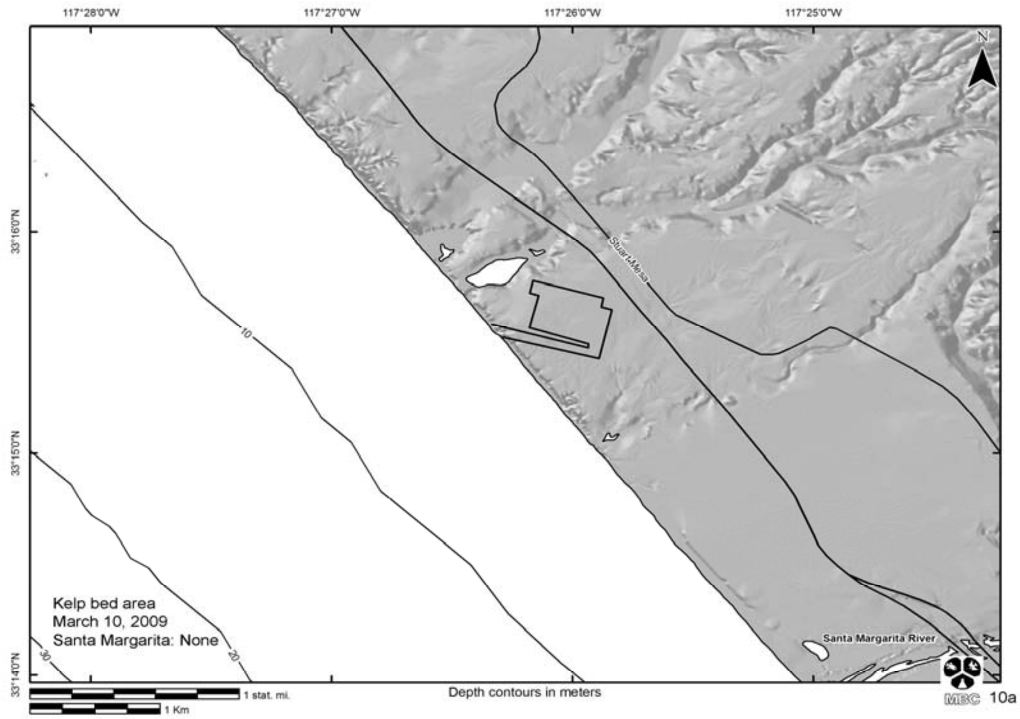

Kelp bed area
Barn kelp: 0.274 km^2
21 March 1989
Kelp bed area
Barn Kelp: 0.382 km^2
8 April 1990
Kelp bed area
Barn Kelp: 0.260 km^2
27 January & 31 December 1991
Kelp bed area
Barn Kelp: 0.124 km^2
16 March 1992
Kelp bed area
Barn Kelp: 0.002 km^2
3 January 1993
Kelp bed area
Barn Kelp: 0.010 km^2
26 March 1994
Kelp bed area
Barn Kelp: 0.172 km^2
2 April 1995
Kelp bed area
Barn Kelp: 0.204 km^2
24 March 1996
Kelp bed area
Barn Kelp: 0.180 km^2
7 January 1997
Kelp bed area
Barn Kelp: none
30 December 1998
Kelp bed area
Barn Kelp: 0.163 km^2
30 December 1999
Kelp bed area
Barn Kelp: 0.375 km^2
21 December 2000
Las Pulgas Cyn.
1 stat. mi.
1 km.
Depth contours in feet

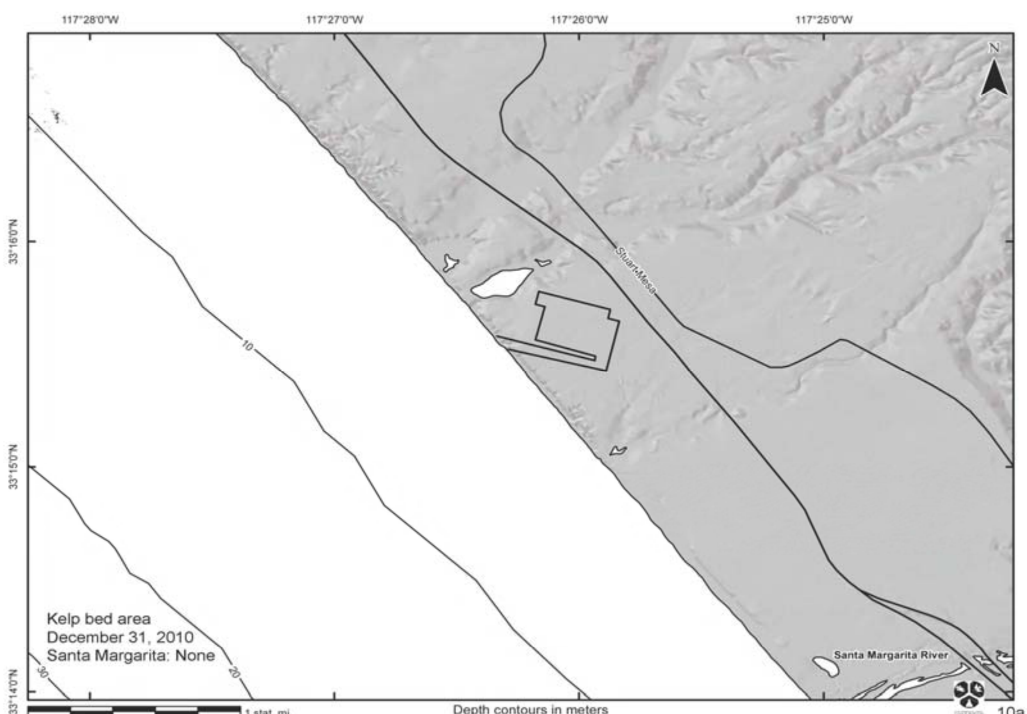


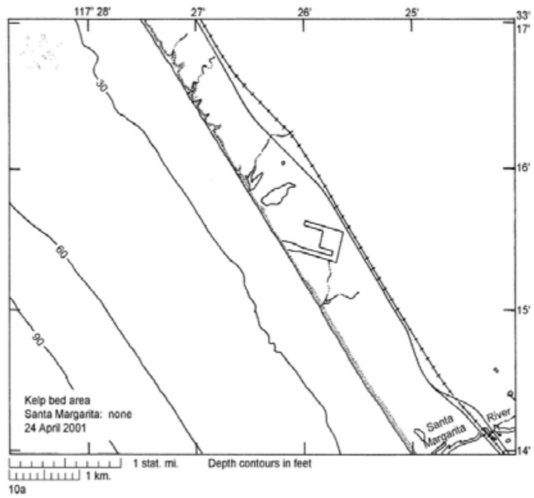
Historical charts of south Horno Canyon and of Barn kelp from 1967 to 1989.

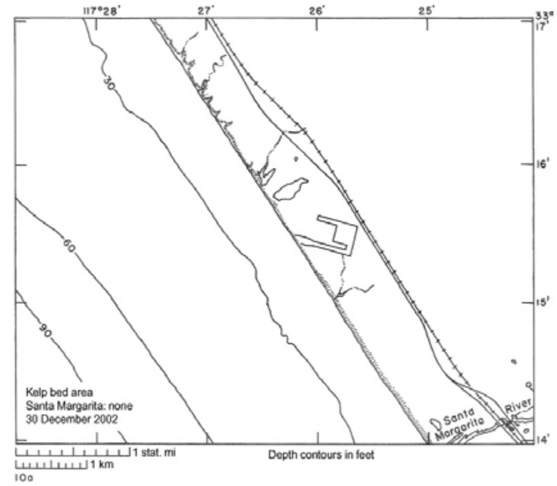


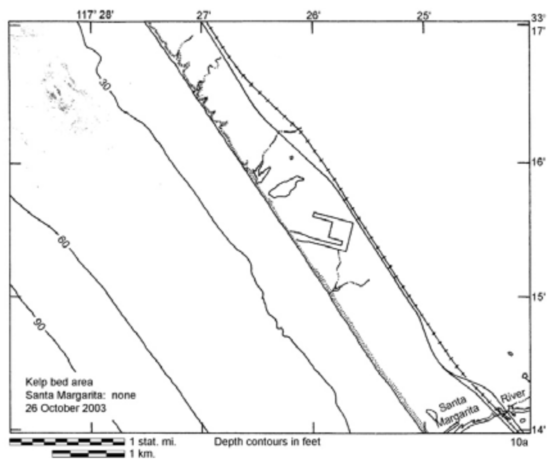
Historical charts of kelp beds from San Clemente to Barn Kelp from 1911 to 1973.

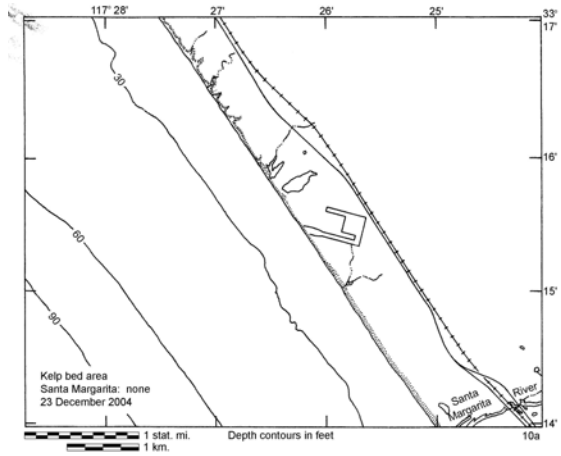

117°28'0"W
117°27'0"W
117°26'0"W
117°25'0"W
33°16'0"N
33°15'0"N
33°14'0"N
N
Stuart Mesa
10
20
30
Kelp bed area
March 10, 2009
Santa Margarita: None
Santa Margarita River
1 stat. mi.
1 Km
Depth contours in meters
MBC
10a

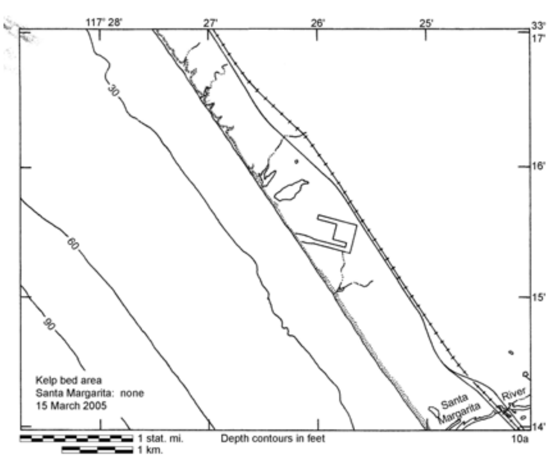

117°28'0"W
117°27'0"W
117°26'0"W
117°25'0"W
33°16'0"N
33°15'0"N
33°14'0"N
N
Stuart Mesa
10
20
30
Kelp bed area
December 31, 2010
Santa Margarita: None
Santa Margarita River
1 stat. mi.
1 Km
Depth contours in meters
MBC
10a

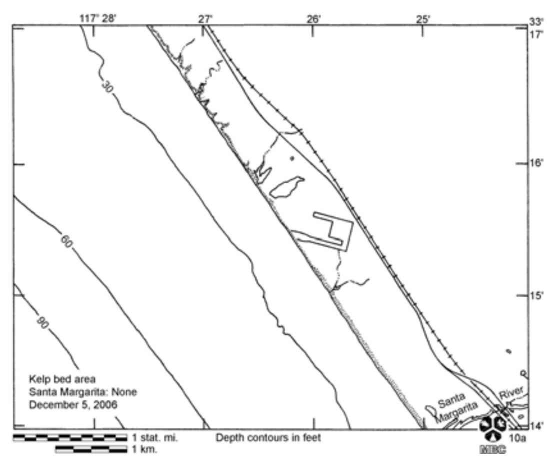

117° 28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: none
24 April 2001
Santa
Margarita
River
1 stat. mi.
1 km.
Depth contours in feet
10a

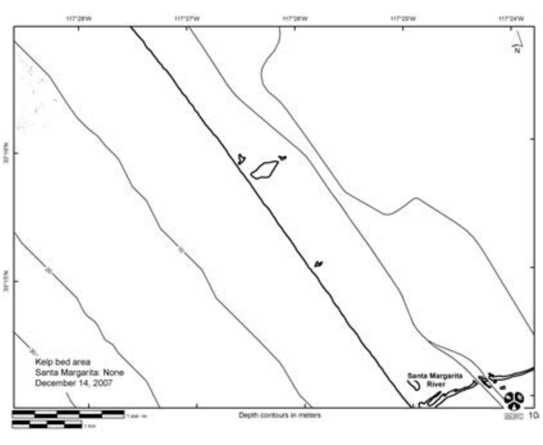

117°28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: none
30 December 2002
Santa
Margarita
River
1 stat. mi
1 km
Depth contours in feet
10a

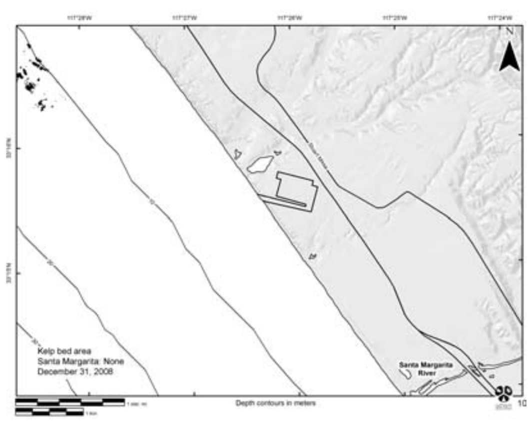

117° 28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: none
26 October 2003
Santa
Margarita
River
1 stat. mi.
1 km.
Depth contours in feet
10a

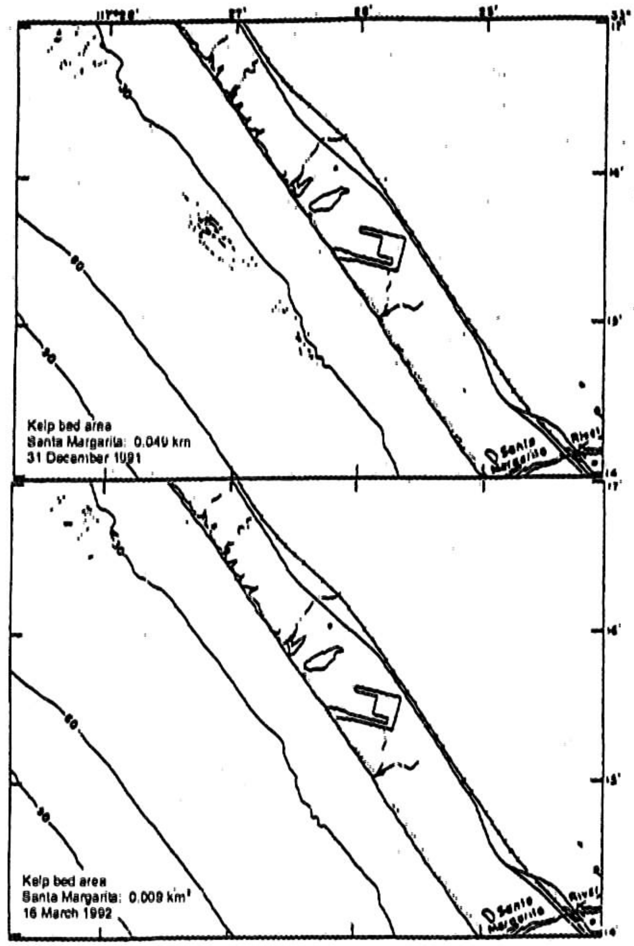

117° 28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: none
23 December 2004
Santa
Margarita
River
1 stat. mi.
1 km.
Depth contours in feet
10a

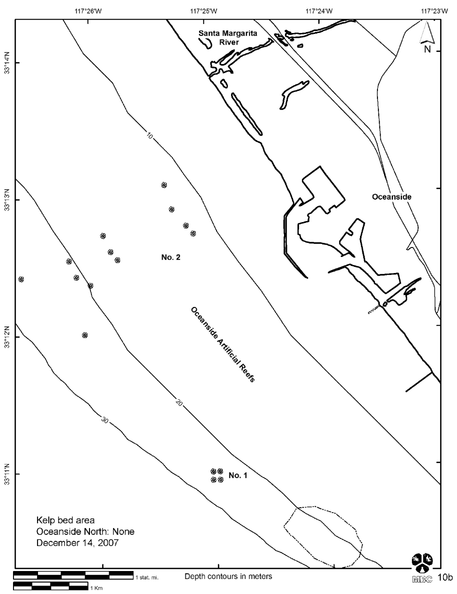

117° 28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: none
15 March 2005
Santa
Margarita
River
1 stat. mi.
1 km.
Depth contours in feet
10a

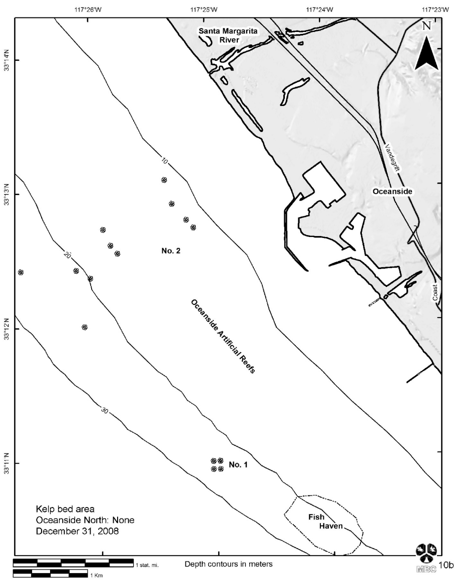

117° 28'
27'
26'
25'
33°
17'
16'
15'
14'
30
60
90
Kelp bed area
Santa Margarita: None
December 5, 2006
Santa
Margarita
River
1 stat. mi.
1 km.
Depth contours in feet
10a
MBC

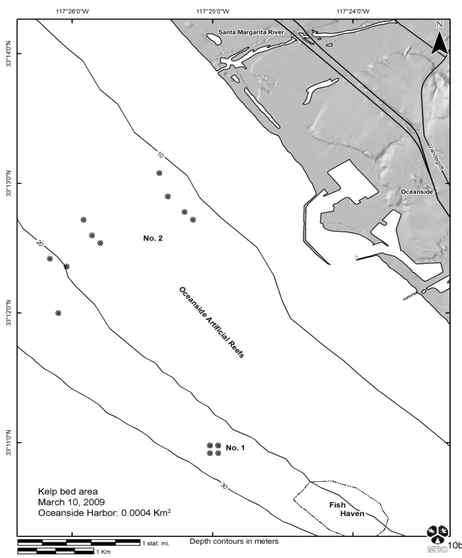

Kelp bed area
Santa Margarita: None
December 14, 2007
Santa Margarita
River
Depth contours in meters
10a

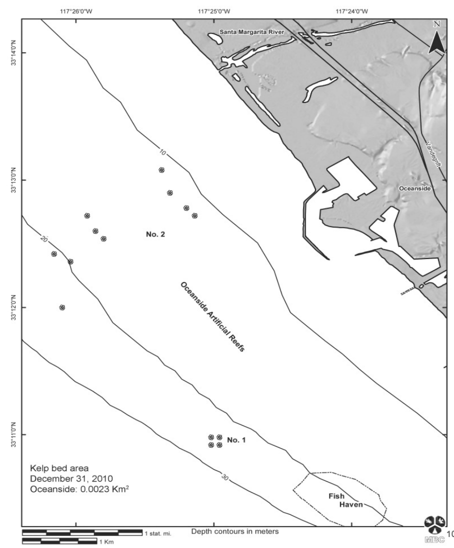

Kelp bed area
Santa Margarita: None
December 31, 2008
Santa Margarita
River
Depth contours in meters
10

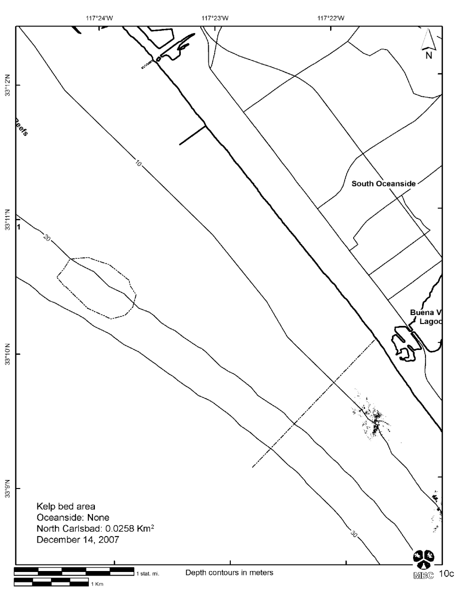

Kelp bed area
Santa Margarita: 0.049 km
31 December 1991
Santa
Margarita
River
Kelp bed area
Santa Margarita: 0.009 km²
16 March 1992

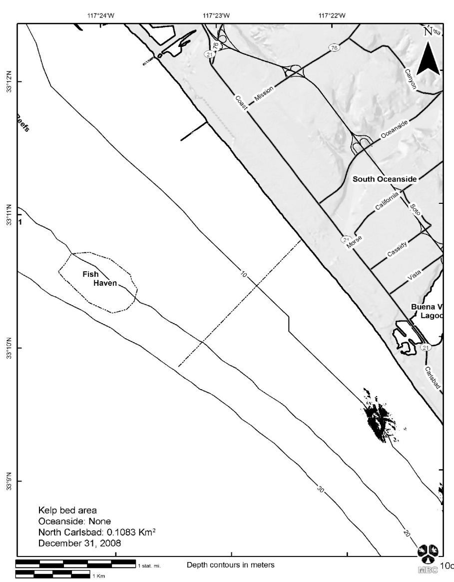

117°26'W
117°25'W
117°24'W
117°23'W
Santa Margarita River
Oceanside
No. 2
Oceanside Artificial Reefs
No. 1
Kelp bed area
Oceanside North: None
December 14, 2007
1 stat. mi.
1 Km
Depth contours in meters
10b

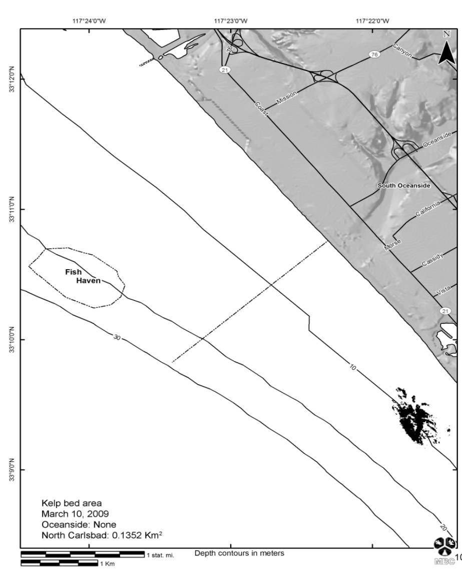

117°26'W
117°25'W
117°24'W
117°23'W
Santa Margarita River
Oceanside
No. 2
Oceanside Artificial Reefs
No. 1
Fish Haven
Kelp bed area
Oceanside North: None
December 31, 2008
1 stat. mi.
1 Km
Depth contours in meters
10b

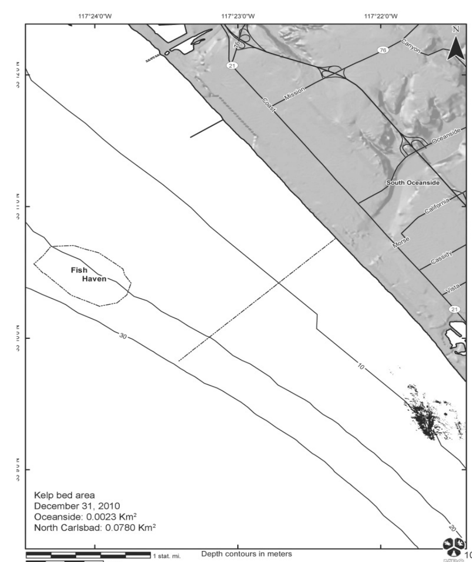

117°26'0"W
117°25'0"W
117°24'0"W
Santa Margarita River
Oceanside
No. 2
Oceanside Artificial Reefs
No. 1
Fish Haven
Kelp bed area
March 10, 2009
Oceanside Harbor: 0.0004 Km²
1 stat. mi.
1 Km
Depth contours in meters
10b

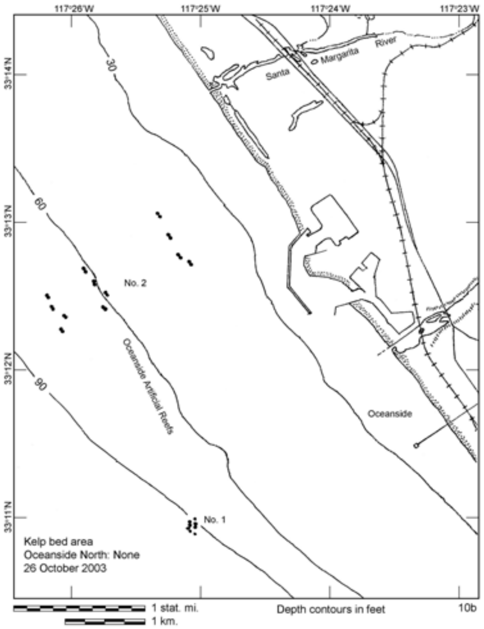

117°26'0"W
117°25'0"W
117°24'0"W
Santa Margarita River
Oceanside
No. 2
Oceanside Artificial Reefs
No. 1
Fish Haven
Kelp bed area
December 31, 2010
Oceanside: 0.0023 Km²
1 stat. mi.
1 Km
Depth contours in meters
10b

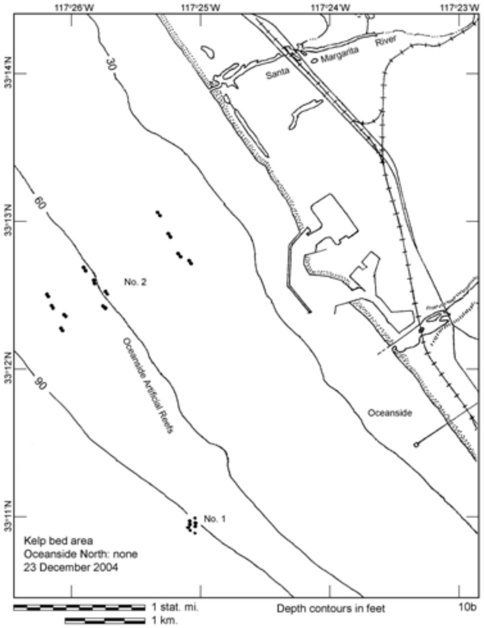

117°24'W
117°23'W
117°22'W
South Oceanside
Kelp bed area
Oceanside: None
North Carlsbad: 0.0258 Km²
December 14, 2007
1 stat. mi.
1 Km
Depth contours in meters
10c

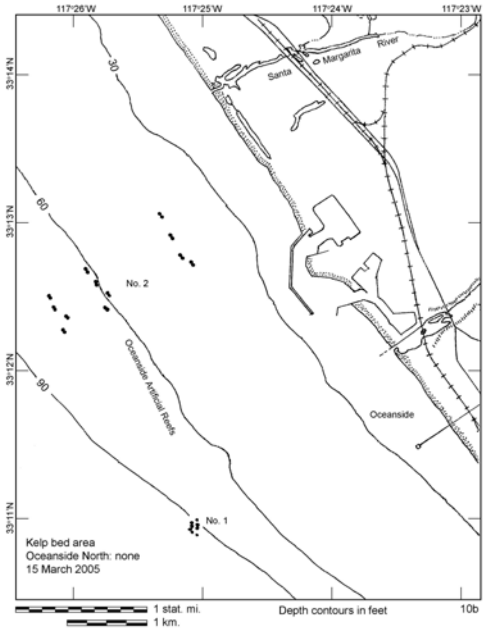

117°24'W
117°23'W
117°22'W
South Oceanside
Fish Haven
Kelp bed area
Oceanside: None
North Carlsbad: 0.1083 Km²
December 31, 2008
1 stat. mi.
1 Km
Depth contours in meters
10c

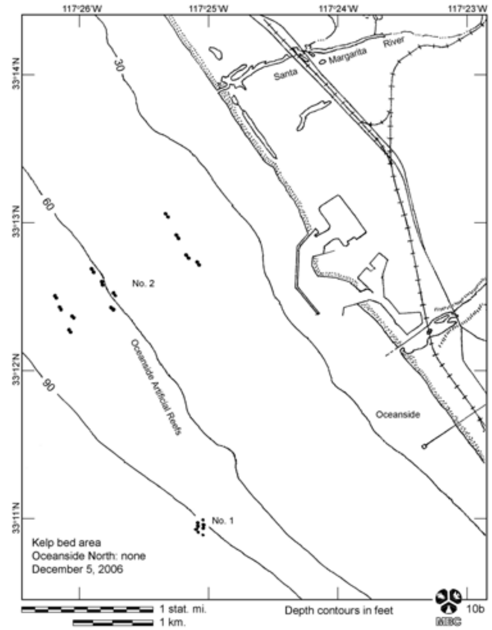

117°24'0"W
117°23'0"W
117°22'0"W
South Oceanside
Fish Haven
Kelp bed area
March 10, 2009
Oceanside: None
North Carlsbad: 0.1352 Km²
1 stat. mi.
1 Km
Depth contours in meters
10c

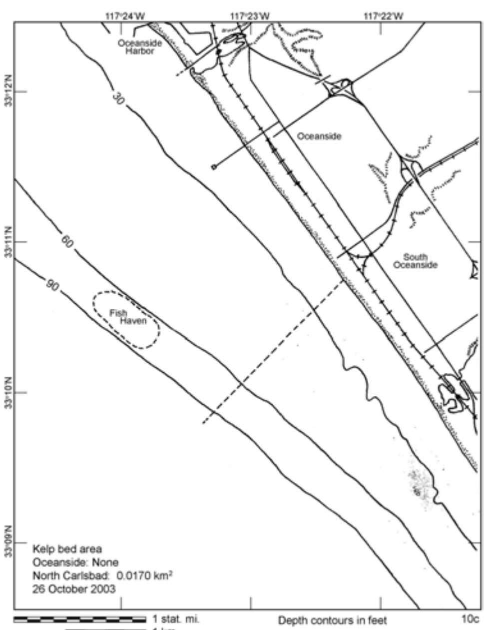

117°24'0"W
117°23'0"W
117°22'0"W
South Oceanside
Fish Haven
Kelp bed area
December 31, 2010
Oceanside: 0.0023 Km²
North Carlsbad: 0.0780 Km²
1 stat. mi.
1 Km
Depth contours in meters
10c

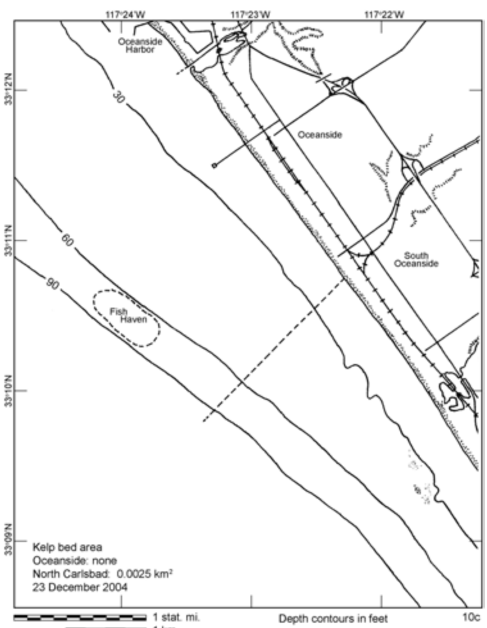

117°26'W
117°25'W
117°24'W
117°23'W
33°14'N
33°13'N
33°12'N
33°11'N
Santa Margarita River
30
60
90
No. 2
No. 1
Oceanside Artificial Reefs
Oceanside
Kelp bed area
Oceanside North: None
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
10b

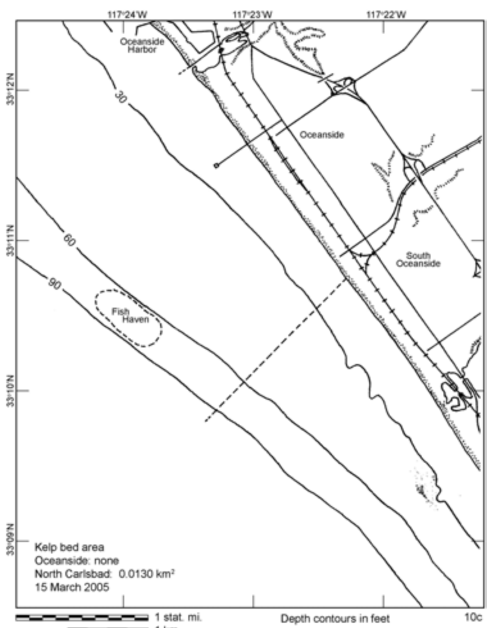

117°26'W
117°25'W
117°24'W
117°23'W
33°14'N
33°13'N
33°12'N
33°11'N
Santa Margarita River
30
60
90
No. 2
No. 1
Oceanside Artificial Reefs
Oceanside
Kelp bed area
Oceanside North: none
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
10b

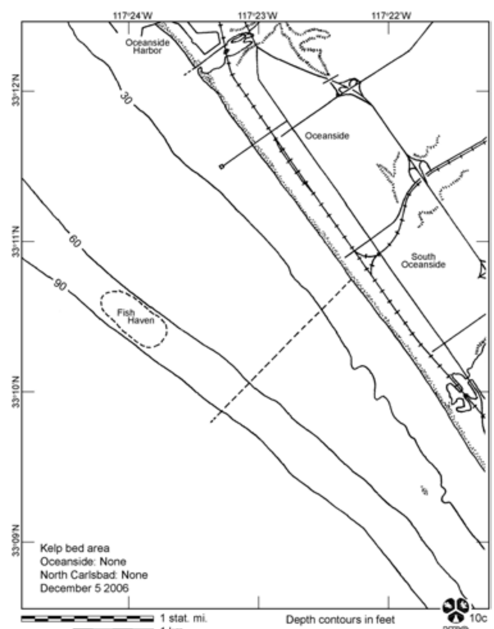

117°26'W
117°25'W
117°24'W
117°23'W
33°14'N
33°13'N
33°12'N
33°11'N
Santa Margarita River
30
60
90
No. 2
No. 1
Oceanside Artificial Reefs
Oceanside
Kelp bed area
Oceanside North: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
10b

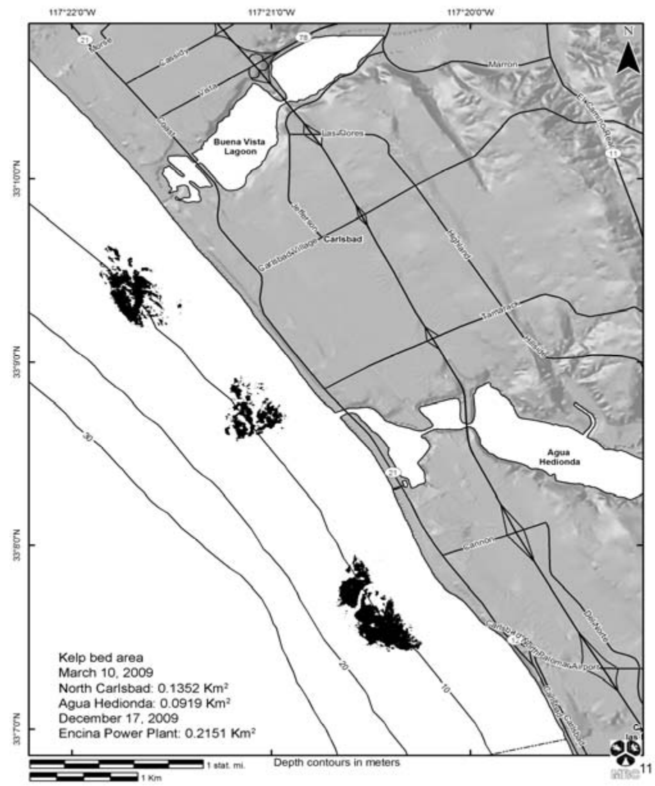

117°26'W
117°25'W
117°24'W
117°23'W
33°14'N
33°13'N
33°12'N
33°11'N
Santa Margarita River
30
60
90
No. 2
No. 1
Oceanside Artificial Reefs
Oceanside
Kelp bed area
Oceanside North: none
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
10b

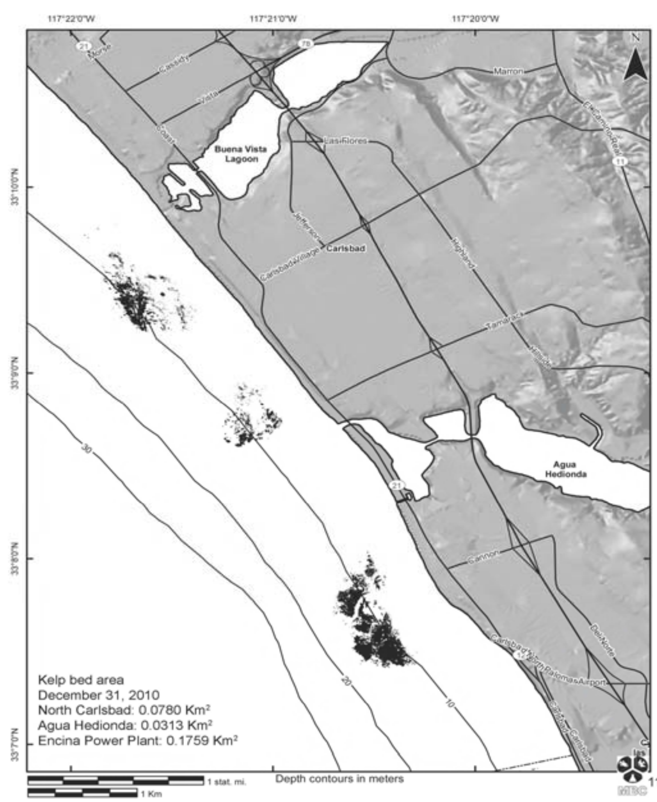

117°24'W
117°23'W
117°22'W
33°12'N
33°11'N
33°10'N
33°09'N
Oceanside Harbor
Oceanside
South Oceanside
30
60
90
Fish Haven
Kelp bed area
Oceanside: None
North Carlsbad: 0.0170 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
10c


117°24'W
117°23'W
117°22'W
33°12'N
33°11'N
33°10'N
33°09'N
Oceanside Harbor
Oceanside
South Oceanside
30
60
90
Fish Haven
Kelp bed area
Oceanside: none
North Carlsbad: 0.0025 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
10c

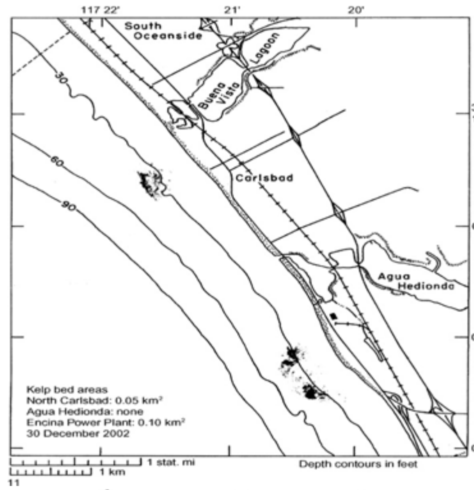

117°24'W
117°23'W
117°22'W
33°12'N
33°11'N
33°10'N
33°09'N
Oceanside Harbor
Oceanside
South Oceanside
30
60
90
Fish Haven
Kelp bed area
Oceanside: none
North Carlsbad: 0.0130 km²
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
10c

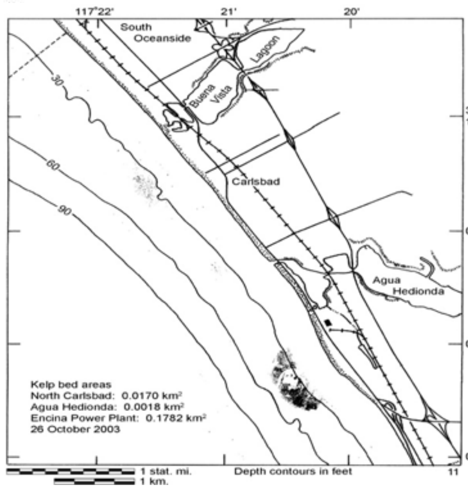

117°24'W
117°23'W
117°22'W
33°12'N
33°11'N
33°10'N
33°09'N
Oceanside Harbor
Oceanside
South Oceanside
30
60
90
Fish Haven
Kelp bed area
Oceanside: None
North Carlsbad: None
December 5 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
10c

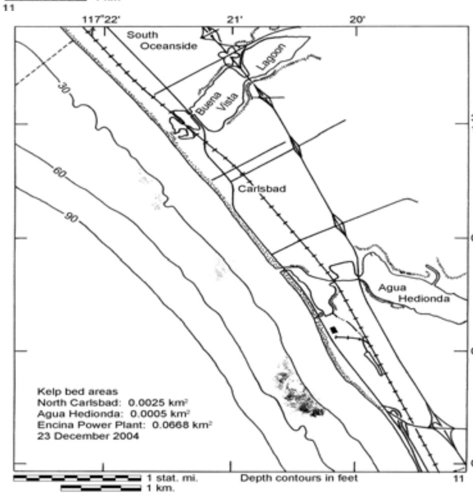

117°22'0"W
117°21'0"W
117°20'0"W
33°10'0"N
33°9'0"N
33°8'0"N
33°7'0"N
Buena Vista Lagoon
Carlsbad
Agua Hedionda
Kelp bed area
March 10, 2009
North Carlsbad: 0.1352 Km²
Agua Hedionda: 0.0919 Km²
December 17, 2009
Encina Power Plant: 0.2151 Km²
Depth contours in meters
1 stat. mi.
1 Km
30
20
10

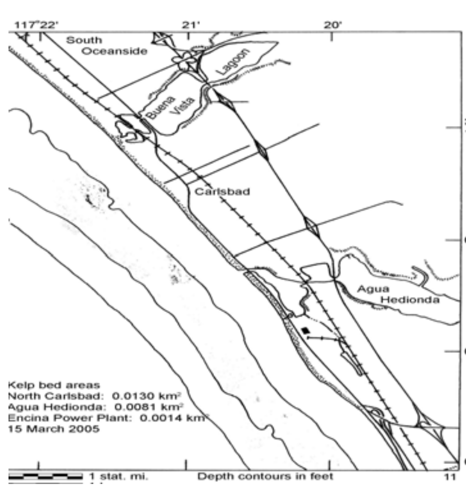

117°22'0"W
117°21'0"W
117°20'0"W
33°10'0"N
33°9'0"N
33°8'0"N
33°7'0"N
Buena Vista Lagoon
Carlsbad
Agua Hedionda
Kelp bed area
December 31, 2010
North Carlsbad: 0.0780 Km²
Agua Hedionda: 0.0313 Km²
Encina Power Plant: 0.1759 Km²
Depth contours in meters
1 stat. mi.
1 Km
30
20
10

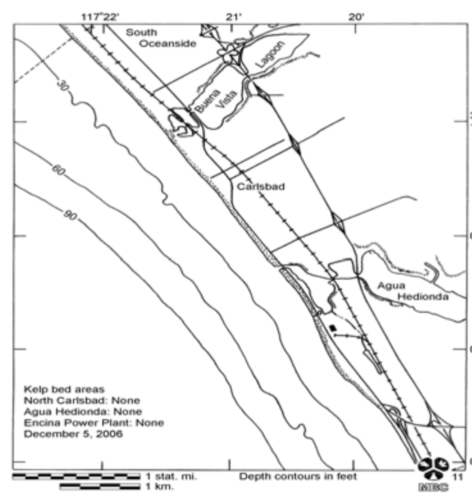

117°22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
30
60
90
Kelp bed areas
North Carlsbad: 0.02 km²
Agua Hedionda: none
Encina Power Plant: 0.03 km²
24 December 2001
1 stat. mi.
1 km.
Depth contours in feet

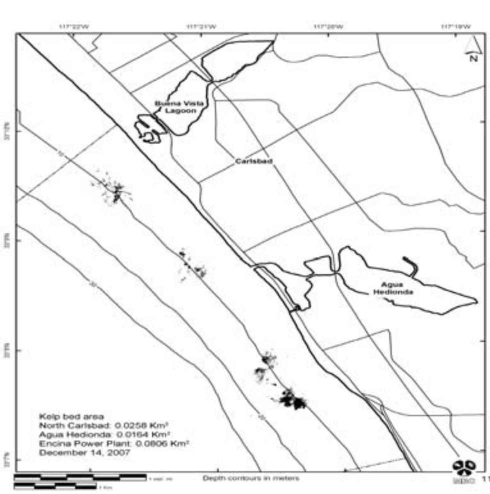

117 22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
30
60
90
Kelp bed areas
North Carlsbad: 0.05 km²
Agua Hedionda: none
Encina Power Plant: 0.10 km²
30 December 2002
1 stat. mi
1 km
Depth contours in feet

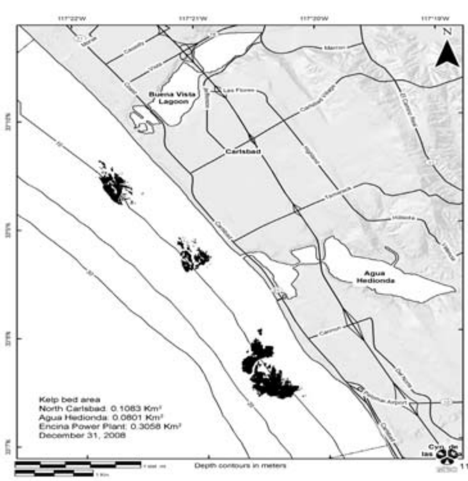

117°22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
30
60
90
Kelp bed areas
North Carlsbad: 0.0170 km²
Agua Hedionda: 0.0018 km²
Encina Power Plant: 0.1782 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet

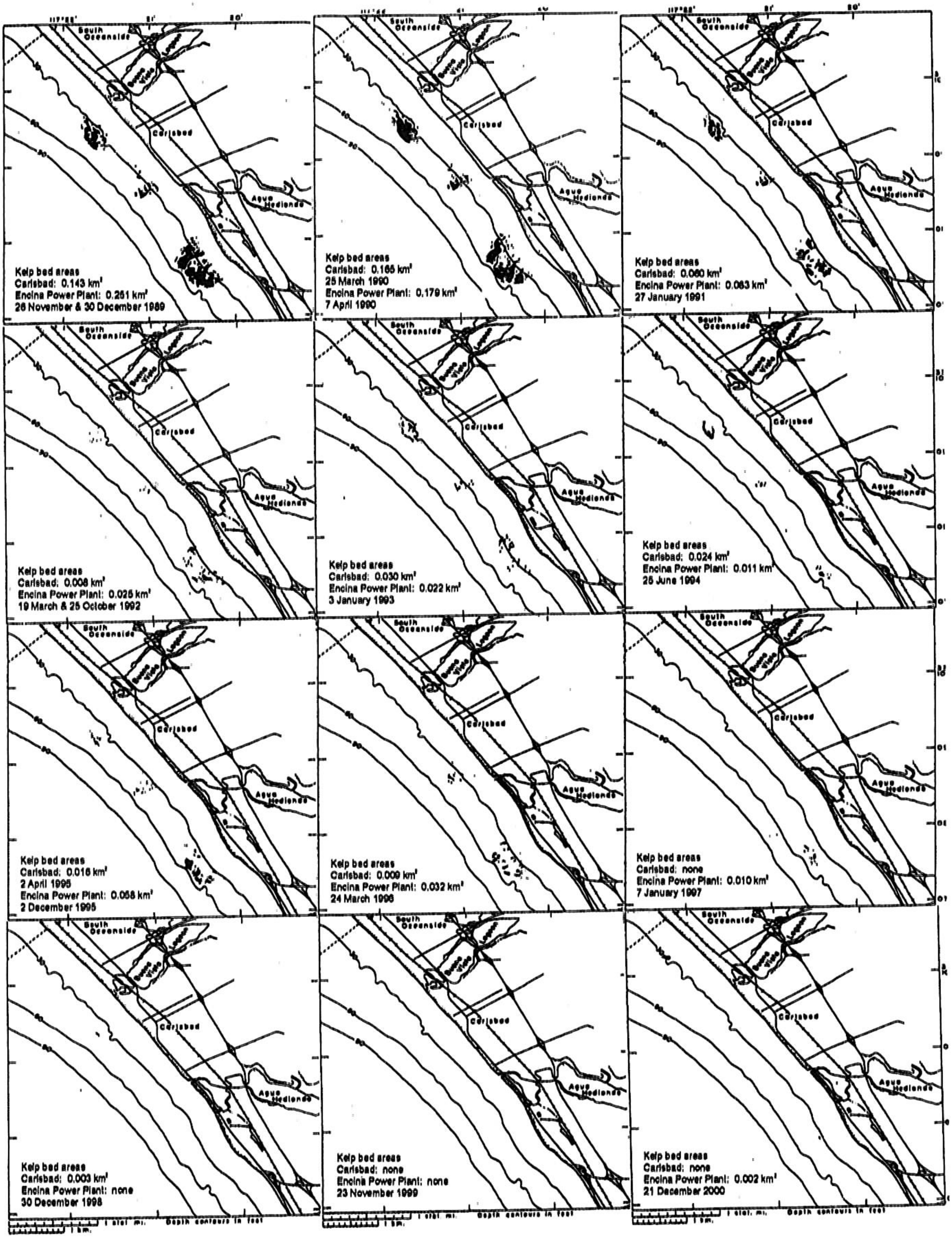

117°22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
30
60
90
Kelp bed areas
North Carlsbad: 0.0025 km²
Agua Hedionda: 0.0005 km²
Encina Power Plant: 0.0668 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet


117°22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
Kelp bed areas
North Carlsbad: 0.0130 km²
Agua Hedionda: 0.0081 km²
Encina Power Plant: 0.0014 km²
15 March 2005
1 stat. mi.
Depth contours in feet

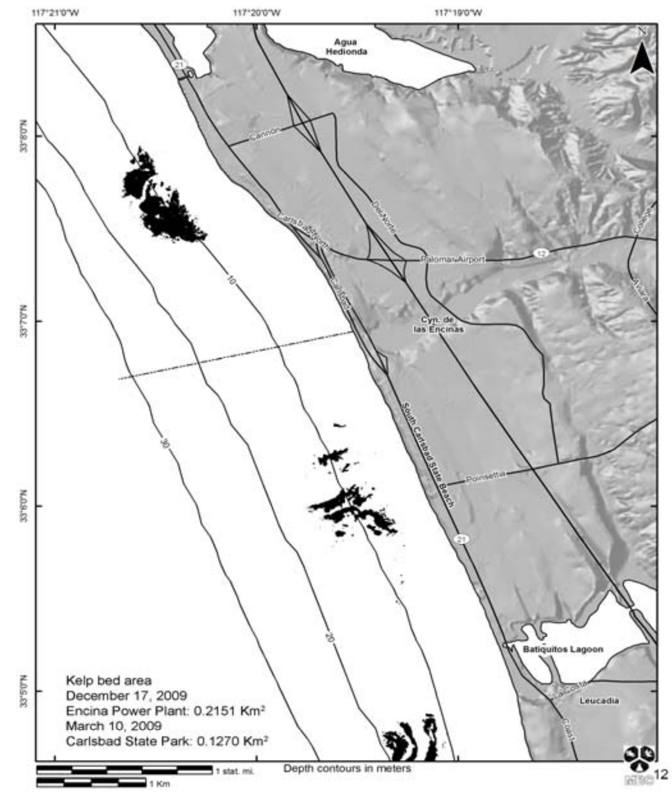

117°22'
21'
20'
South Oceanside
Buena Vista Lagoon
Carlsbad
Agua Hedionda
33° 10'
09'
08'
07'
30
60
90
Kelp bed areas
North Carlsbad: None
Agua Hedionda: None
Encina Power Plant: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC

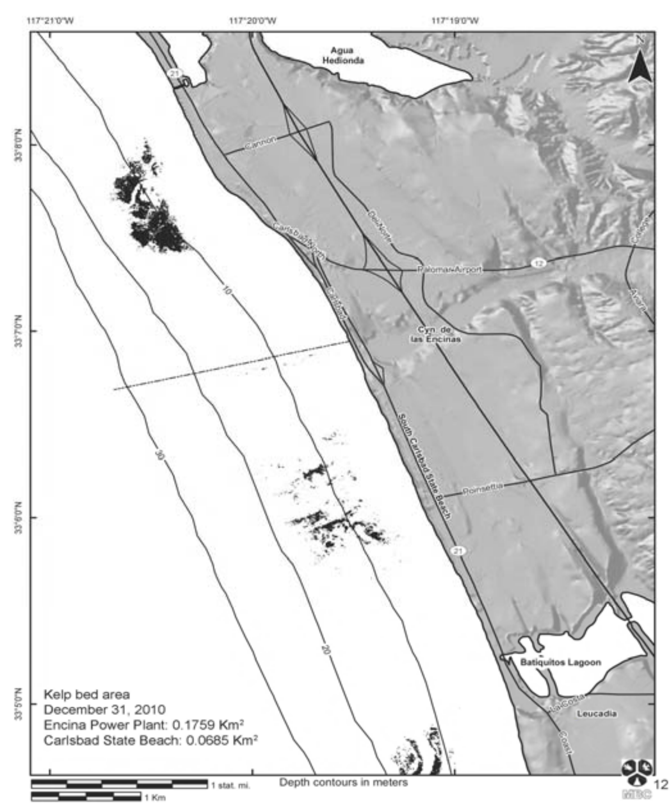

117°22'W
117°21'W
117°20'W
117°19'W
N
Buena Vista Lagoon
Carlsbad
Agua Hedionda
Kelp bed area
North Carlsbad: 0.0258 Km²
Agua Hedionda: 0.0164 Km²
Encina Power Plant: 0.0806 Km²
December 14, 2007
Depth contours in meters
MBC

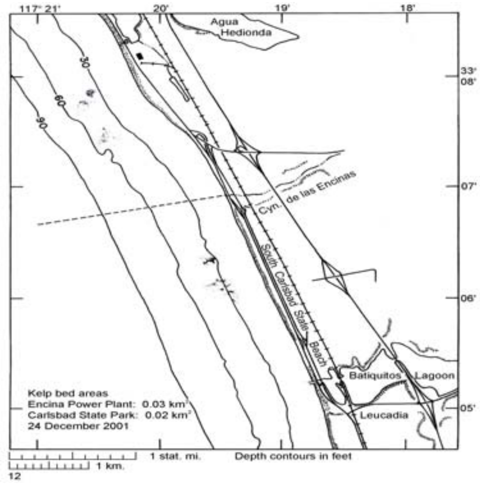

117°22'W
117°21'W
117°20'W
117°19'W
N
Buena Vista Lagoon
Carlsbad
Agua Hedionda
Kelp bed area
North Carlsbad: 0.1083 Km²
Agua Hedionda: 0.0801 Km²
Encina Power Plant: 0.3058 Km²
December 31, 2008
Depth contours in meters
MBC



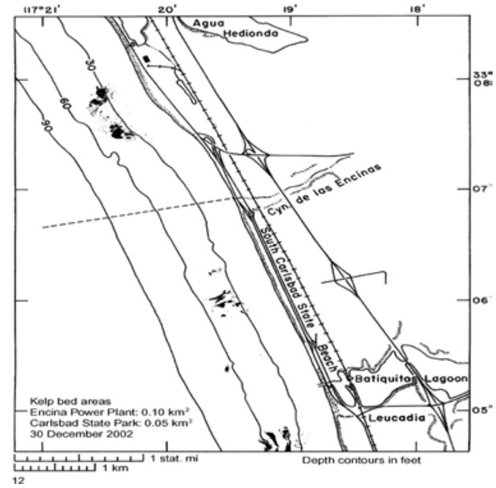
Kelp bed areas
Carlsbad: 0.143 km²
Encina Power Plant: 0.251 km²
26 November & 30 December 1989
Kelp bed areas
Carlsbad: 0.165 km²
25 March 1990
Encina Power Plant: 0.179 km²
7 April 1990
Kelp bed areas
Carlsbad: 0.060 km²
Encina Power Plant: 0.063 km²
27 January 1991
Kelp bed areas
Carlsbad: 0.008 km²
Encina Power Plant: 0.025 km²
19 March & 25 October 1992
Kelp bed areas
Carlsbad: 0.030 km²
Encina Power Plant: 0.022 km²
3 January 1993
Kelp bed areas
Carlsbad: 0.024 km²
Encina Power Plant: 0.011 km²
25 June 1994
Kelp bed areas
Carlsbad: 0.016 km²
2 April 1995
Encina Power Plant: 0.058 km²
2 December 1995
Kelp bed areas
Carlsbad: 0.009 km²
Encina Power Plant: 0.032 km²
24 March 1996
Kelp bed areas
Carlsbad: none
Encina Power Plant: 0.010 km²
7 January 1997
Kelp bed areas
Carlsbad: 0.003 km²
Encina Power Plant: none
30 December 1998
Kelp bed areas
Carlsbad: none
Encina Power Plant: none
23 November 1999
Kelp bed areas
Carlsbad: none
Encina Power Plant: 0.002 km²
21 December 2000
South Oceanside
Buena Vista
Lagoon
Carlsbad
Agua Hedionda
1 stat. mi.
1 km.
Depth contours in feet


117°21'0"W
117°20'0"W
117°19'0"W
33°8'0"N
33°7'0"N
33°6'0"N
33°5'0"N
N
Agua Hedionda
Cannon
Carlsbad
Del Norte
Palomar Airport
Cyn. de las Encinas
South Carlsbad State Beach
Poinsettia
Batiquitos Lagoon
Leucadia
10
20
30
Kelp bed area
December 17, 2009
Encina Power Plant: 0.2151 Km²
March 10, 2009
Carlsbad State Park: 0.1270 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
12

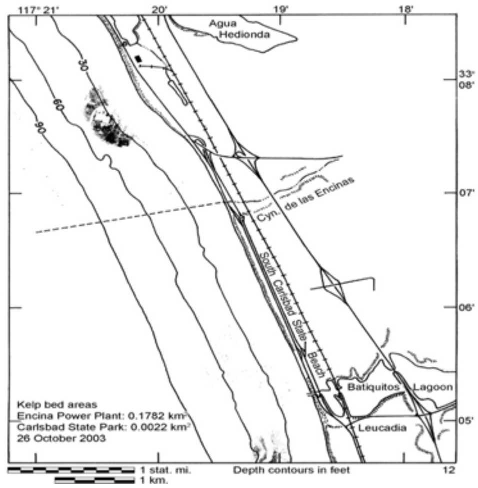

117°21'0"W
117°20'0"W
117°19'0"W
33°8'0"N
33°7'0"N
33°6'0"N
33°5'0"N
N
Agua Hedionda
Cannon
Carlsbad
Del Norte
Palomar Airport
Cyn. de las Encinas
South Carlsbad State Beach
Poinsettia
Batiquitos Lagoon
Leucadia
10
20
30
Kelp bed area
December 31, 2010
Encina Power Plant: 0.1759 Km²
Carlsbad State Beach: 0.0685 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
12



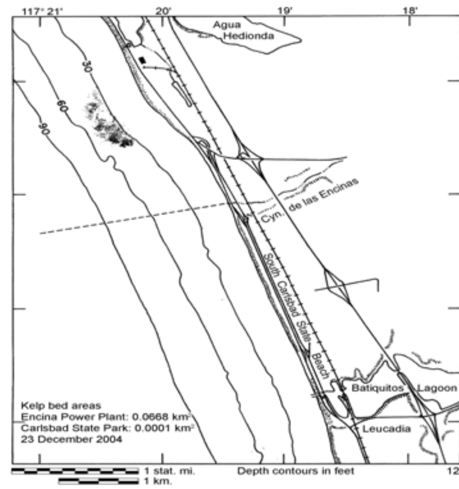
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: 0.03 km²
Carlsbad State Park: 0.02 km²
24 December 2001
1 stat. mi.
1 km.
Depth contours in feet
12



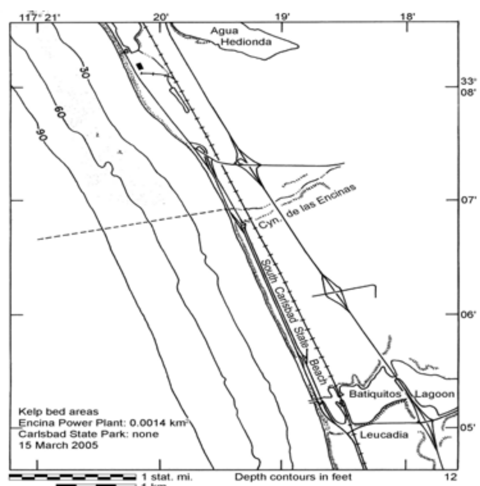
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: 0.10 km²
Carlsbad State Park: 0.05 km²
30 December 2002
1 stat. mi.
1 km
Depth contours in feet
12



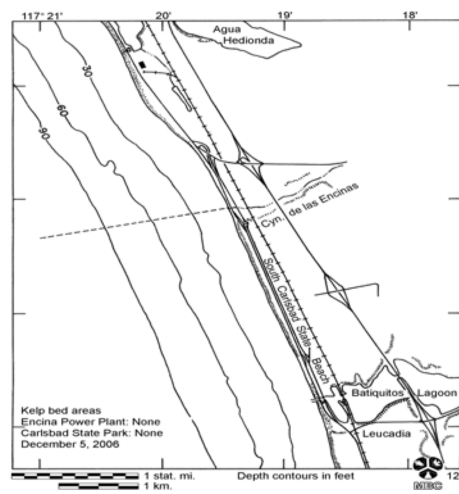
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: 0.1782 km²
Carlsbad State Park: 0.0022 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
12



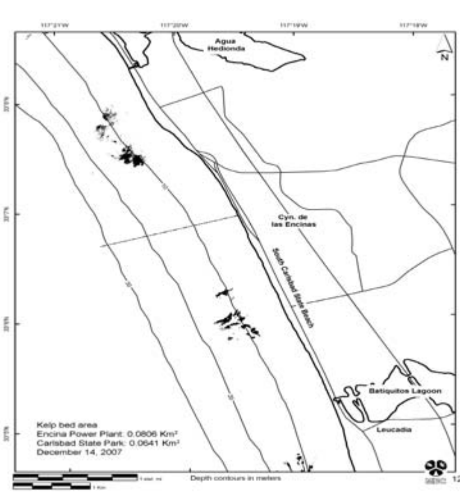
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: 0.0668 km²
Carlsbad State Park: 0.0001 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
12



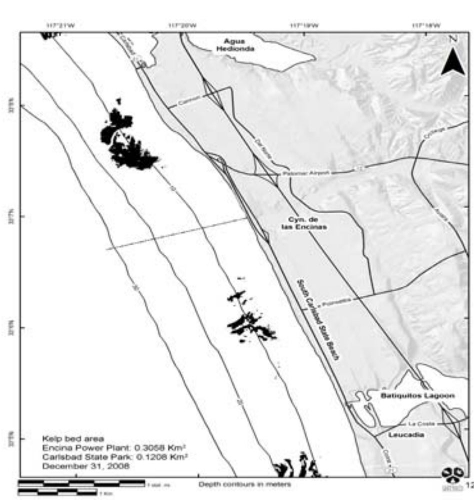
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: 0.0014 km²
Carlsbad State Park: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
12



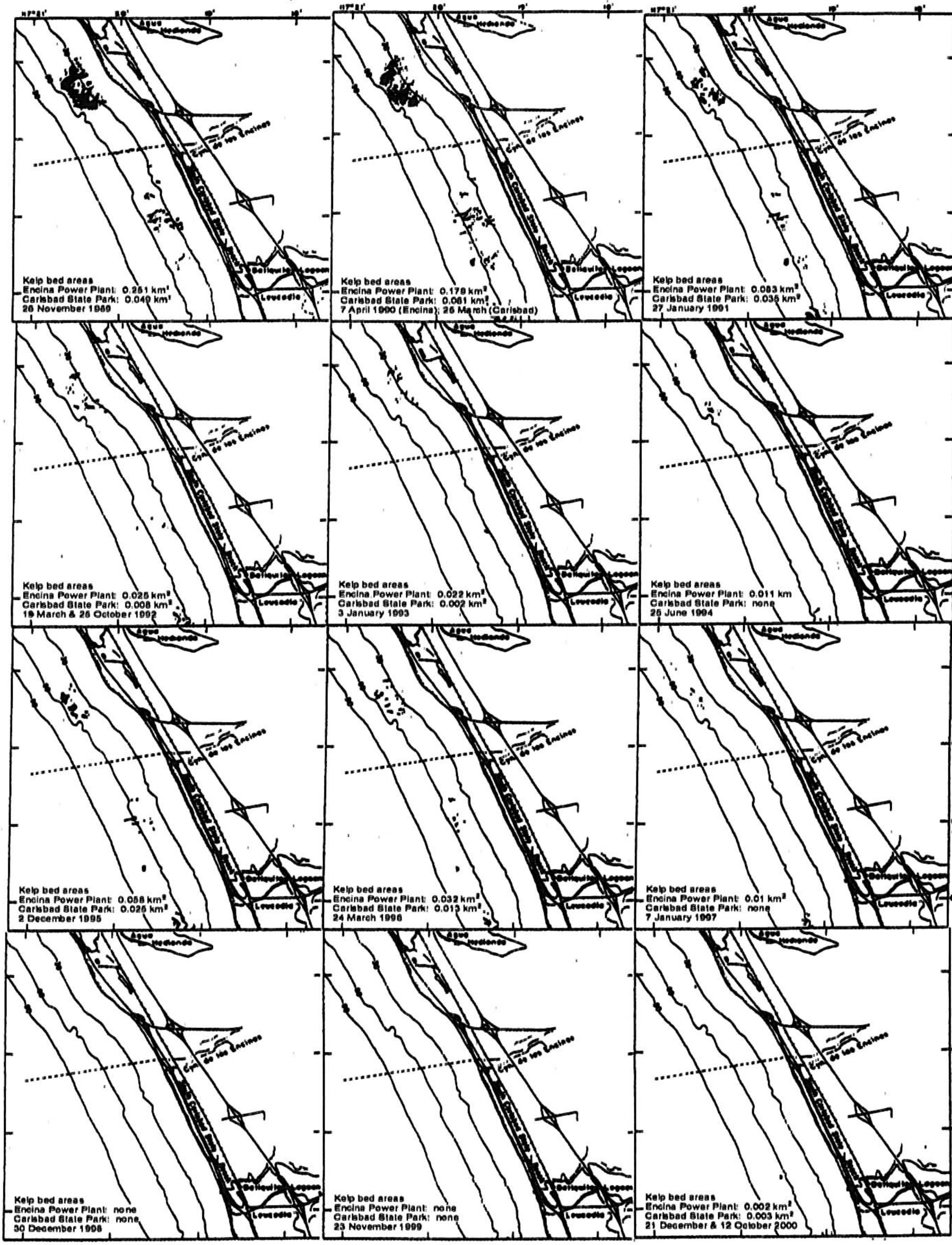
117° 21'
20'
19'
18'
Agua Hedionda
33° 08'
07'
06'
05'
30
60
90
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed areas
Encina Power Plant: None
Carlsbad State Park: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
12

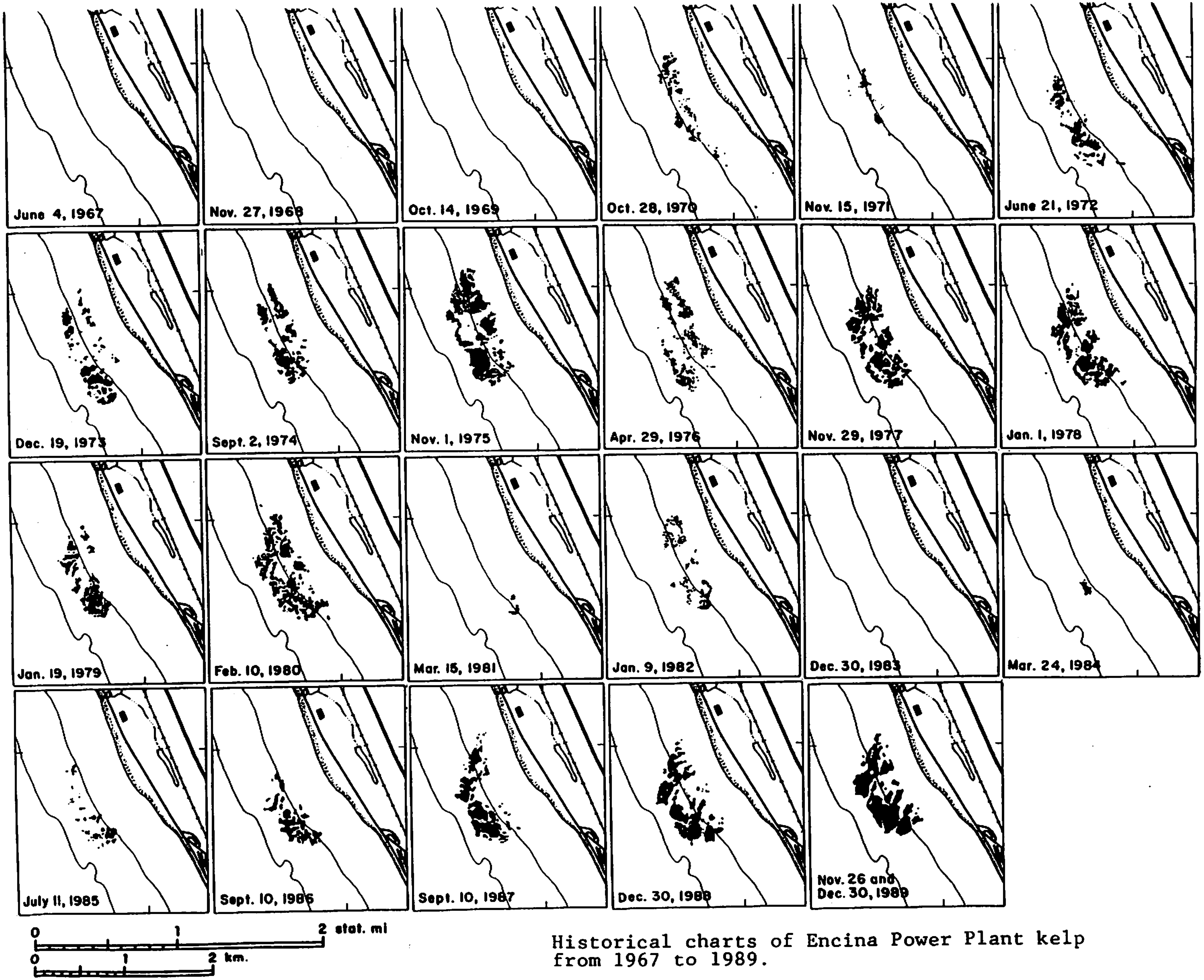


117°21'W
117°20'W
117°19'W
117°18'W
Agua Hedionda
N
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed area
Encina Power Plant: 0.0806 Km²
Carlsbad State Park: 0.0641 Km²
December 14, 2007
Depth contours in meters
12

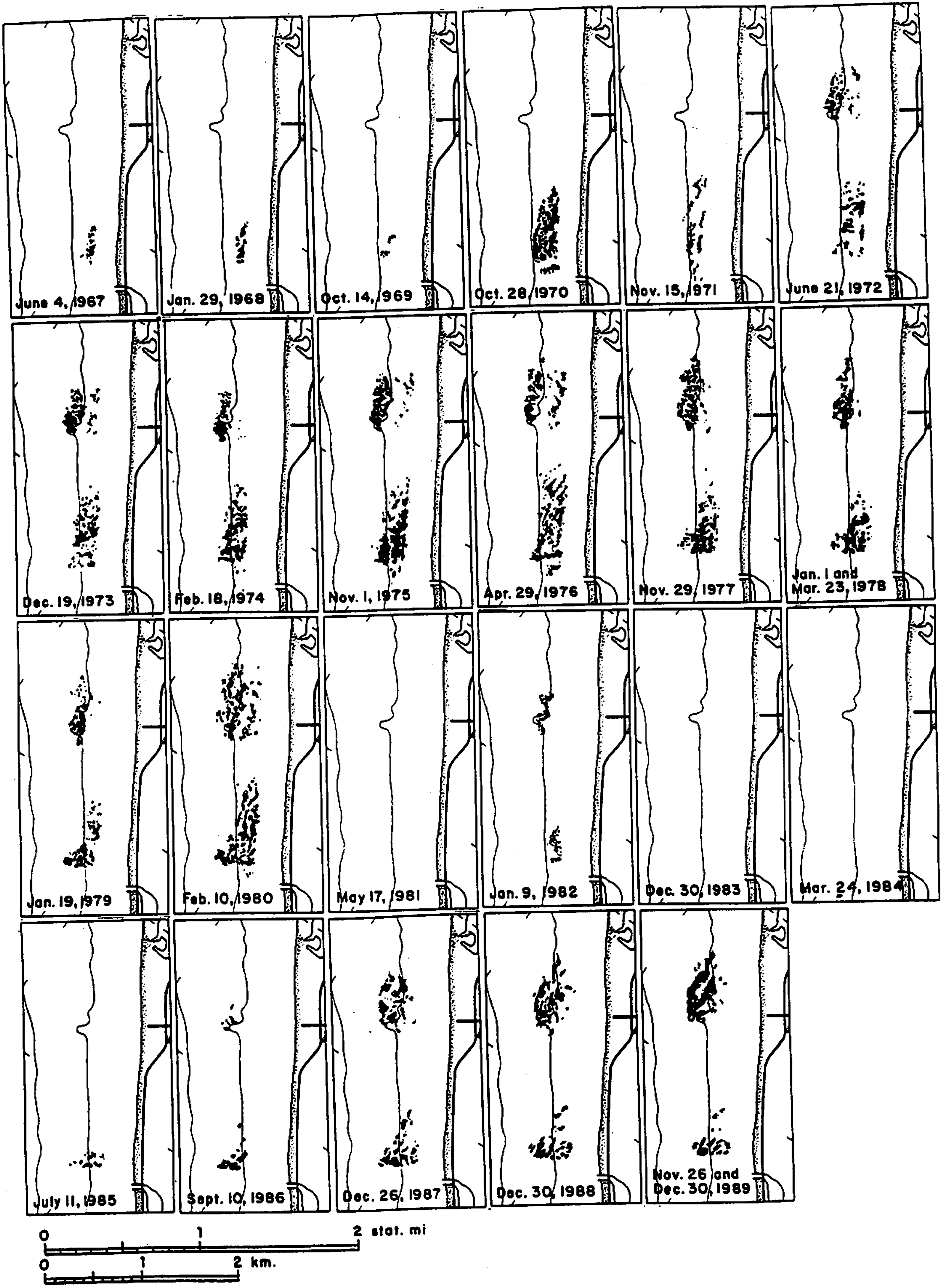


117°21'W
117°20'W
117°19'W
117°18'W
Agua Hedionda
Palomar Airport
Cyn. de las Encinas
South Carlsbad State Beach
Batiquitos Lagoon
La Costa
Leucadia
Kelp bed area
Encina Power Plant: 0.3058 Km²
Carlsbad State Park: 0.1208 Km²
December 31, 2008
Depth contours in meters
12

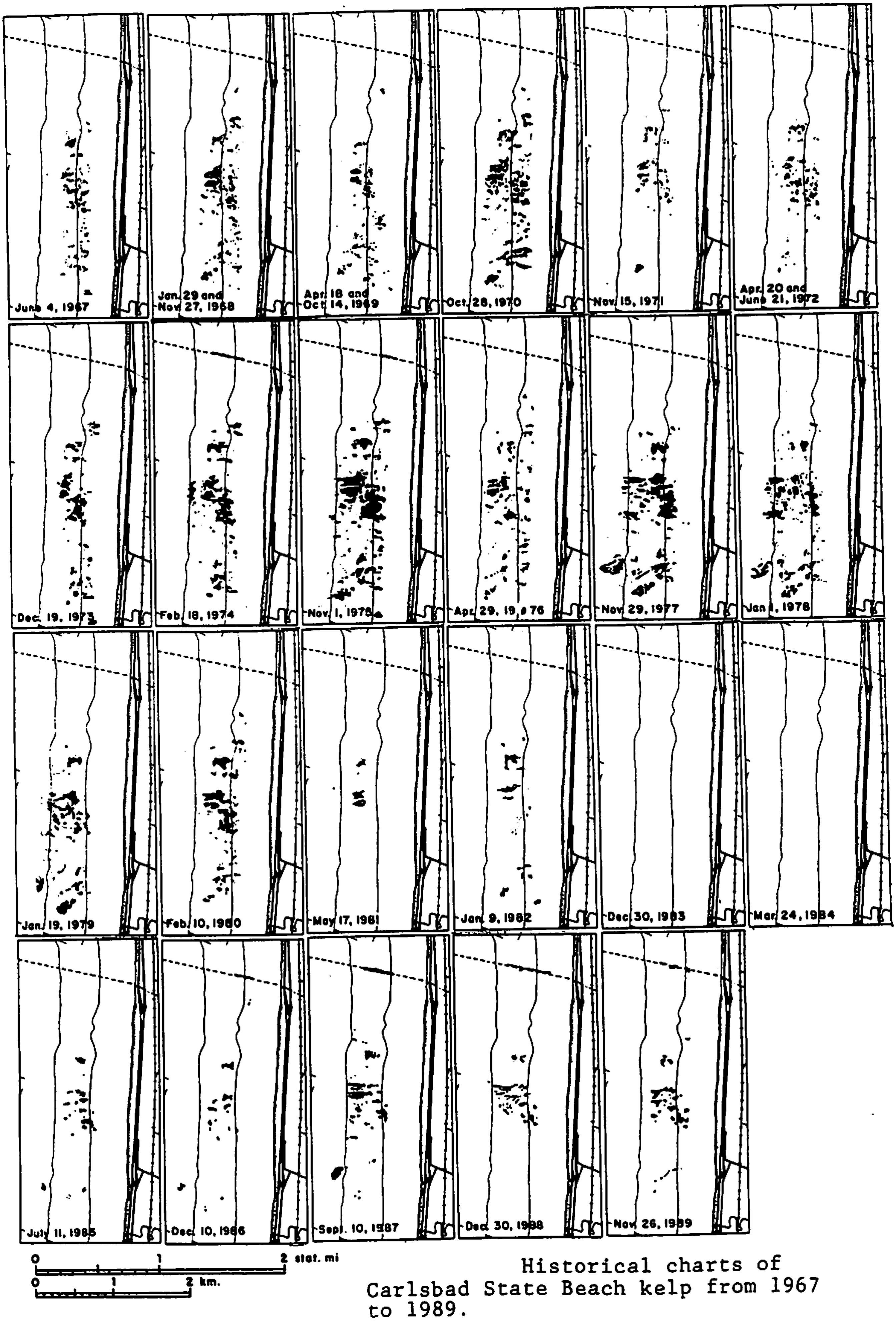

Kelp bed areas
Encina Power Plant: 0.251 km²
Carlsbad State Park: 0.049 km²
26 November 1989
Kelp bed areas
Encina Power Plant: 0.179 km²
Carlsbad State Park: 0.081 km²
7 April 1990 (Encina); 26 March (Carlsbad)
Kelp bed areas
Encina Power Plant: 0.083 km²
Carlsbad State Park: 0.036 km²
27 January 1991
Kelp bed areas
Encina Power Plant: 0.025 km²
Carlsbad State Park: 0.008 km²
19 March & 26 October 1992
Kelp bed areas
Encina Power Plant: 0.022 km²
Carlsbad State Park: 0.002 km²
3 January 1993
Kelp bed areas
Encina Power Plant: 0.011 km
Carlsbad State Park: none
25 June 1994
Kelp bed areas
Encina Power Plant: 0.058 km²
Carlsbad State Park: 0.025 km²
2 December 1995
Kelp bed areas
Encina Power Plant: 0.032 km²
Carlsbad State Park: 0.013 km²
24 March 1996
Kelp bed areas
Encina Power Plant: 0.01 km²
Carlsbad State Park: none
7 January 1997
Kelp bed areas
Encina Power Plant: none
Carlsbad State Park: none
30 December 1998
Kelp bed areas
Encina Power Plant: none
Carlsbad State Park: none
23 November 1999
Kelp bed areas
Encina Power Plant: 0.002 km²
Carlsbad State Park: 0.003 km²
21 December & 12 October 2000



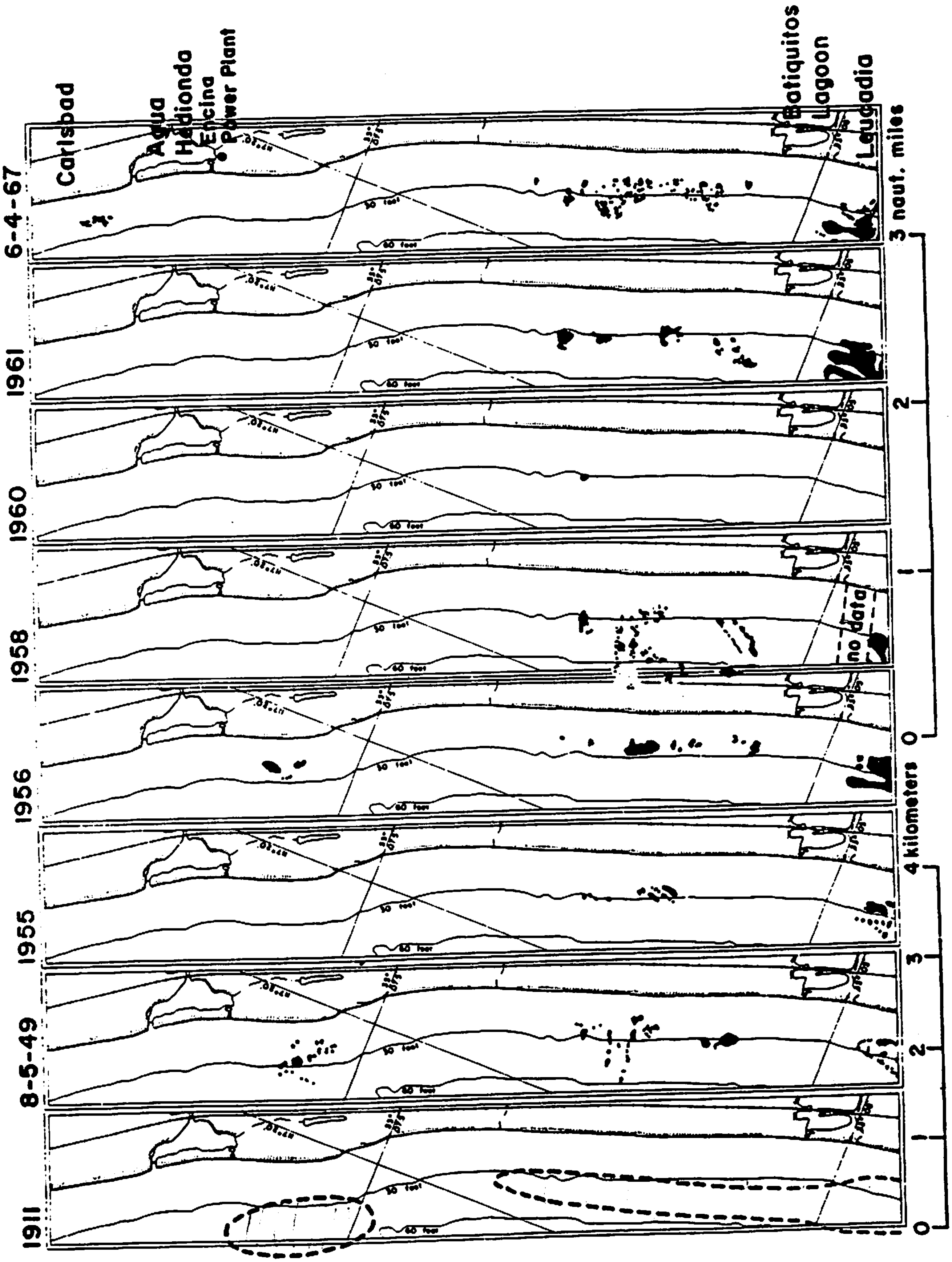
Historical charts of Encina Power Plant kelp from 1967 to 1989.



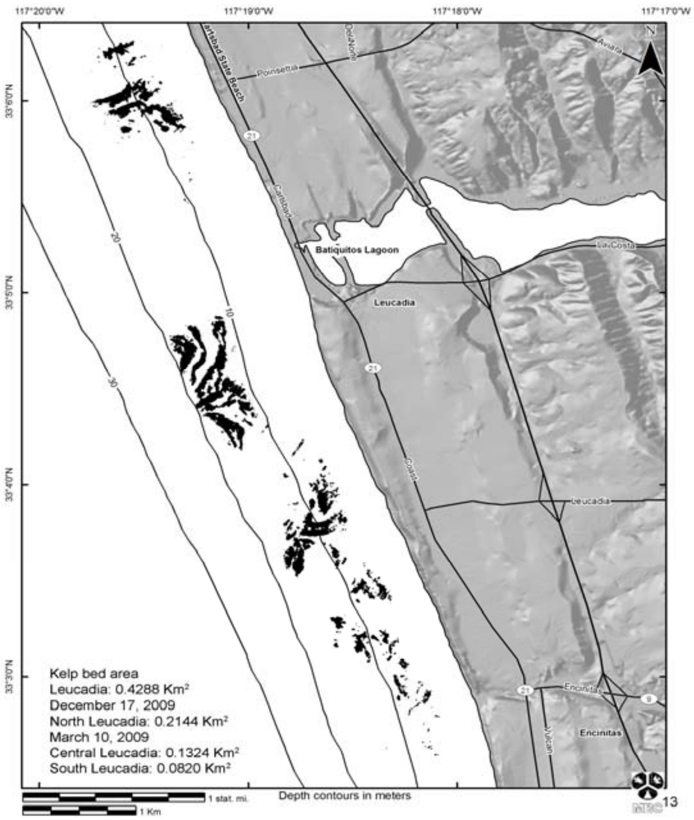
Historical charts of North Carlsbad from 1967 to 1989.

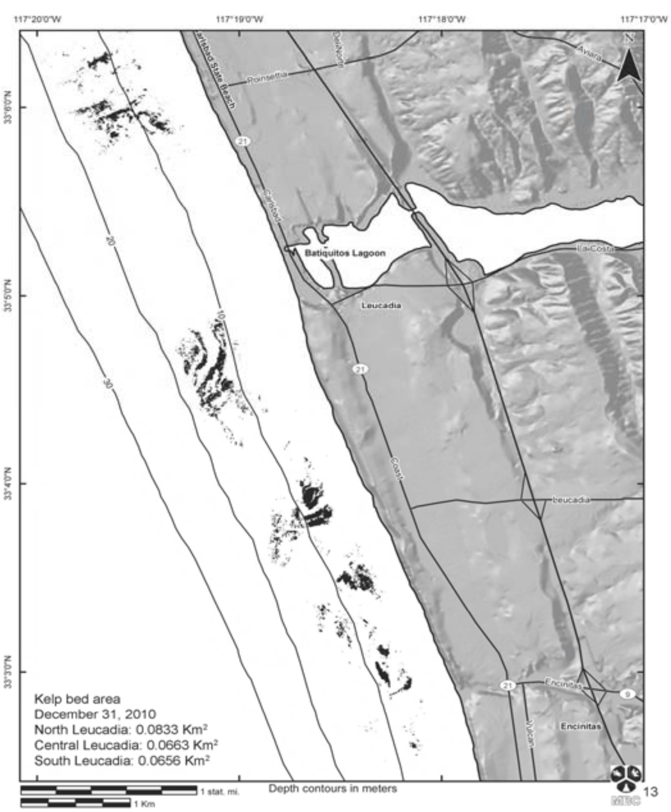


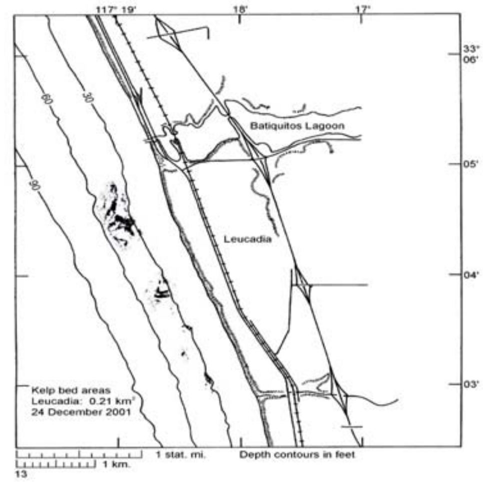
Historical charts of Carlsbad State Beach kelp from 1967 to 1989.

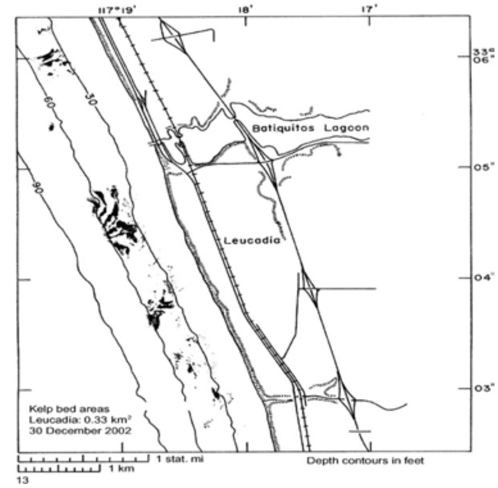


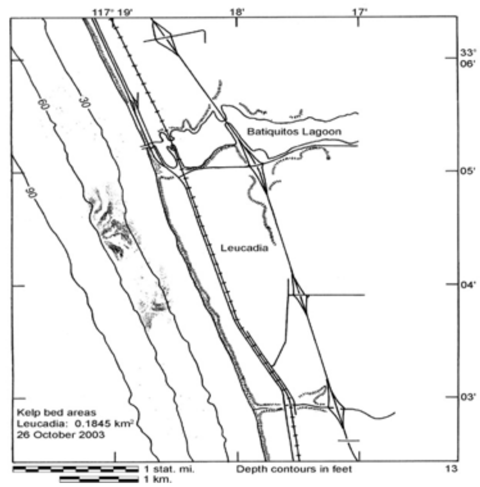
Historical charts of kelp beds from North Carlsbad to North Leucadia from 1911 to 1967.

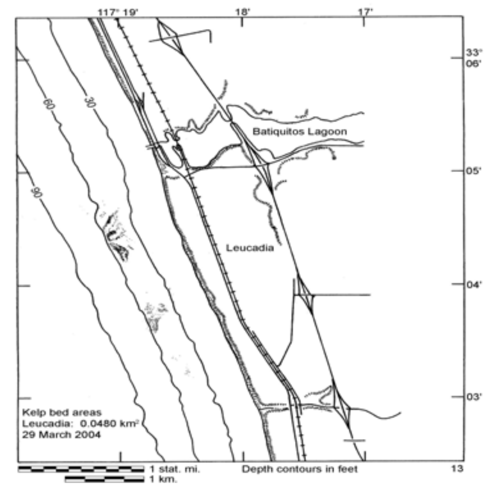

117°20'0"W
117°19'0"W
117°18'0"W
117°17'0"W
33°6'0"N
33°5'0"N
33°4'0"N
33°3'0"N
Poinsettia
Aviara
Batiquitos Lagoon
La Costa
Leucadia
Leucadia
Encinitas
Encinitas
Vulcan
Coast
21
20
10
30
Kelp bed area
Leucadia: 0.4288 Km²
December 17, 2009
North Leucadia: 0.2144 Km²
March 10, 2009
Central Leucadia: 0.1324 Km²
South Leucadia: 0.0820 Km²
1 stat. mi.
1 Km
Depth contours in meters
13

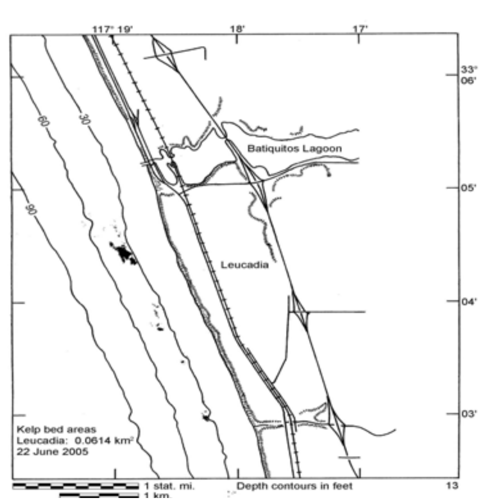

117°20'0"W
117°19'0"W
117°18'0"W
117°17'0"W
33°6'0"N
33°5'0"N
33°4'0"N
33°3'0"N
Poinsettia
Aviara
Batiquitos Lagoon
La Costa
Leucadia
Leucadia
Encinitas
Encinitas
Vulcan
Coast
21
20
10
30
Kelp bed area
December 31, 2010
North Leucadia: 0.0833 Km²
Central Leucadia: 0.0663 Km²
South Leucadia: 0.0656 Km²
1 stat. mi.
1 Km
Depth contours in meters
13

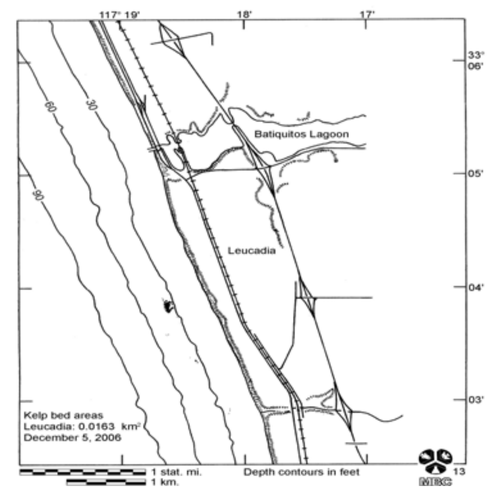

117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.21 km²
24 December 2001
1 stat. mi.
1 km.
Depth contours in feet
13

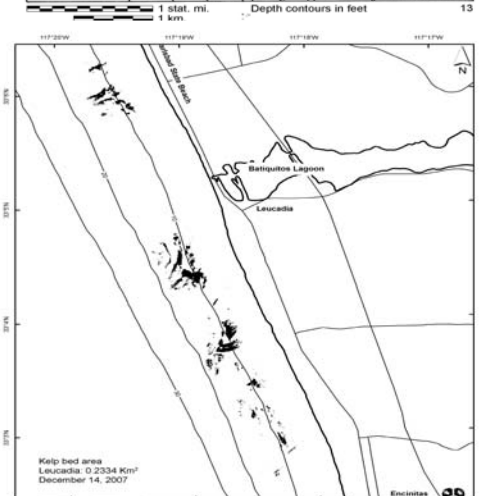

117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.33 km²
30 December 2002
1 stat. mi
1 km
Depth contours in feet
13

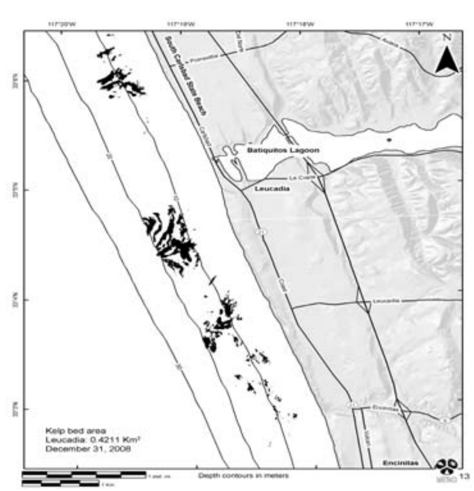

117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.1845 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
13

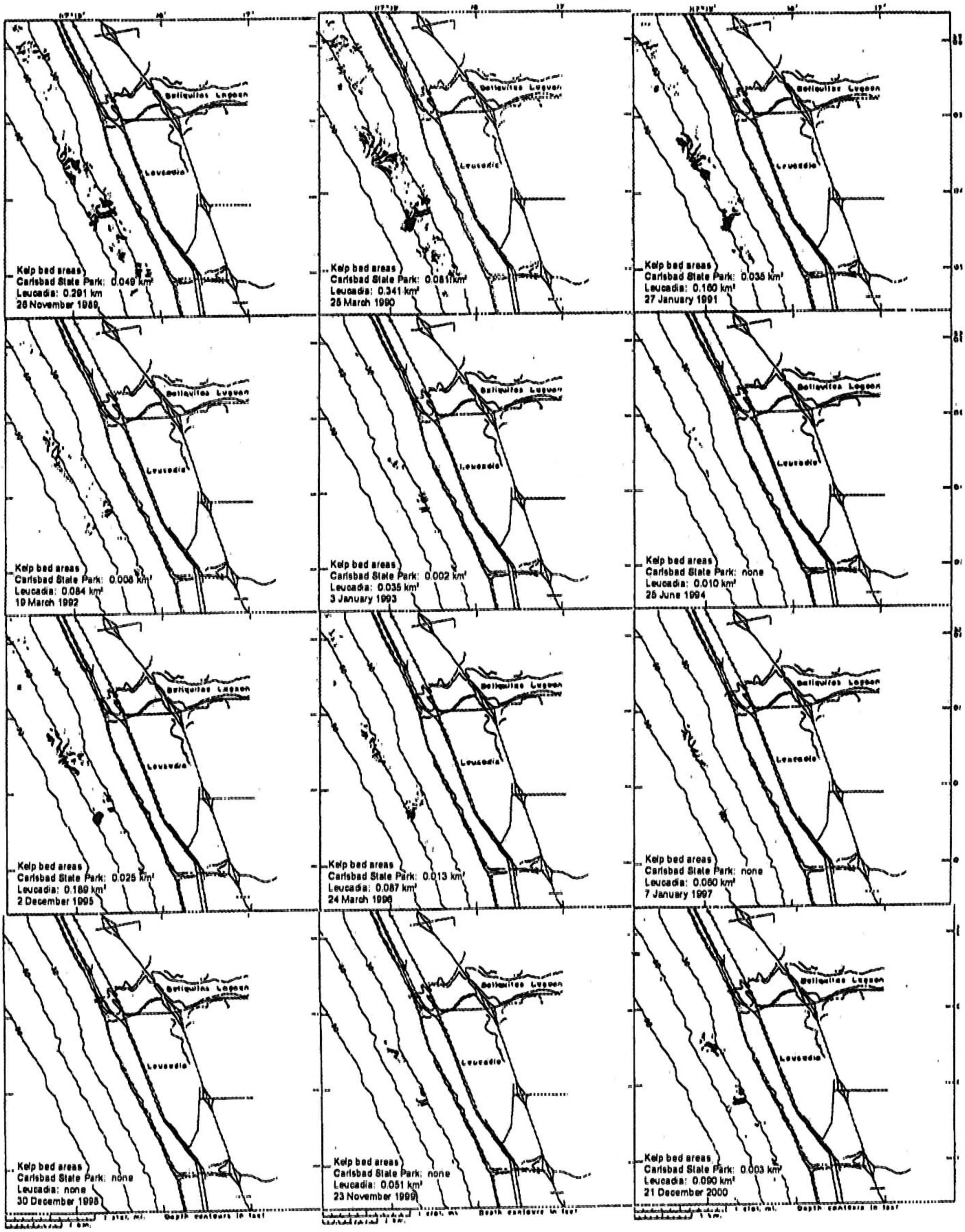

117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.0480 km²
29 March 2004
1 stat. mi.
1 km.
Depth contours in feet
13

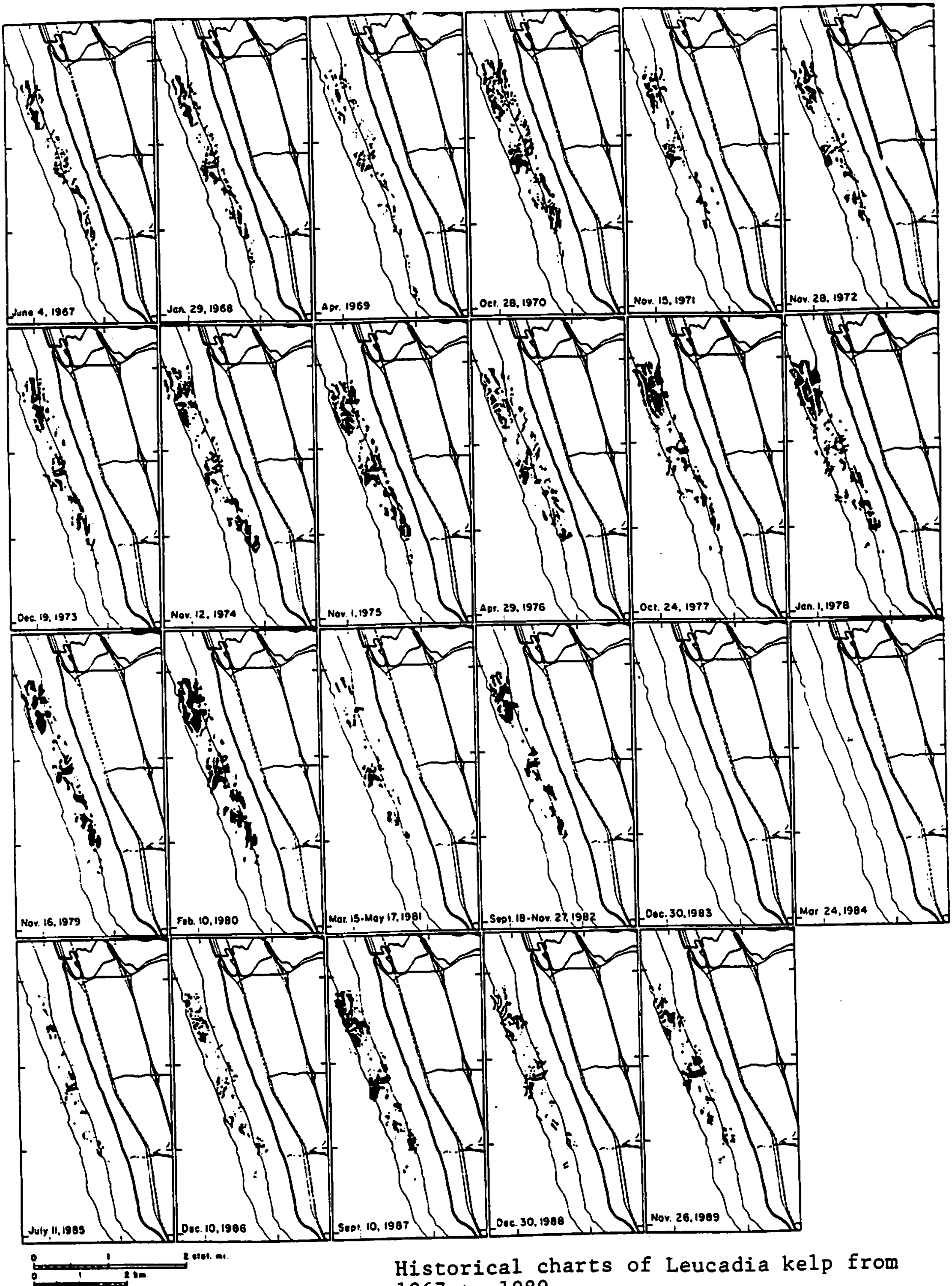

117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.0614 km²
22 June 2005
1 stat. mi.
1 km.
Depth contours in feet
13


117° 19'
18'
17'
33° 06'
05'
04'
03'
60
30
90
Batiquitos Lagoon
Leucadia
Kelp bed areas
Leucadia: 0.0163 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
13

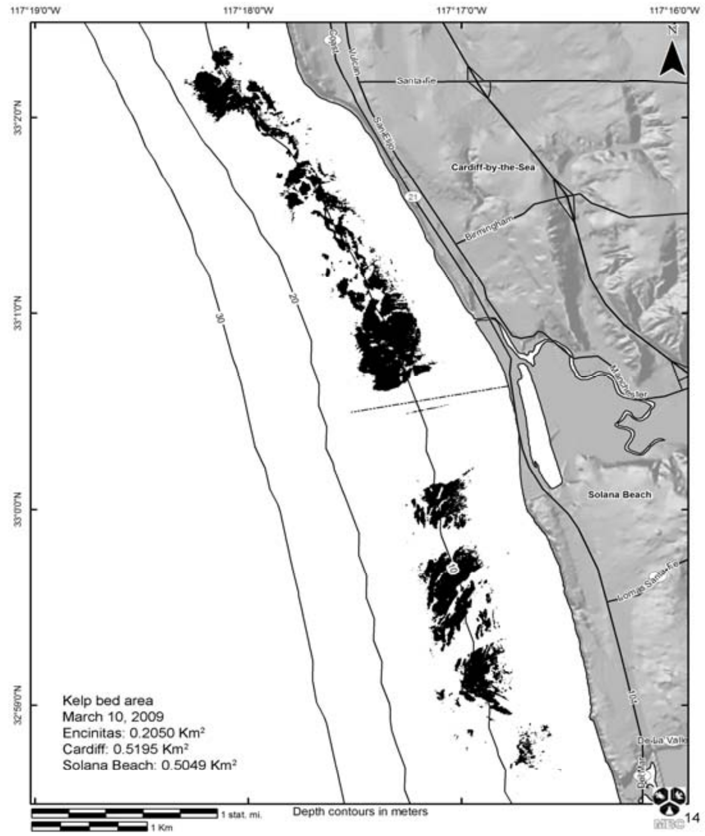

117°20'W
117°19'W
117°18'W
117°17'W
N
Batiquitos Lagoon
Leucadia
Kelp bed area
Leucadia: 0.2334 Km²
December 14, 2007
Encinitas
Depth contours in meters
MBC
13

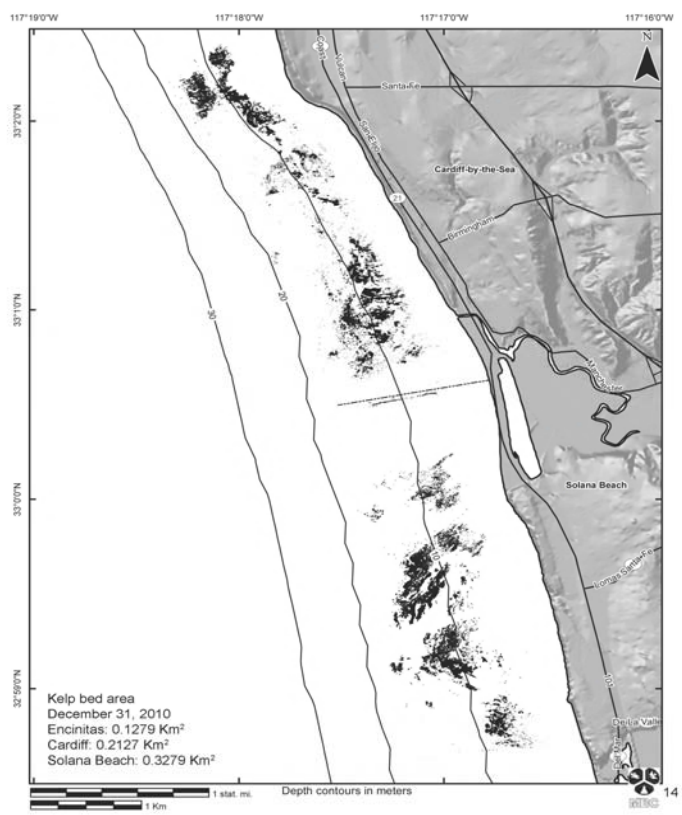

117°20'W
117°19'W
117°18'W
117°17'W
N
South Carlsbad State Beach
Batiquitos Lagoon
Leucadia
Kelp bed area
Leucadia: 0.4211 Km²
December 31, 2008
Encinitas
Depth contours in meters
MBC
13

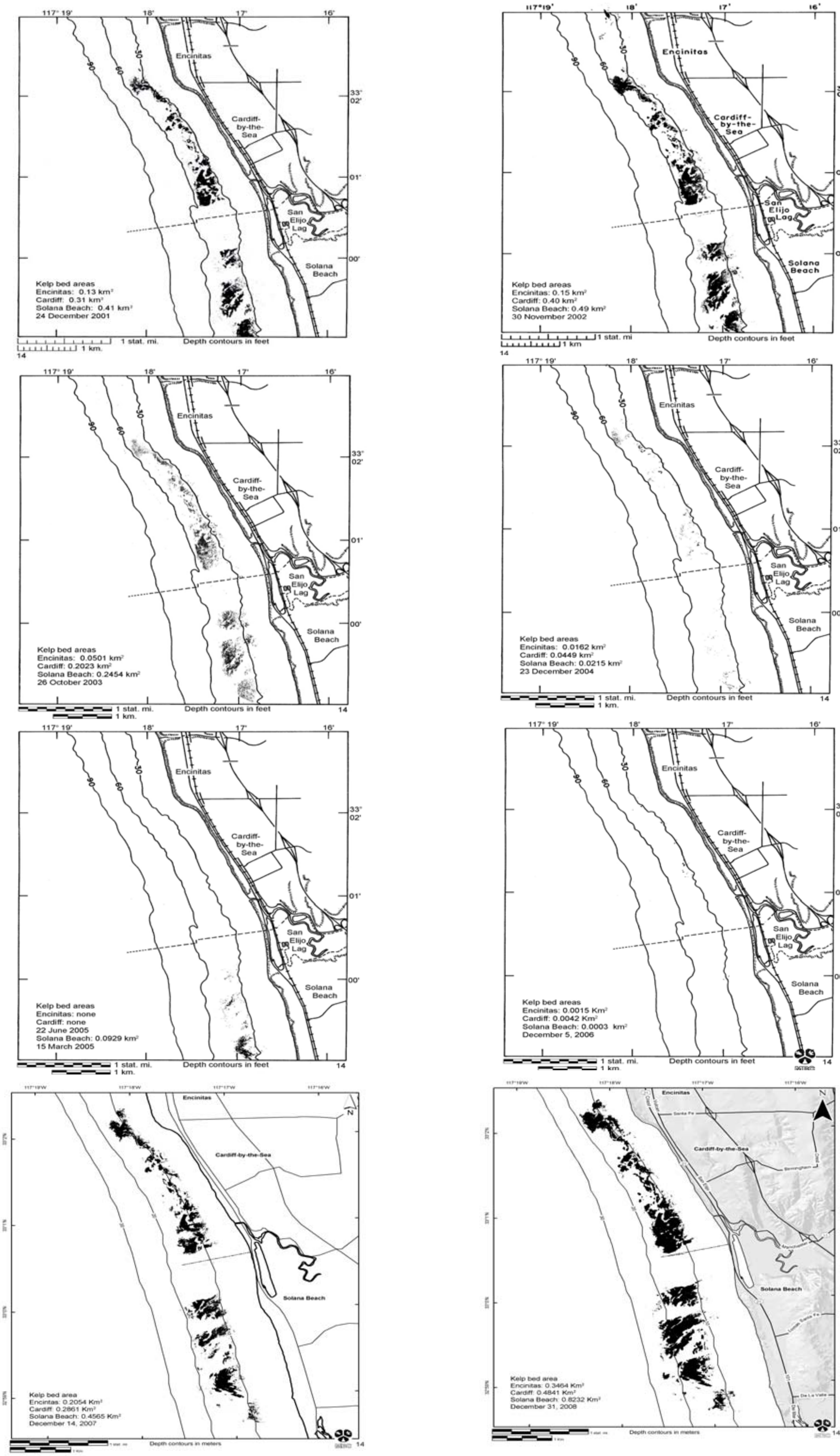

Batiquitos Lagoon
Leucadia
Kelp bed areas
Carlsbad State Park: 0.049 km²
Leucadia: 0.291 km
26 November 1989
Kelp bed areas
Carlsbad State Park: 0.081 km²
Leucadia: 0.341 km²
25 March 1990
Kelp bed areas
Carlsbad State Park: 0.035 km²
Leucadia: 0.160 km²
27 January 1991
Kelp bed areas
Carlsbad State Park: 0.008 km²
Leucadia: 0.084 km²
19 March 1992
Kelp bed areas
Carlsbad State Park: 0.002 km²
Leucadia: 0.035 km²
3 January 1993
Kelp bed areas
Carlsbad State Park: none
Leucadia: 0.010 km²
25 June 1994
Kelp bed areas
Carlsbad State Park: 0.025 km²
Leucadia: 0.189 km²
2 December 1995
Kelp bed areas
Carlsbad State Park: 0.013 km²
Leucadia: 0.087 km²
24 March 1996
Kelp bed areas
Carlsbad State Park: none
Leucadia: 0.060 km²
7 January 1997
Kelp bed areas
Carlsbad State Park: none
Leucadia: none
30 December 1998
Kelp bed areas
Carlsbad State Park: none
Leucadia: 0.051 km²
23 November 1999
Kelp bed areas
Carlsbad State Park: 0.003 km²
Leucadia: 0.090 km²
21 December 2000
1 stat. mi.
1 km
Depth contours in feet



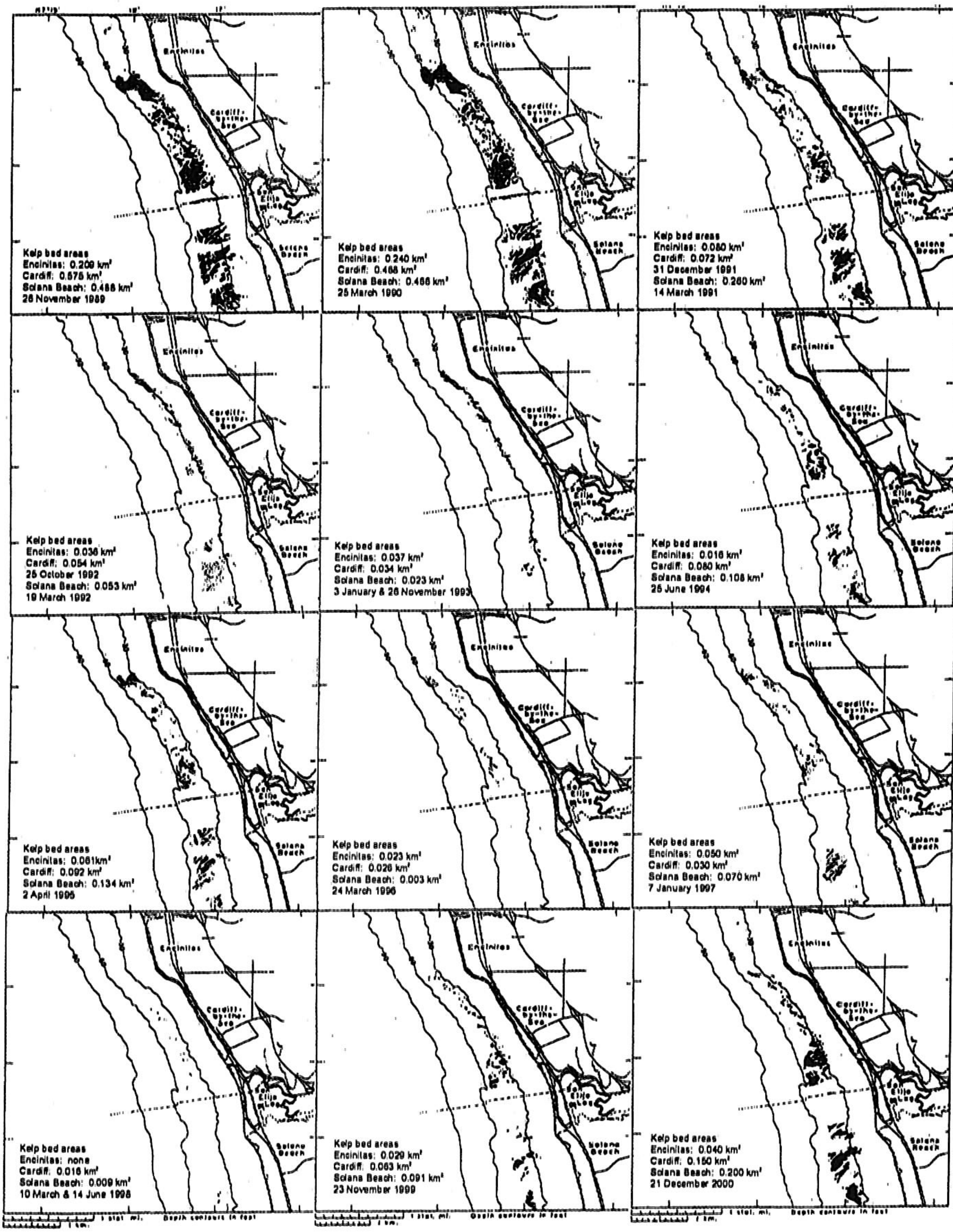
Historical charts of Leucadia kelp from 1967 to 1989.

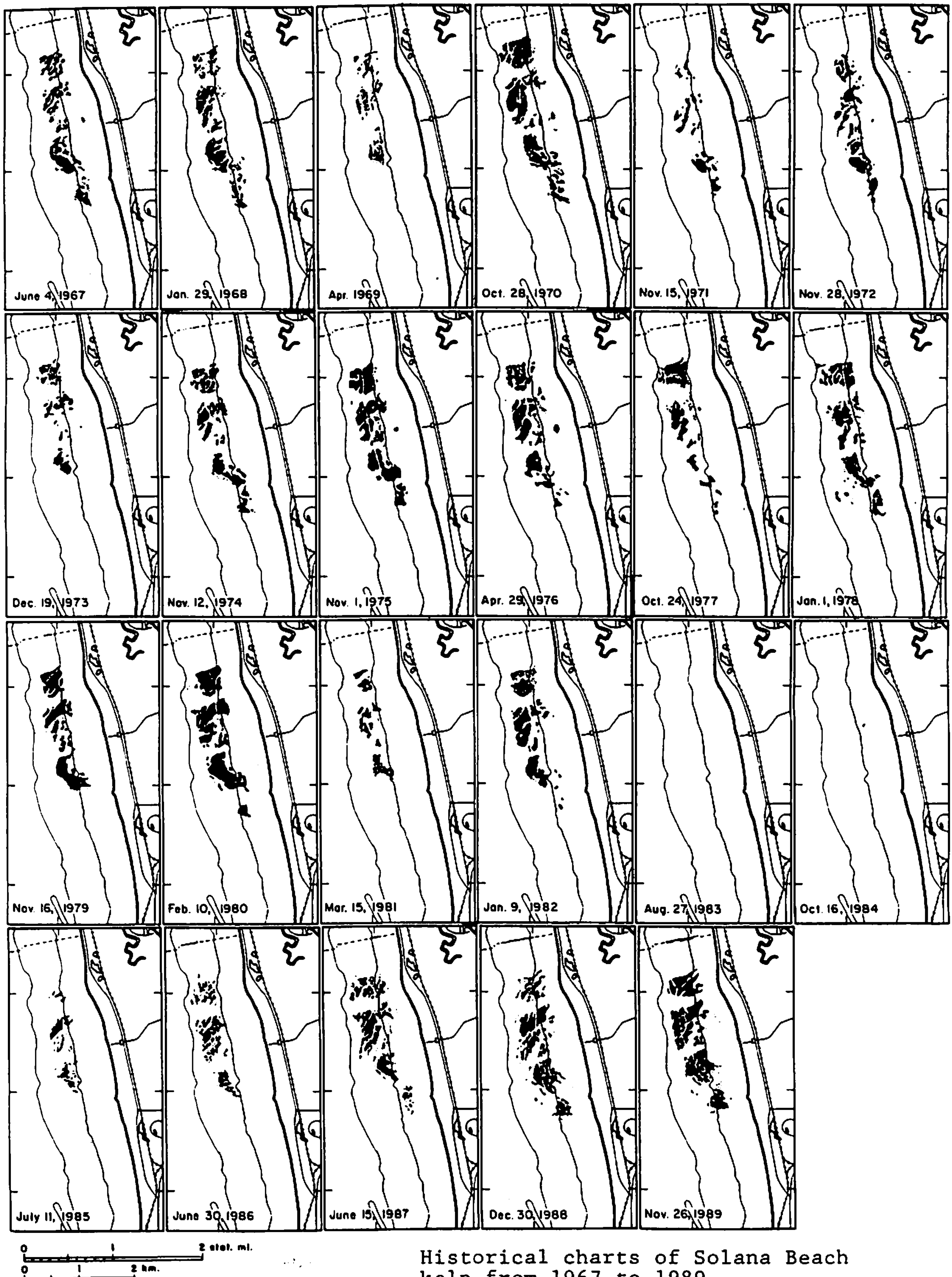

117°19'0"W
117°18'0"W
117°17'0"W
117°16'0"W
33°2'0"N
33°1'0"N
33°0'0"N
32°59'0"N
Santa Fe
Cardiff-by-the-Sea
Birmingham
Manchester
Solana Beach
Lomas Santa Fe
Del a Valle
30
20
10
Kelp bed area
March 10, 2009
Encinitas: 0.2050 Km²
Cardiff: 0.5195 Km²
Solana Beach: 0.5049 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
14


117°19'0"W
117°18'0"W
117°17'0"W
117°16'0"W
33°2'0"N
33°1'0"N
33°0'0"N
32°59'0"N
Santa Fe
Cardiff-by-the-Sea
Birmingham
Manchester
Solana Beach
Lomas Santa Fe
Del a Valle
30
20
Kelp bed area
December 31, 2010
Encinitas: 0.1279 Km²
Cardiff: 0.2127 Km²
Solana Beach: 0.3279 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
14

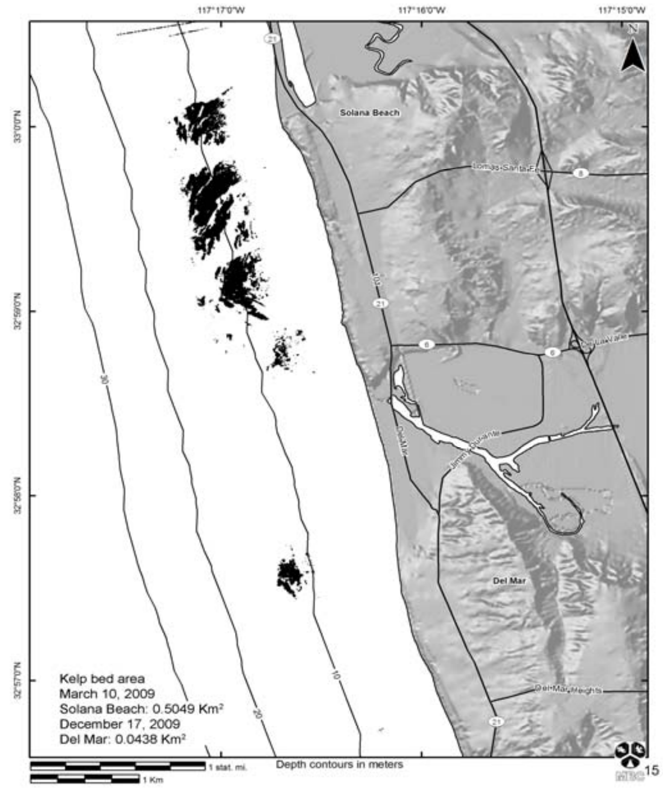


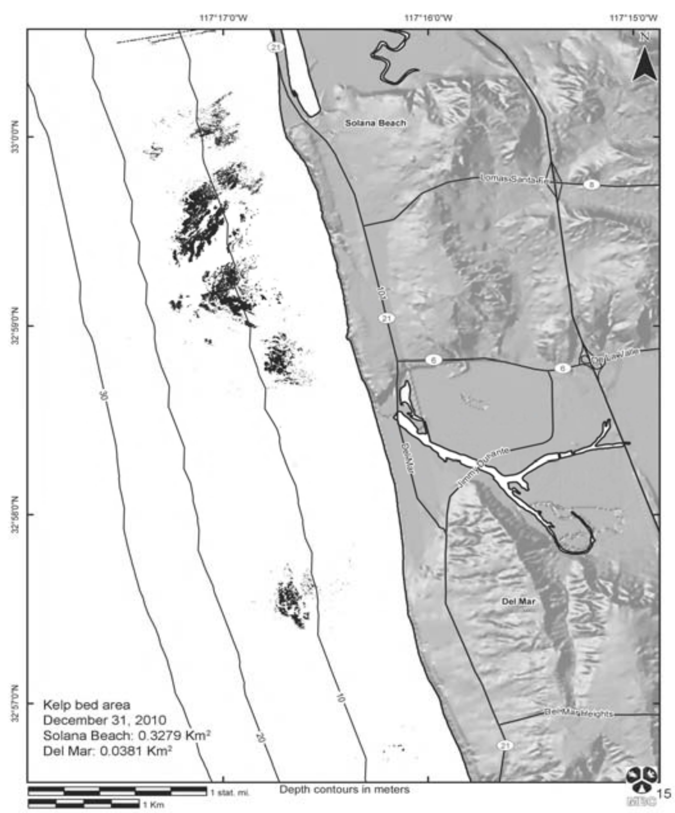
117° 19'
18'
17'
16'
Encinitas
Cardiff-by-the-Sea
San Elijo Lag
Solana Beach
33° 02'
01'
00'
90
60
30
Kelp bed areas
Encinitas: 0.13 km²
Cardiff: 0.31 km²
Solana Beach: 0.41 km²
24 December 2001
1 stat. mi.
1 km.
Depth contours in feet
14
Kelp bed areas
Encinitas: 0.15 km²
Cardiff: 0.40 km²
Solana Beach: 0.49 km²
30 November 2002
Kelp bed areas
Encinitas: 0.0501 km²
Cardiff: 0.2023 km²
Solana Beach: 0.2454 km²
26 October 2003
Kelp bed areas
Encinitas: 0.0162 km²
Cardiff: 0.0449 km²
Solana Beach: 0.0215 km²
23 December 2004
Kelp bed areas
Encinitas: none
Cardiff: none
22 June 2005
Solana Beach: 0.0929 km²
15 March 2005
Kelp bed areas
Encinitas: 0.0015 Km²
Cardiff: 0.0042 Km²
Solana Beach: 0.0003 km²
December 5, 2006
Kelp bed area
Encinitas: 0.2054 Km²
Cardiff: 0.2861 Km²
Solana Beach: 0.4565 Km²
December 14, 2007
Depth contours in meters
Kelp bed area
Encinitas: 0.3464 Km²
Cardiff: 0.4841 Km²
Solana Beach: 0.8232 Km²
December 31, 2008
N


Encinitas
Cardiff-by-the-Sea
San Elijo Lagoon
Solana Beach
Kelp bed areas
Encinitas: 0.209 km^2
Cardiff: 0.575 km^2
Solana Beach: 0.488 km^2
26 November 1989
Kelp bed areas
Encinitas: 0.240 km^2
Cardiff: 0.468 km^2
Solana Beach: 0.466 km^2
25 March 1990
Kelp bed areas
Encinitas: 0.080 km^2
Cardiff: 0.072 km^2
31 December 1991
Solana Beach: 0.260 km^2
14 March 1991
Kelp bed areas
Encinitas: 0.036 km^2
Cardiff: 0.054 km^2
25 October 1992
Solana Beach: 0.053 km^2
19 March 1992
Kelp bed areas
Encinitas: 0.037 km^2
Cardiff: 0.034 km^2
Solana Beach: 0.023 km^2
3 January & 26 November 1993
Kelp bed areas
Encinitas: 0.016 km^2
Cardiff: 0.080 km^2
Solana Beach: 0.108 km^2
25 June 1994
Kelp bed areas
Encinitas: 0.061km^2
Cardiff: 0.092 km^2
Solana Beach: 0.134 km^2
2 April 1995
Kelp bed areas
Encinitas: 0.023 km^2
Cardiff: 0.026 km^2
Solana Beach: 0.003 km^2
24 March 1996
Kelp bed areas
Encinitas: 0.050 km^2
Cardiff: 0.030 km^2
Solana Beach: 0.070 km^2
7 January 1997
Kelp bed areas
Encinitas: none
Cardiff: 0.016 km^2
Solana Beach: 0.009 km^2
10 March & 14 June 1998
Kelp bed areas
Encinitas: 0.029 km^2
Cardiff: 0.063 km^2
Solana Beach: 0.091 km^2
23 November 1999
Kelp bed areas
Encinitas: 0.040 km^2
Cardiff: 0.150 km^2
Solana Beach: 0.200 km^2
21 December 2000
1 stat. mi.
1 km.
Depth contours in feet

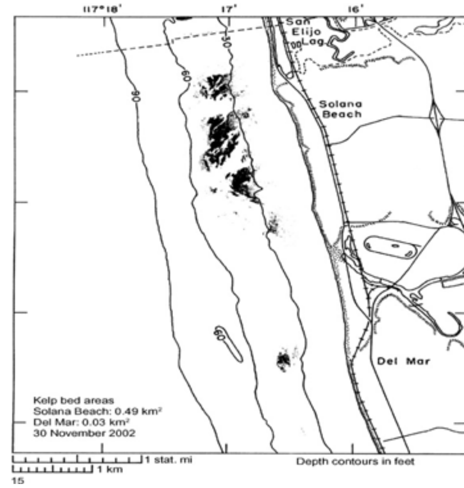


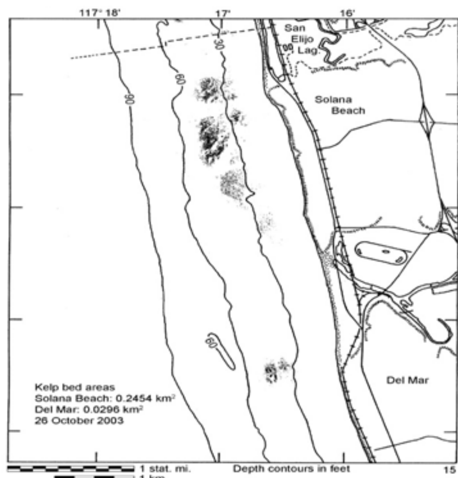
Historical charts of Solana Beach
kelp from 1967 to 1989.

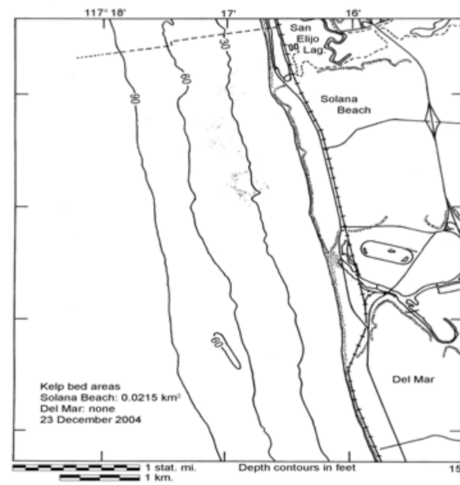

117°17'0"W
117°16'0"W
117°15'0"W
33°0'0"N
32°59'0"N
32°58'0"N
32°57'0"N
N
Solana Beach
Lomas Santa Fe
Jimmy Durante
Del Mar
Del Mar Heights
30
20
10
Kelp bed area
March 10, 2009
Solana Beach: 0.5049 Km²
December 17, 2009
Del Mar: 0.0438 Km²
1 stat. mi.
1 Km
Depth contours in meters
15

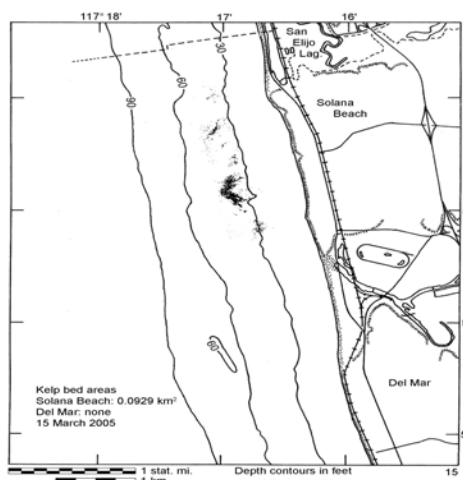

117°17'0"W
117°16'0"W
117°15'0"W
33°0'0"N
32°59'0"N
32°58'0"N
32°57'0"N
N
Solana Beach
Lomas Santa Fe
Jimmy Durante
Del Mar
Del Mar Heights
30
20
10
Kelp bed area
December 31, 2010
Solana Beach: 0.3279 Km²
Del Mar: 0.0381 Km²
1 stat. mi.
1 Km
Depth contours in meters
15

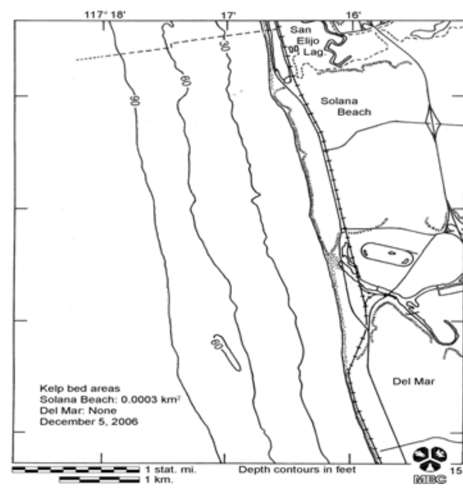

117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.41 km²
27 November 2001
Del Mar: 0.02 km²
24 April 2001
1 stat. mi.
1 km.
Depth contours in feet
15

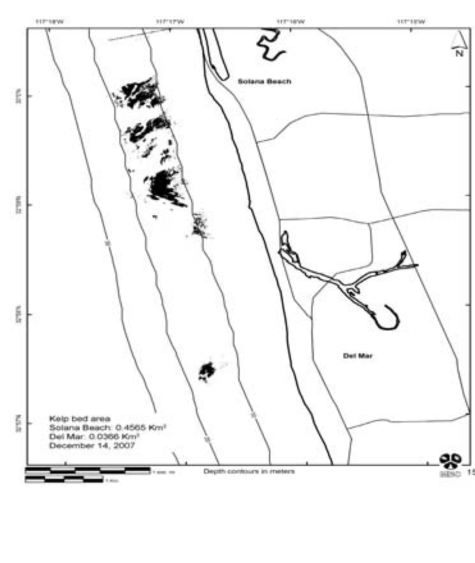

117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
32° 59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.49 km²
Del Mar: 0.03 km²
30 November 2002
1 stat. mi
1 km
Depth contours in feet
15

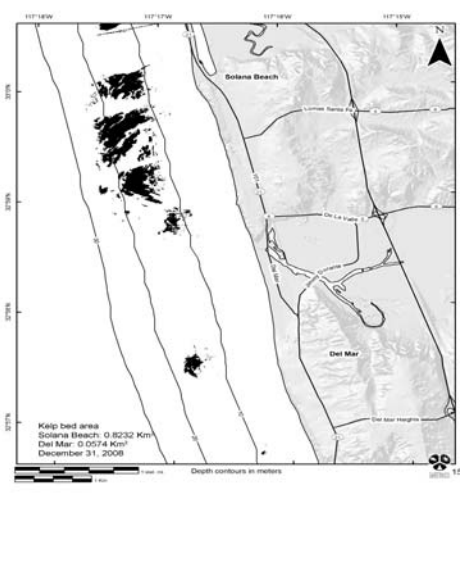

117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.2454 km²
Del Mar: 0.0296 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
15

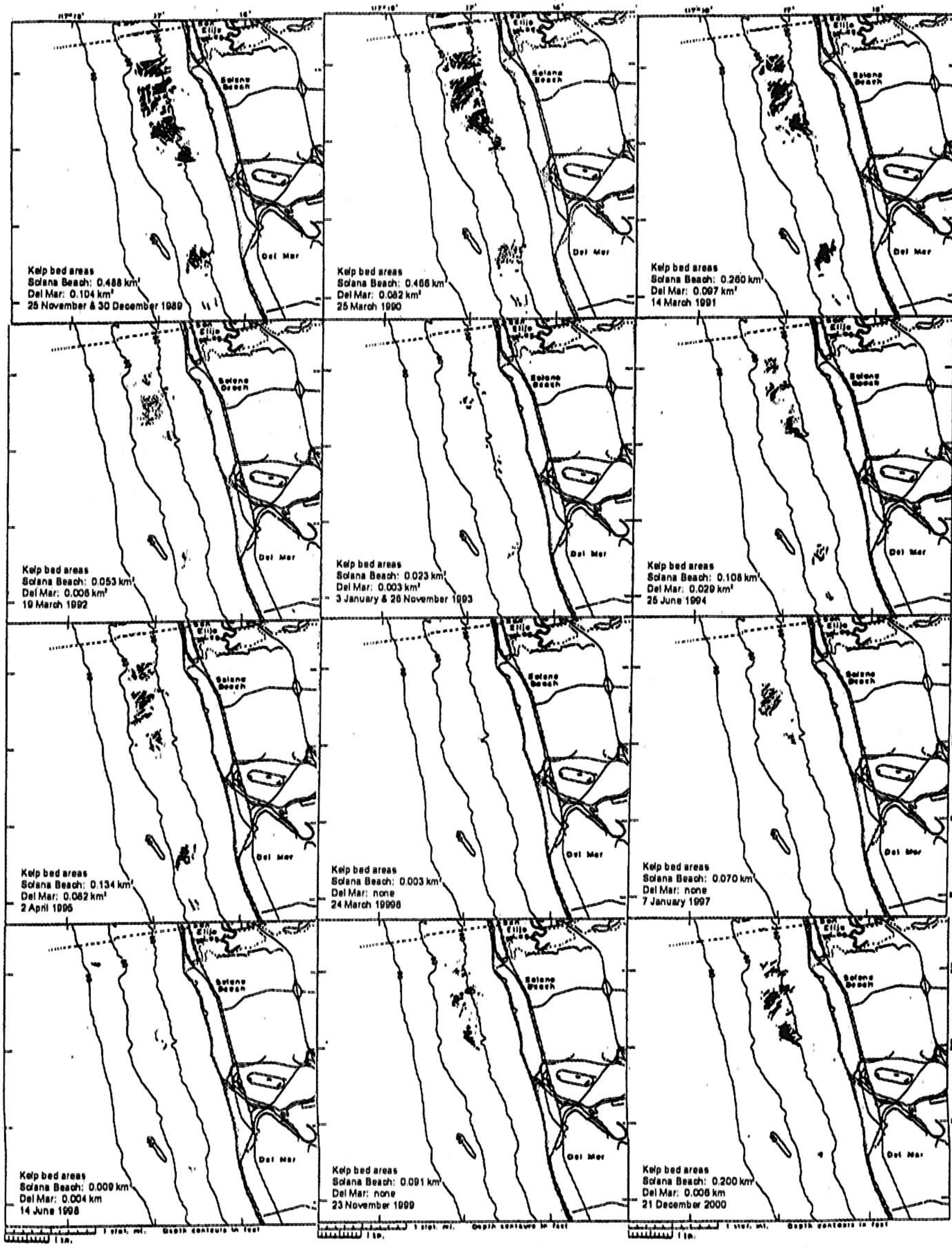

117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.0215 km²
Del Mar: none
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
15

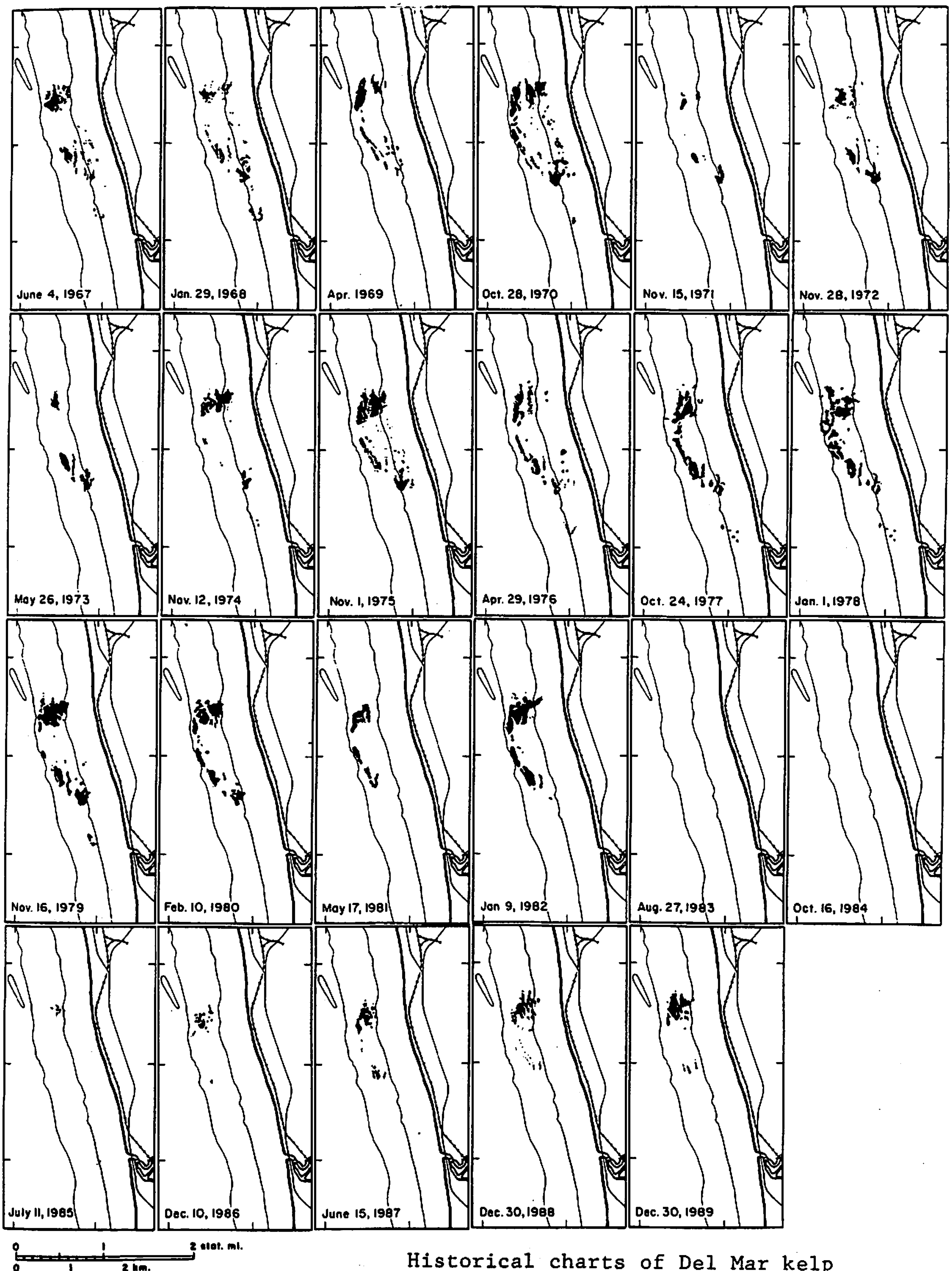

117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.0929 km²
Del Mar: none
15 March 2005
1 stat. mi.
1 km.
Depth contours in feet
15


117° 18'
17'
16'
San Elijo Lag.
Solana Beach
Del Mar
33° 00'
59'
58'
57'
90
60
30
Kelp bed areas
Solana Beach: 0.0003 km²
Del Mar: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
15

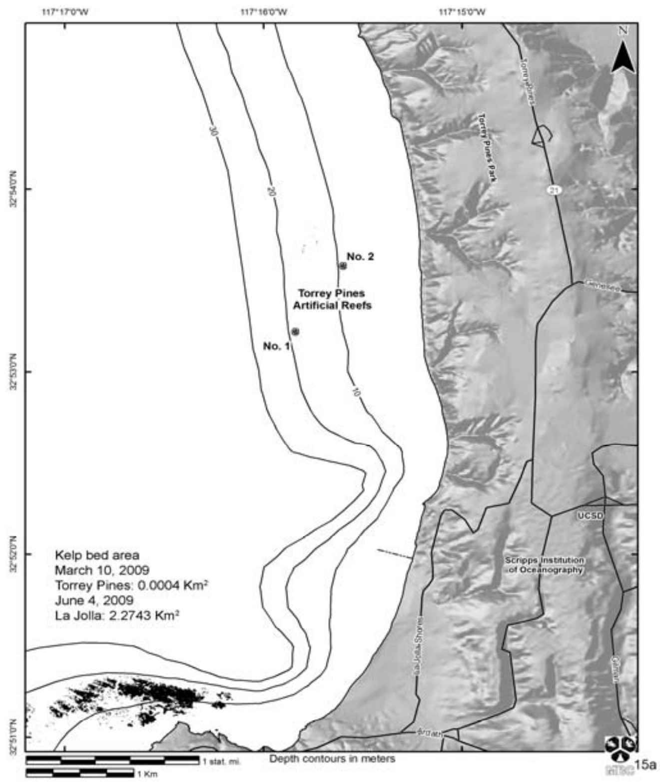

N
Solana Beach
Del Mar
Kelp bed area
Solana Beach: 0.4565 Km²
Del Mar: 0.0366 Km²
December 14, 2007
Depth contours in meters
15

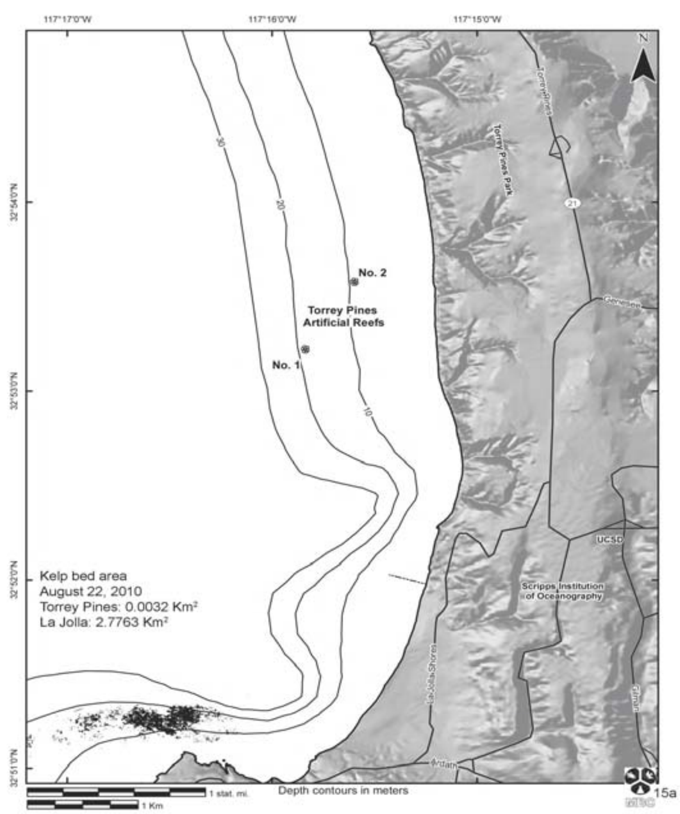

N
Solana Beach
Del Mar
Kelp bed area
Solana Beach: 0.8232 Km²
Del Mar: 0.0574 Km²
December 31, 2008
Depth contours in meters
15

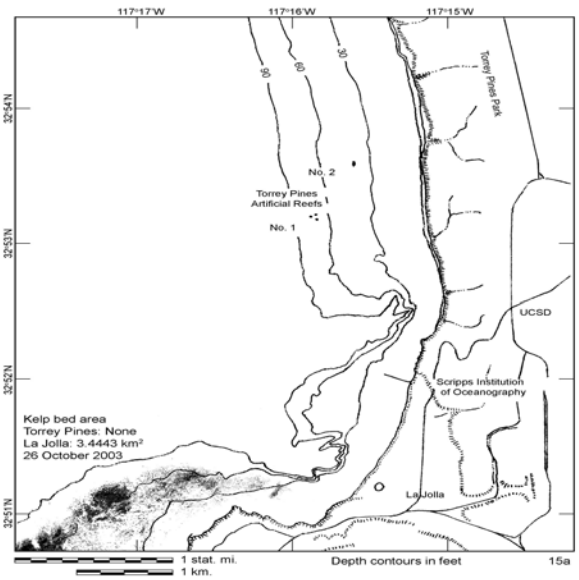

Solana Beach
Del Mar
Kelp bed areas
Solana Beach: 0.488 km^2
Del Mar: 0.104 km^2
25 November & 30 December 1989
Kelp bed areas
Solana Beach: 0.466 km^2
Del Mar: 0.082 km^2
25 March 1990
Kelp bed areas
Solana Beach: 0.260 km^2
Del Mar: 0.097 km^2
14 March 1991
Kelp bed areas
Solana Beach: 0.053 km^2
Del Mar: 0.006 km^2
19 March 1992
Kelp bed areas
Solana Beach: 0.023 km^2
Del Mar: 0.003 km^2
3 January & 26 November 1993
Kelp bed areas
Solana Beach: 0.108 km^2
Del Mar: 0.029 km^2
25 June 1994
Kelp bed areas
Solana Beach: 0.134 km^2
Del Mar: 0.082 km^2
2 April 1995
Kelp bed areas
Solana Beach: 0.003 km^2
Del Mar: none
24 March 19996
Kelp bed areas
Solana Beach: 0.070 km^2
Del Mar: none
7 January 1997
Kelp bed areas
Solana Beach: 0.009 km^2
Del Mar: 0.004 km
14 June 1998
Kelp bed areas
Solana Beach: 0.091 km^2
Del Mar: none
23 November 1999
Kelp bed areas
Solana Beach: 0.200 km^2
Del Mar: 0.006 km
21 December 2000
1 stat. mi.
Depth contours in feet
1 km.

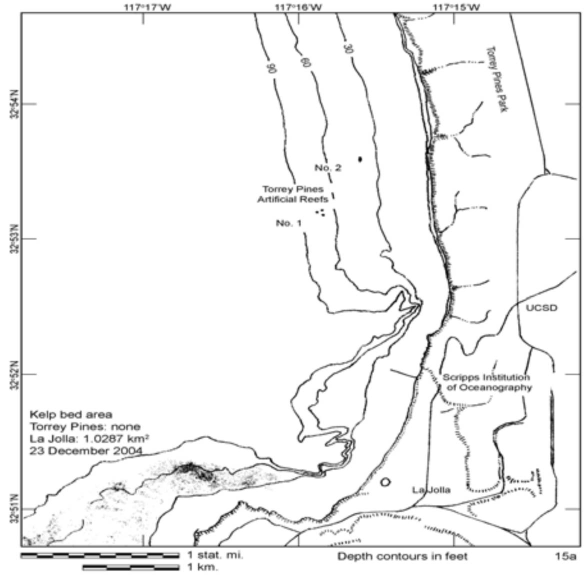


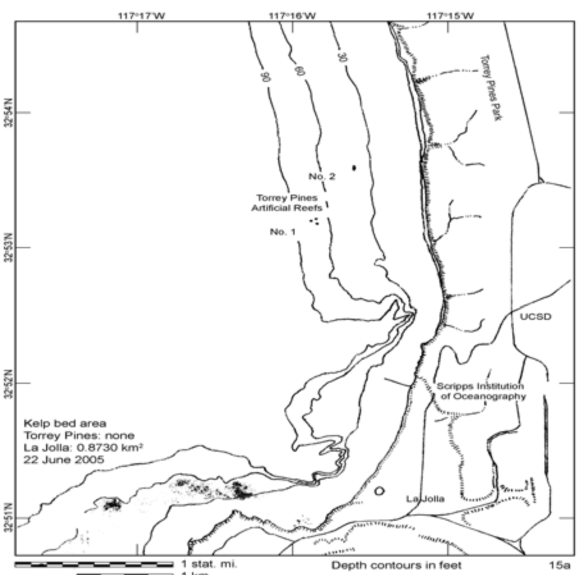
Historical charts of Del Mar kelp from 1967 to 1989.

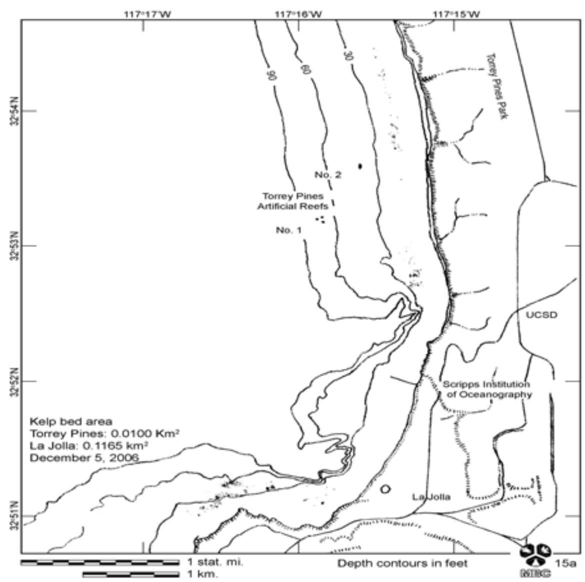

117°17'0"W
117°16'0"W
117°15'0"W
32°54'0"N
32°53'0"N
32°52'0"N
32°51'0"N
N
Torrey Pines
Torrey Pines Park
21
Genesee
30
20
10
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla Shores
Kelp bed area
March 10, 2009
Torrey Pines: 0.0004 Km²
June 4, 2009
La Jolla: 2.2743 Km²
1 stat. mi.
1 Km
Depth contours in meters
15a

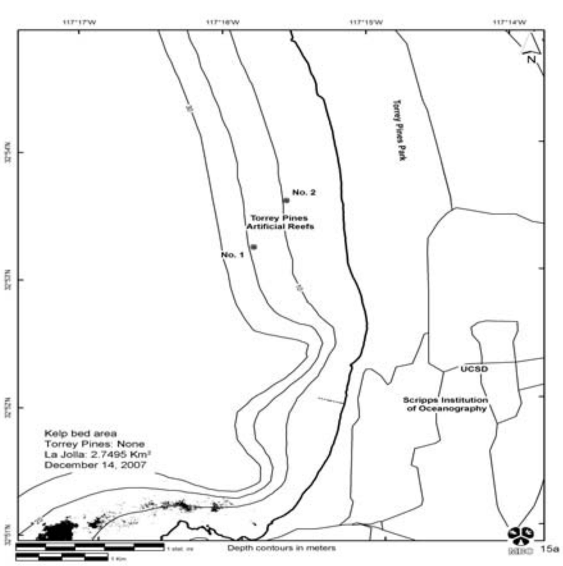

117°17'0"W
117°16'0"W
117°15'0"W
32°54'0"N
32°53'0"N
32°52'0"N
32°51'0"N
N
Torrey Pines
Torrey Pines Park
21
Genesee
30
20
10
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla Shores
Kelp bed area
August 22, 2010
Torrey Pines: 0.0032 Km²
La Jolla: 2.7763 Km²
1 stat. mi.
1 Km
Depth contours in meters
15a

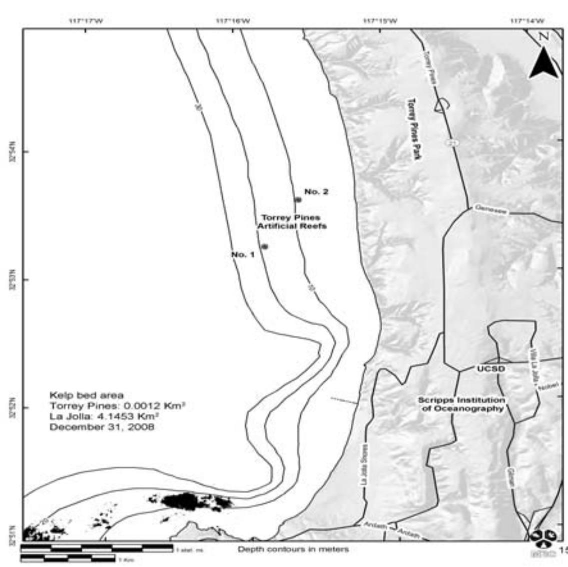

117°17'W
117°16'W
117°15'W
32°54'N
32°53'N
32°52'N
32°51'N
90
60
30
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla
Kelp bed area
Torrey Pines: None
La Jolla: 3.4443 km^2
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
15a

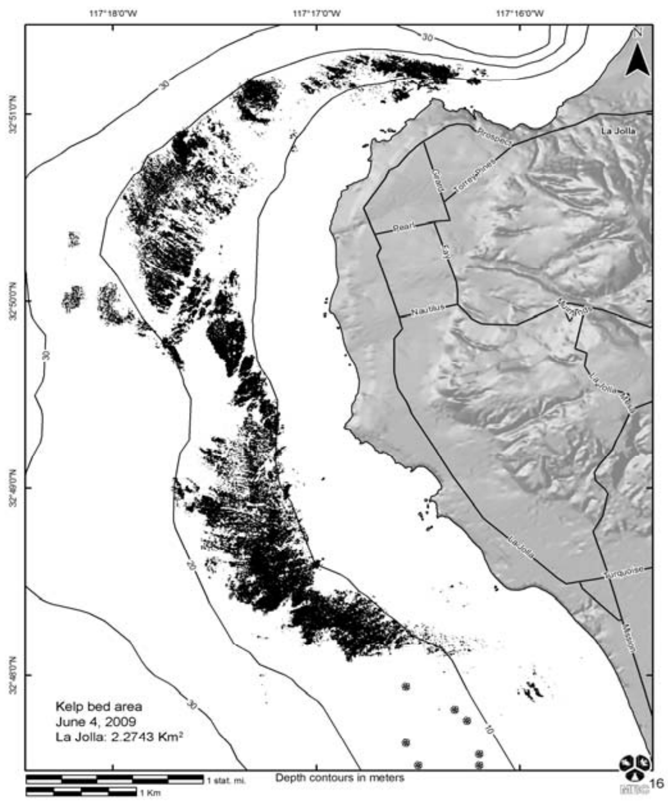

117°17'W
117°16'W
117°15'W
32°54'N
32°53'N
32°52'N
32°51'N
90
60
30
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla
Kelp bed area
Torrey Pines: none
La Jolla: 1.0287 km^2
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
15a


117°17'W
117°16'W
117°15'W
32°54'N
32°53'N
32°52'N
32°51'N
90
60
30
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla
Kelp bed area
Torrey Pines: none
La Jolla: 0.8730 km^2
22 June 2005
1 stat. mi.
1 km.
Depth contours in feet
15a

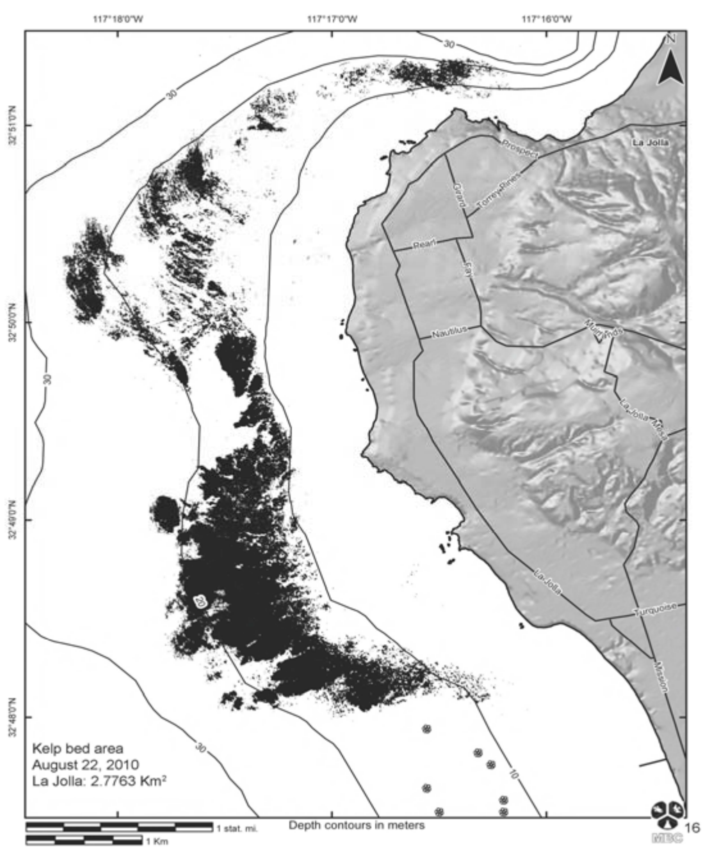

117°17'W
117°16'W
117°15'W
32°54'N
32°53'N
32°52'N
32°51'N
90
60
30
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
La Jolla
Kelp bed area
Torrey Pines: 0.0100 Km^2
La Jolla: 0.1165 km^2
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
15a


117°17'W
117°16'W
117°15'W
117°14'W
N
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
Kelp bed area
Torrey Pines: None
La Jolla: 2.7495 Km^2
December 14, 2007
Depth contours in meters
MBC
15a

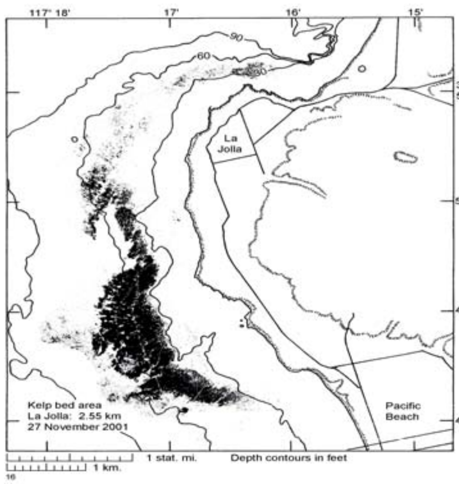

117°17'W
117°16'W
117°15'W
117°14'W
N
Torrey Pines Park
No. 2
Torrey Pines
Artificial Reefs
No. 1
UCSD
Scripps Institution
of Oceanography
Kelp bed area
Torrey Pines: 0.0012 Km^2
La Jolla: 4.1453 Km^2
December 31, 2008
Depth contours in meters
MBC
15a

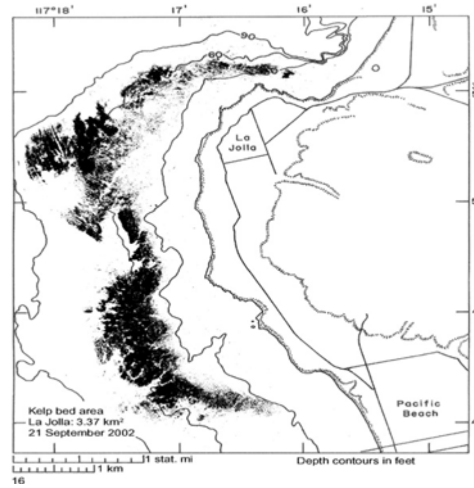


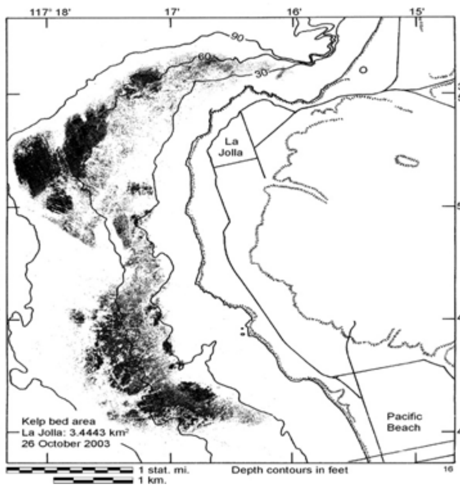
117°18'0"W
117°17'0"W
117°16'0"W
32°51'0"N
32°50'0"N
32°49'0"N
32°48'0"N
30
20
10
La Jolla
Prospect
Torrey Pines
Girard
Pearl
Fay
Nautilus
Muirlands
La Jolla Mesa
La Jolla
Turquoise
Mission
Kelp bed area
June 4, 2009
La Jolla: 2.2743 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
16

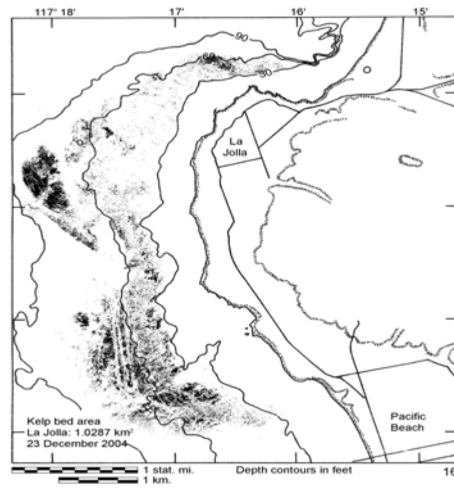


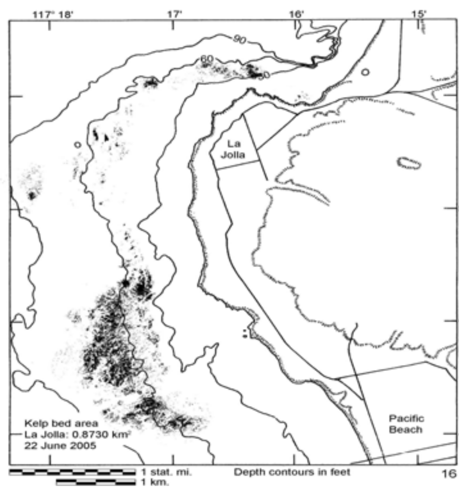
117°18'0"W
117°17'0"W
117°16'0"W
32°51'0"N
32°50'0"N
32°49'0"N
32°48'0"N
30
10
La Jolla
Prospect
Torrey Pines
Girard
Pearl
Fay
Nautilus
Muirlands
La Jolla Mesa
La Jolla
Turquoise
Mission
Kelp bed area
August 22, 2010
La Jolla: 2.7763 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
16

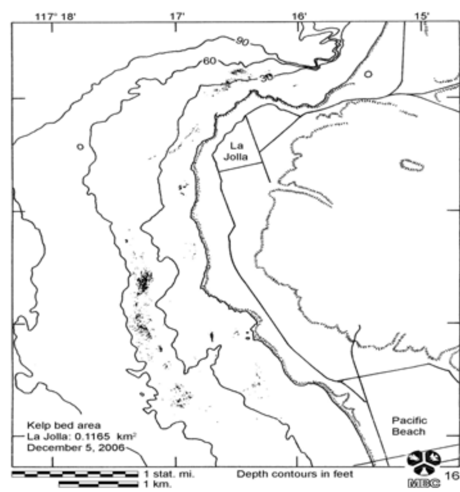

117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
30
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 2.55 km
27 November 2001
1 stat. mi.
1 km.
Depth contours in feet
16

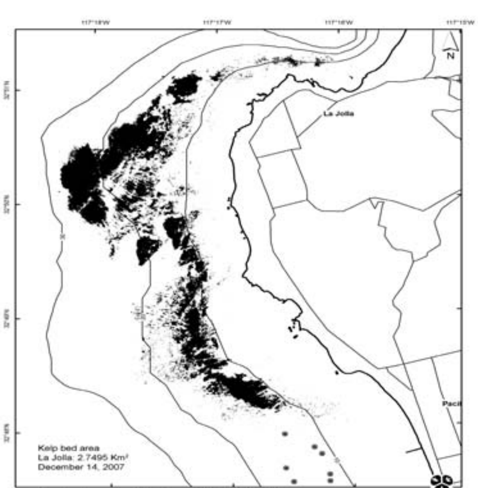

117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 3.37 km²
21 September 2002
1 stat. mi
1 km
Depth contours in feet
16

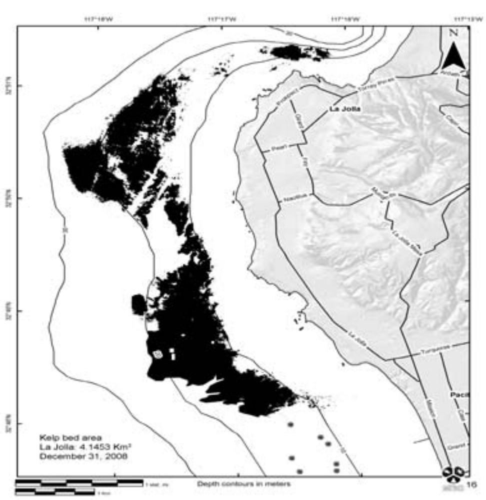

117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
30
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 3.4443 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
16

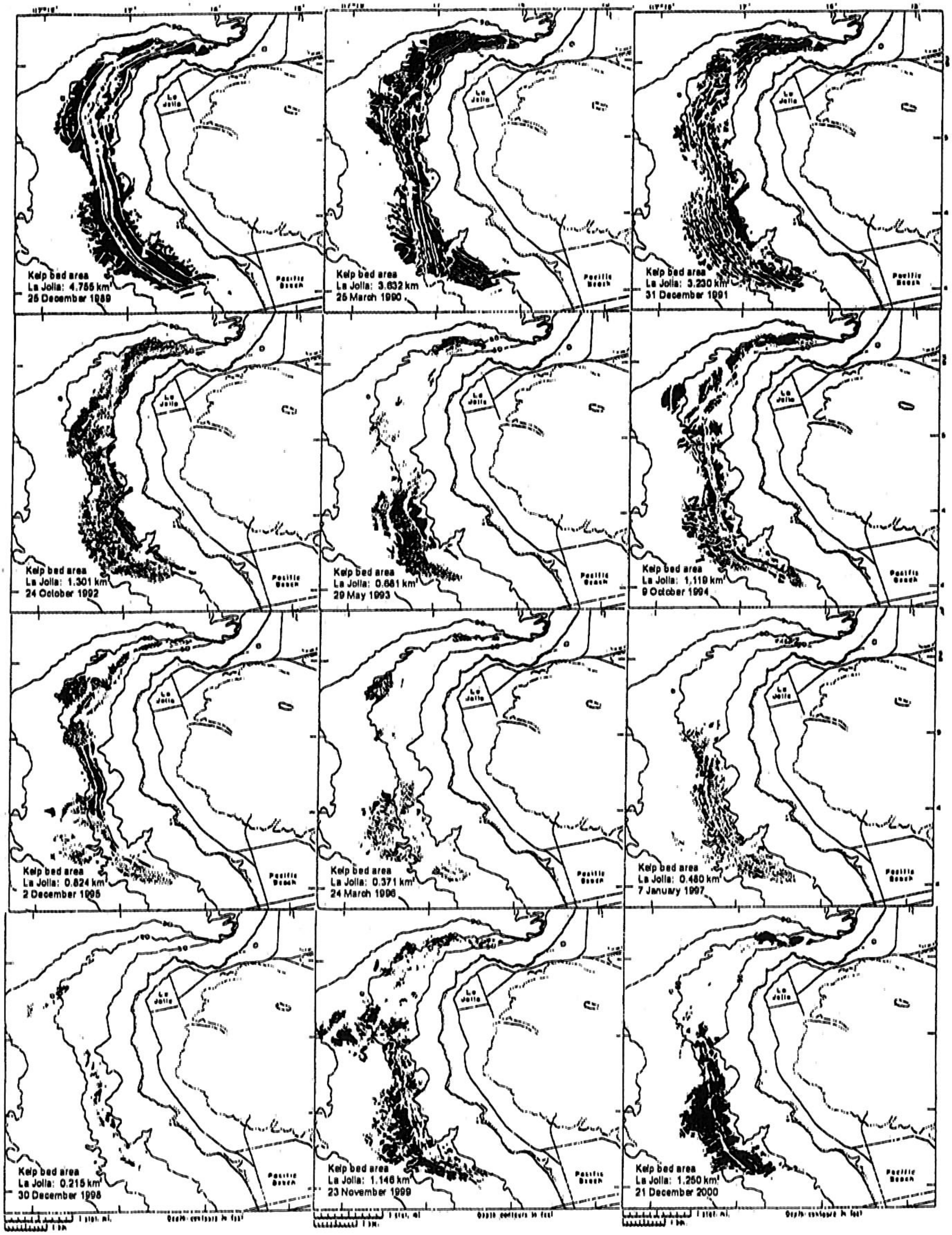

117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
30
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 1.0287 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
16

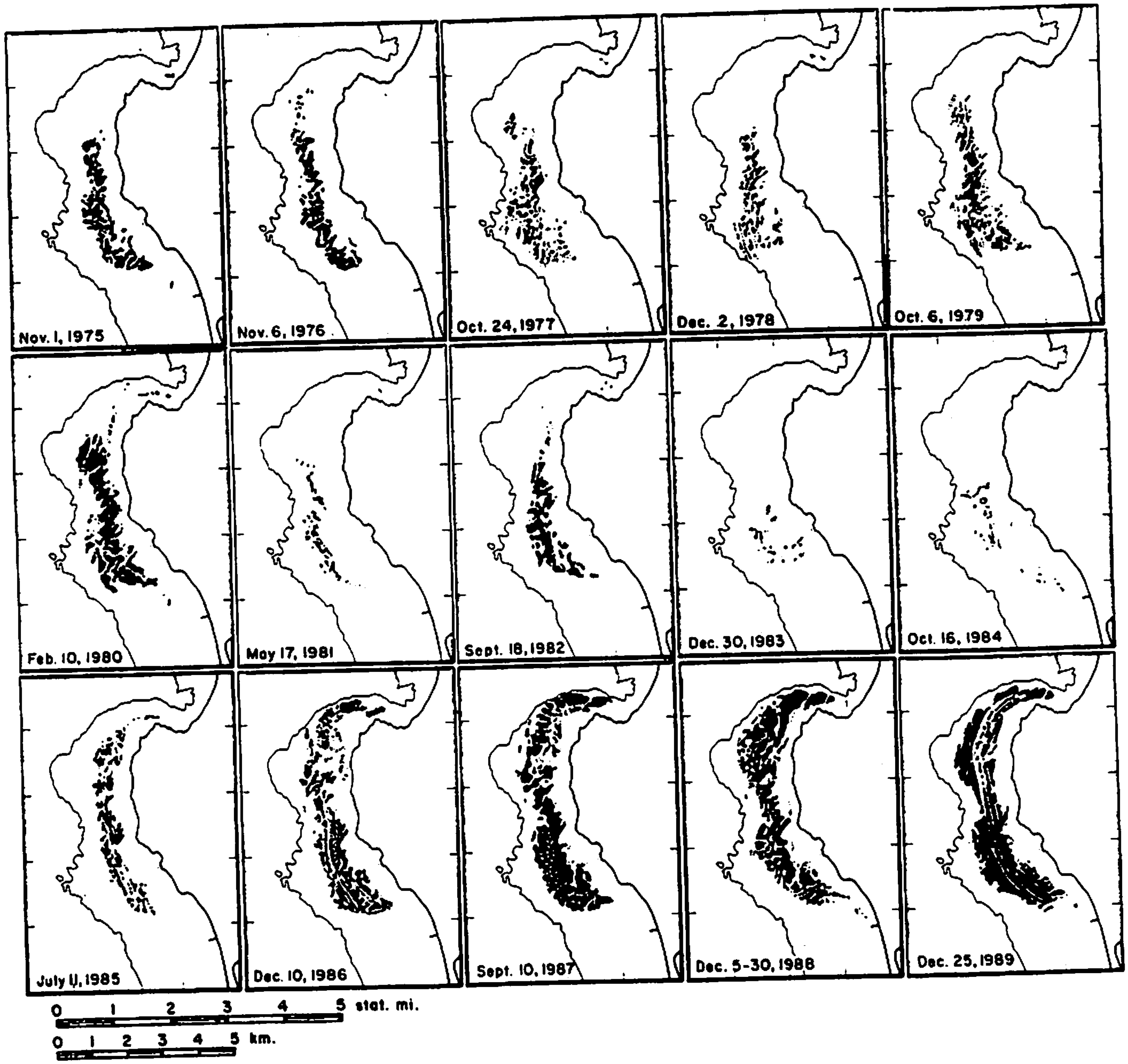

117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
30
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 0.8730 km²
22 June 2005
1 stat. mi.
1 km.
Depth contours in feet
16


117° 18'
17'
16'
15'
32°
51'
50'
49'
48'
90
60
30
La Jolla
Pacific Beach
Kelp bed area
La Jolla: 0.1165 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
16

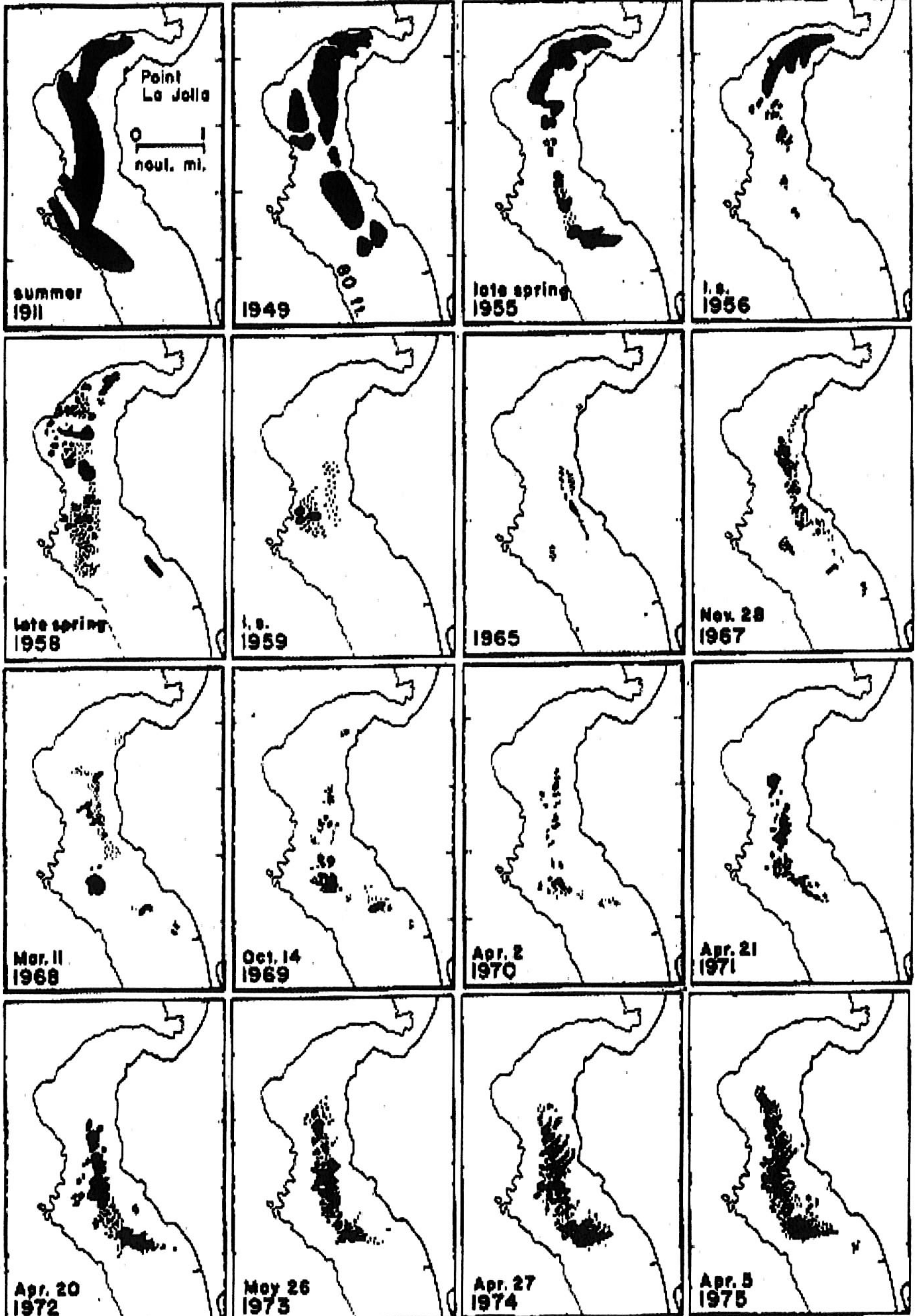

117°18'W
117°17'W
117°16'W
117°15'W
N
La Jolla
Kelp bed area
La Jolla: 2.7495 Km²
December 14, 2007
Depth contours in meters
16


117°18'W
117°17'W
117°16'W
117°15'W
N
La Jolla
Kelp bed area
La Jolla: 4.1453 Km²
December 31, 2008
Depth contours in meters
16

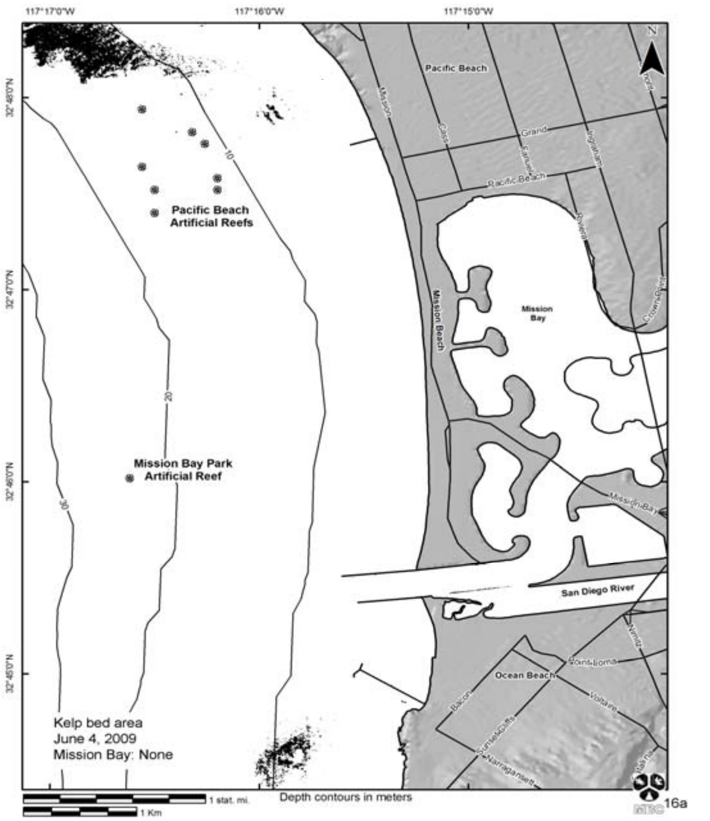

Kelp bed area
La Jolla: 4.755 km²
25 December 1989
Kelp bed area
La Jolla: 3.632 km²
25 March 1990
Kelp bed area
La Jolla: 3.230 km²
31 December 1991
Kelp bed area
La Jolla: 1.301 km²
24 October 1992
Kelp bed area
La Jolla: 0.681 km²
29 May 1993
Kelp bed area
La Jolla: 1.119 km²
9 October 1994
Kelp bed area
La Jolla: 0.824 km²
2 December 1995
Kelp bed area
La Jolla: 0.371 km²
24 March 1996
Kelp bed area
La Jolla: 0.480 km²
7 January 1997
Kelp bed area
La Jolla: 0.215 km²
30 December 1998
Kelp bed area
La Jolla: 1.146 km²
23 November 1999
Kelp bed area
La Jolla: 1.250 km²
21 December 2000
La Jolla
Pacific Beach

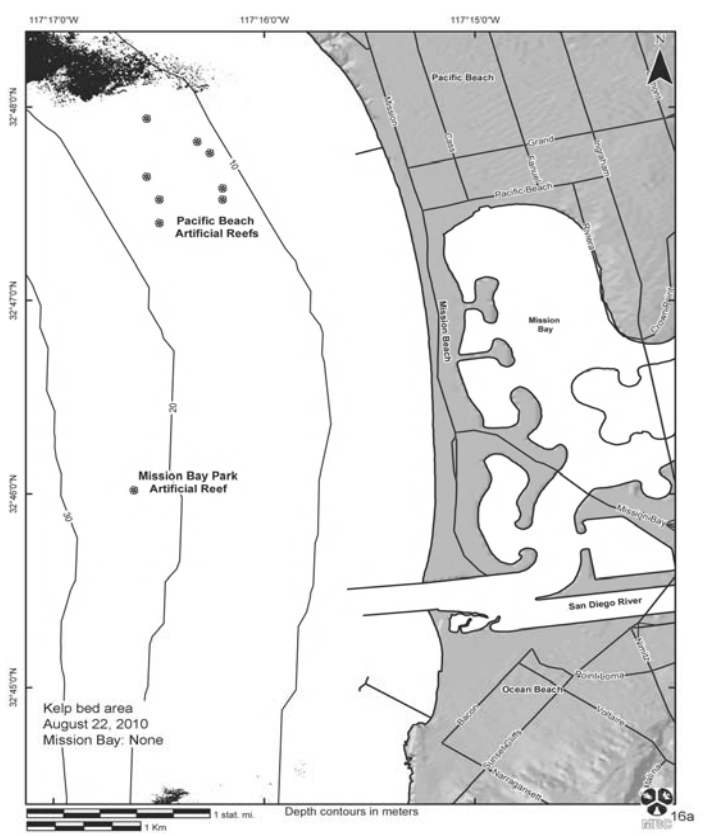


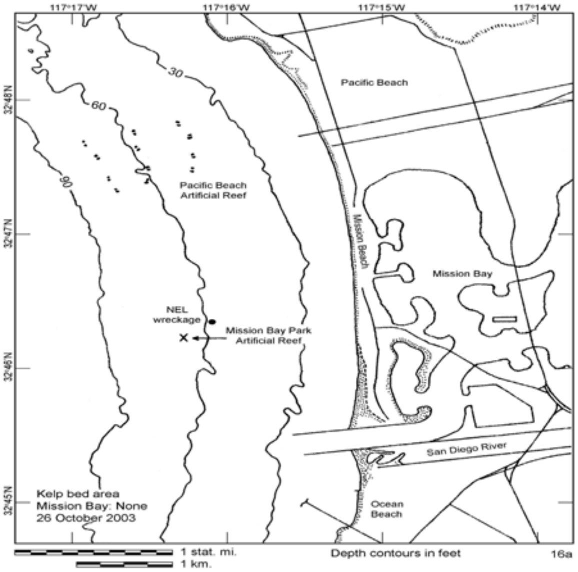
Historical charts of La Jolla kelp from 1975 to 1989.

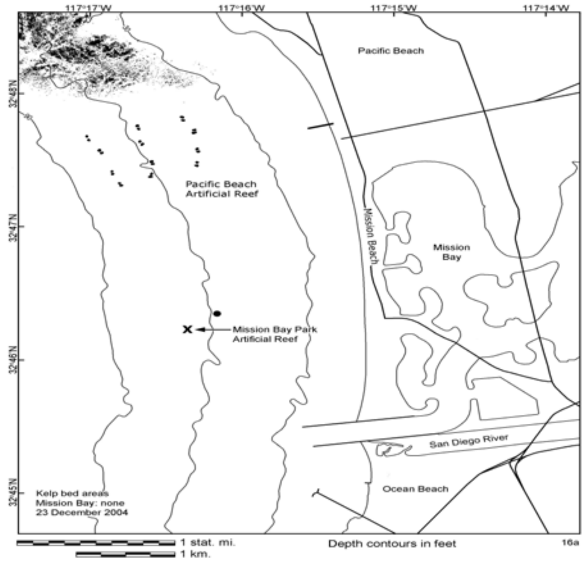


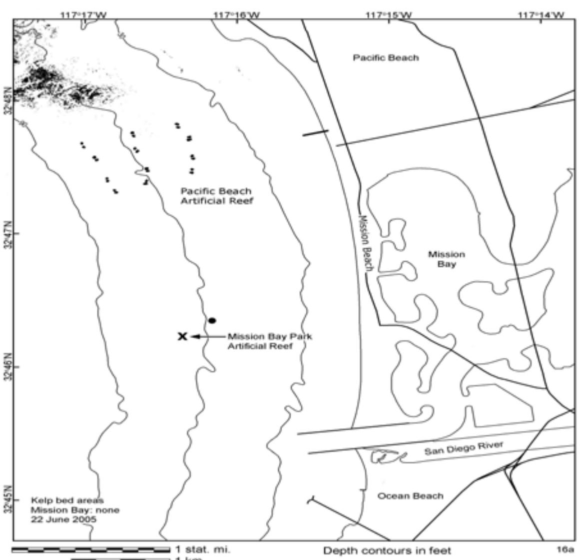
Historical charts of La Jolla kelp from 1911 to 1975.

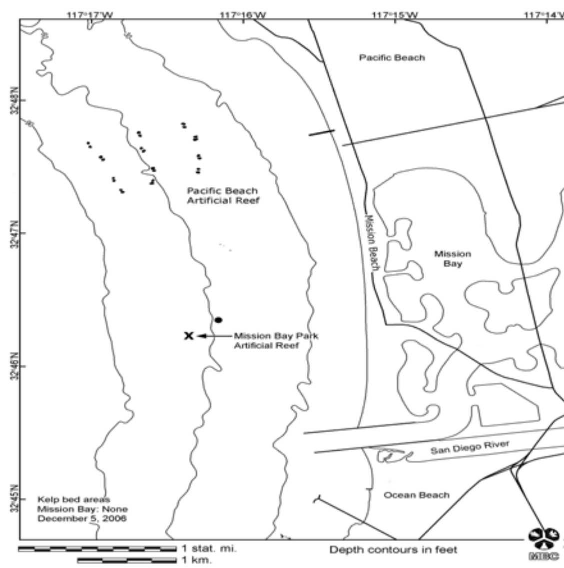

117°17'0"W
117°16'0"W
117°15'0"W
32°48'0"N
32°47'0"N
32°46'0"N
32°45'0"N
Pacific Beach
Mission
Cass
Grand
Garnet
Ingraham
Pacific Beach
Riviera
Crown Point
Pacific Beach Artificial Reefs
Mission Beach
Mission Bay
10
20
30
Mission Bay Park Artificial Reef
Mission Bay
San Diego River
Nimitz
Point Loma
Ocean Beach
Voltaire
Bacon
Sunset Cliffs
Narragansett
Kelp bed area
June 4, 2009
Mission Bay: None
1 stat. mi.
1 Km
Depth contours in meters
MBC
16a


117°17'0"W
117°16'0"W
117°15'0"W
32°48'0"N
32°47'0"N
32°46'0"N
32°45'0"N
Pacific Beach
Mission
Cass
Grand
Garnet
Ingraham
Pacific Beach
Riviera
Crown Point
Pacific Beach Artificial Reefs
Mission Beach
Mission Bay
10
20
30
Mission Bay Park Artificial Reef
Mission Bay
San Diego River
Nimitz
Point Loma
Ocean Beach
Voltaire
Bacon
Sunset Cliffs
Narragansett
Kelp bed area
August 22, 2010
Mission Bay: None
1 stat. mi.
1 Km
Depth contours in meters
MBC
16a

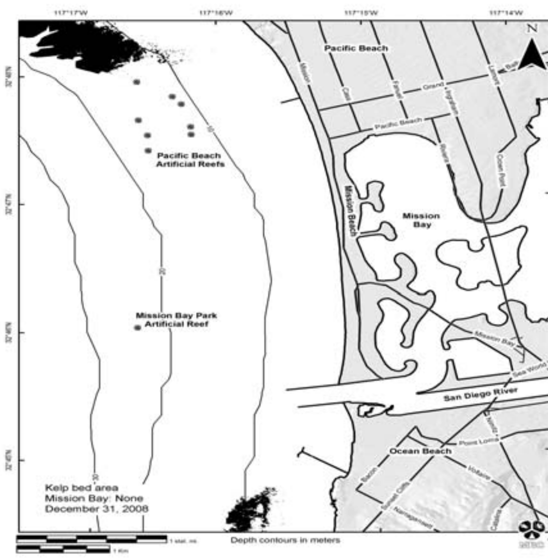

117°17'W
117°16'W
117°15'W
117°14'W
32°48'N
32°47'N
32°46'N
32°45'N
30
60
90
Pacific Beach
Pacific Beach
Artificial Reef
Mission Beach
Mission Bay
NEL
wreckage
Mission Bay Park
Artificial Reef
San Diego River
Ocean
Beach
Kelp bed area
Mission Bay: None
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
16a

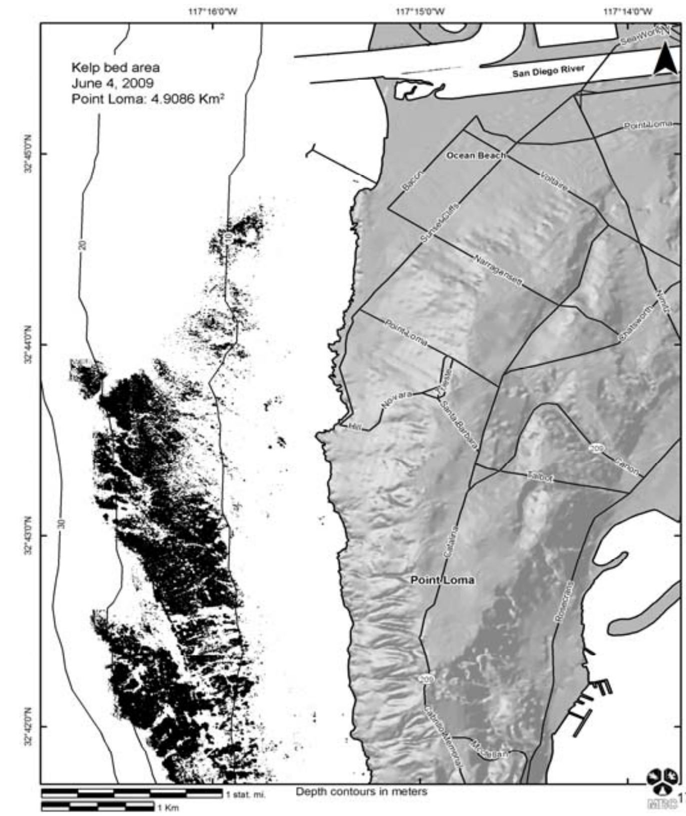

117°17'W
117°16'W
117°15'W
117°14'W
32°48'N
32°47'N
32°46'N
32°45'N
Pacific Beach
Pacific Beach
Artificial Reef
Mission Beach
Mission
Bay
Mission Bay Park
Artificial Reef
San Diego River
Ocean Beach
Kelp bed areas
Mission Bay: none
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
16a


117°17'W
117°16'W
117°15'W
117°14'W
32°48'N
32°47'N
32°46'N
32°45'N
Pacific Beach
Pacific Beach
Artificial Reef
Mission Beach
Mission
Bay
Mission Bay Park
Artificial Reef
San Diego River
Ocean Beach
Kelp bed areas
Mission Bay: none
22 June 2005
1 stat. mi.
1 km.
Depth contours in feet
16a


117°17'W
117°16'W
117°15'W
117°14'W
32°48'N
32°47'N
32°46'N
32°45'N
Pacific Beach
Pacific Beach
Artificial Reef
Mission Beach
Mission
Bay
Mission Bay Park
Artificial Reef
San Diego River
Ocean Beach
Kelp bed areas
Mission Bay: None
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
16a

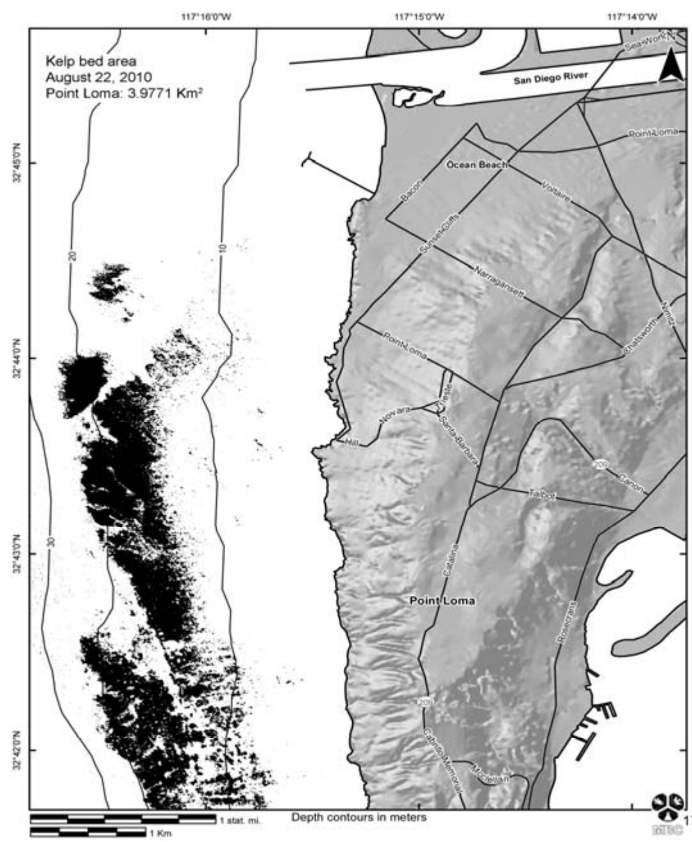

117°17'W
117°16'W
117°15'W
117°14'W
N
Pacific Beach
Pacific Beach
Artificial Reefs
Mission Beach
Mission
Bay
Mission Bay Park
Artificial Reef
San Diego River
Ocean Beach
Kelp bed area
Mission Bay: None
December 14, 2007
Depth contours in meters
MBC
16a


117°17'W
117°16'W
117°15'W
117°14'W
N
Pacific Beach
Pacific Beach
Artificial Reefs
Mission Beach
Mission
Bay
Mission Bay Park
Artificial Reef
San Diego River
Ocean Beach
Kelp bed area
Mission Bay: None
December 31, 2008
Depth contours in meters
MBC
16a



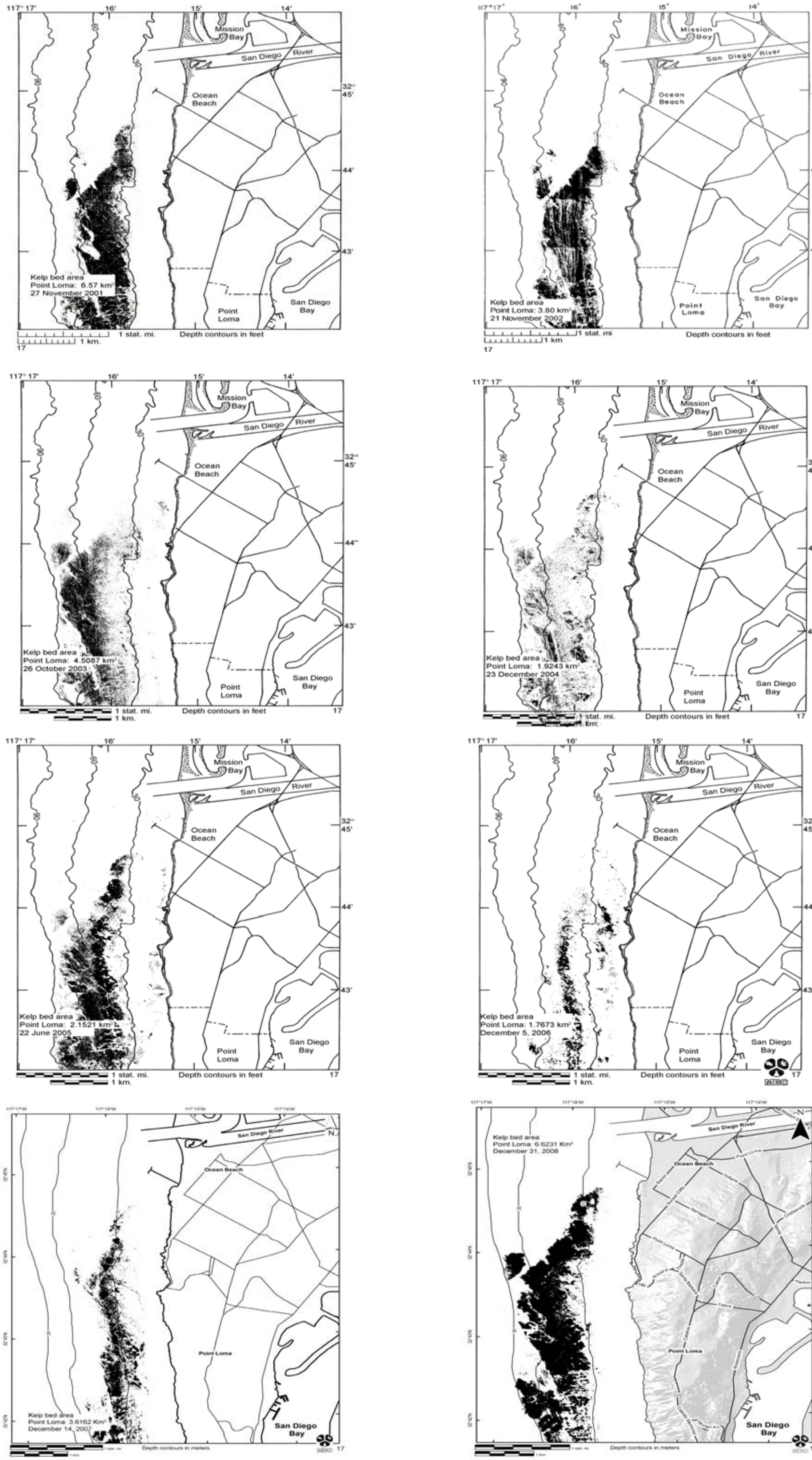
117°16'0"W
117°15'0"W
117°14'0"W
Kelp bed area
June 4, 2009
Point Loma: 4.9086 Km²
San Diego River
Ocean Beach
Point Loma
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
1 stat. mi.
1 Km
Depth contours in meters

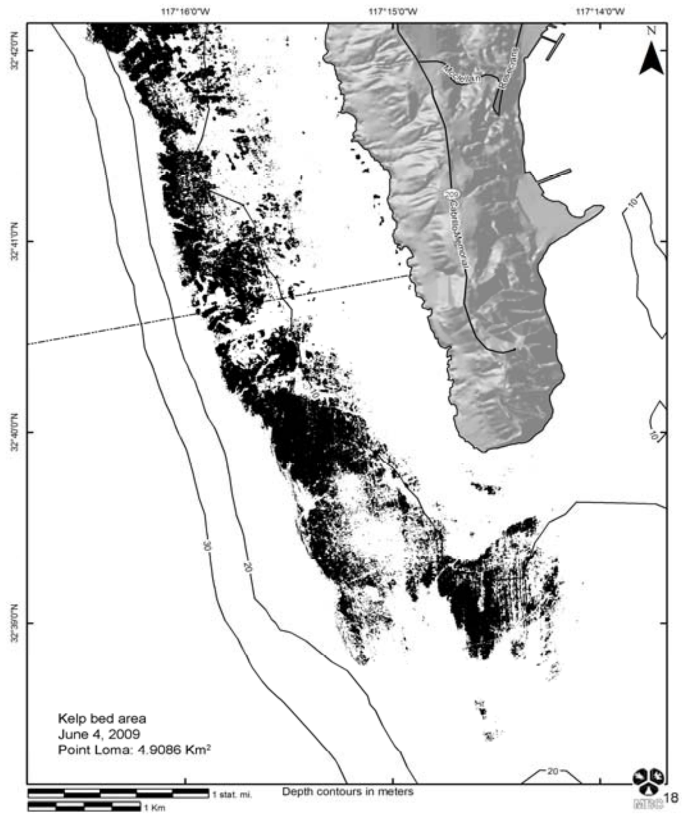
17



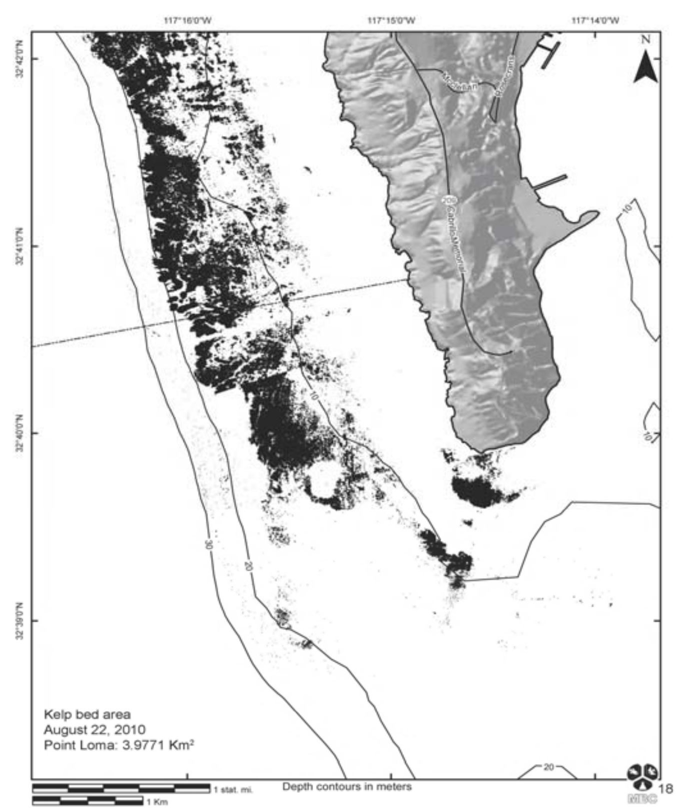
117°16'0"W
117°15'0"W
117°14'0"W
Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km²
San Diego River
Ocean Beach
Point Loma
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
1 stat. mi.
1 Km
Depth contours in meters

17

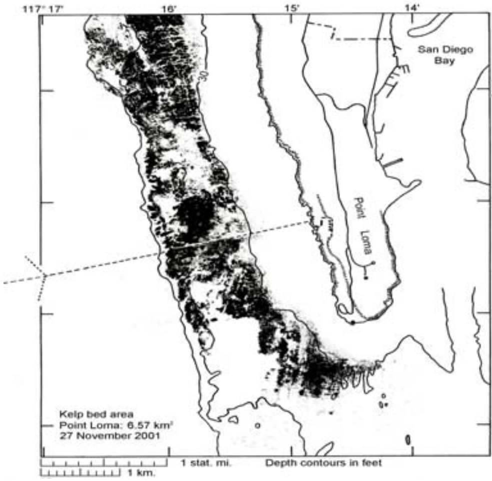

Kelp bed area
Point Loma: 6.57 km²
27 November 2001
Kelp bed area
Point Loma: 3.80 km²
21 November 2002
Kelp bed area
Point Loma: 4.5087 km²
26 October 2003
Kelp bed area
Point Loma: 1.9243 km²
23 December 2004
Kelp bed area
Point Loma: 2.1521 km²
22 June 2005
Kelp bed area
Point Loma: 1.7673 km²
December 5, 2006
Kelp bed area
Point Loma: 3.6162 Km²
December 14, 2007
Kelp bed area
Point Loma: 6.6231 Km²
December 31, 2008
Mission Bay
San Diego River
Ocean Beach
Point Loma
San Diego Bay
Depth contours in feet
Depth contours in meters
1 stat. mi.
1 km.

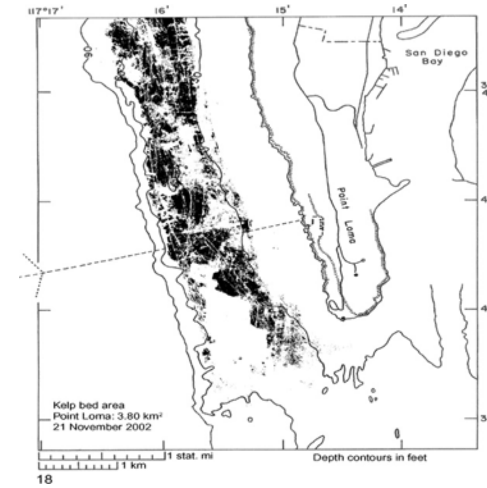


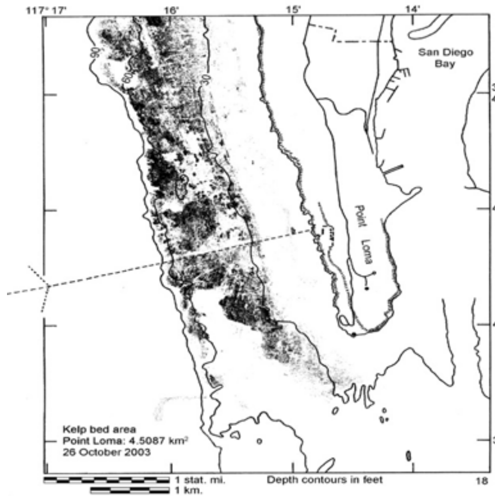
117°16'0"W
117°15'0"W
117°14'0"W
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
30
20
10
Kelp bed area
June 4, 2009
Point Loma: 4.9086 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18

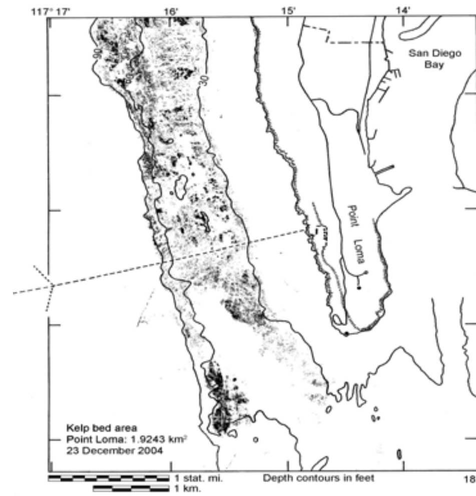


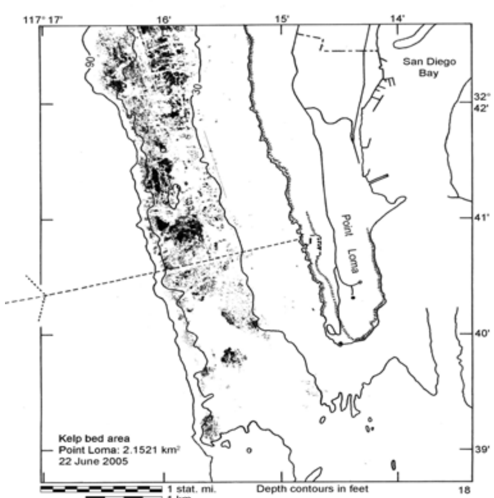
117°16'0"W
117°15'0"W
117°14'0"W
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
30
20
10
Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18

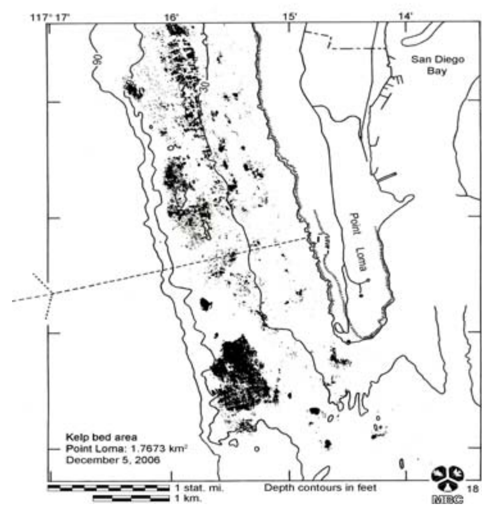

117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40'
39'
Point Loma
30
Kelp bed area
Point Loma: 6.57 km²
27 November 2001
1 stat. mi.
1 km.
Depth contours in feet

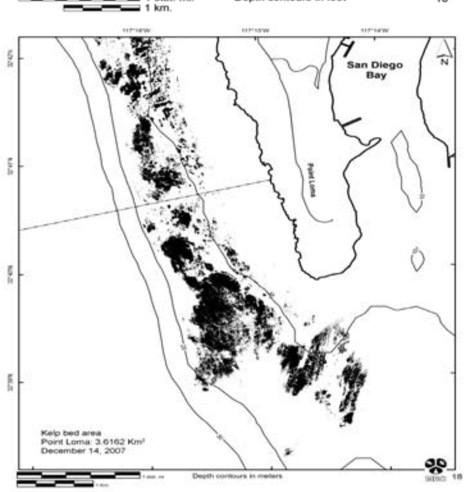

117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40
39'
Point Loma
30
Kelp bed area
Point Loma: 3.80 km²
21 November 2002
1 stat. mi
1 km
Depth contours in feet
18

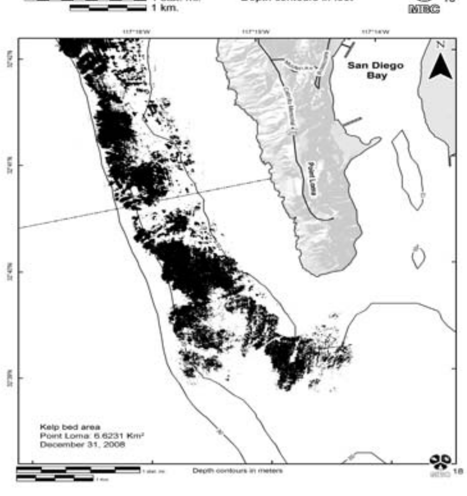

117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40'
39'
Point Loma
30
Kelp bed area
Point Loma: 4.5087 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
18

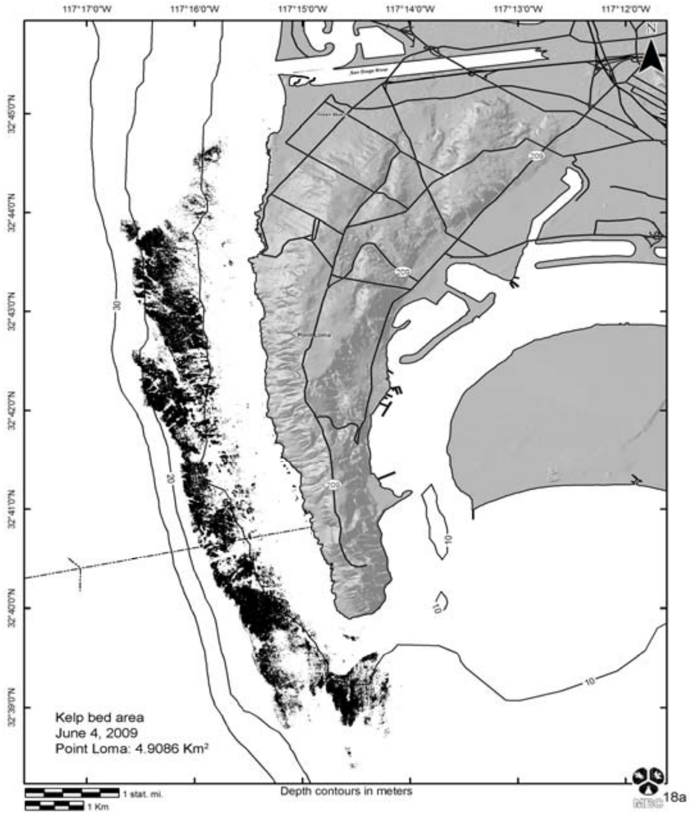

117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40'
39'
Point Loma
Kelp bed area
Point Loma: 1.9243 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
18


117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40'
39'
Point Loma
90
30
Kelp bed area
Point Loma: 2.1521 km²
22 June 2005
1 stat. mi.
1 km.
Depth contours in feet
18

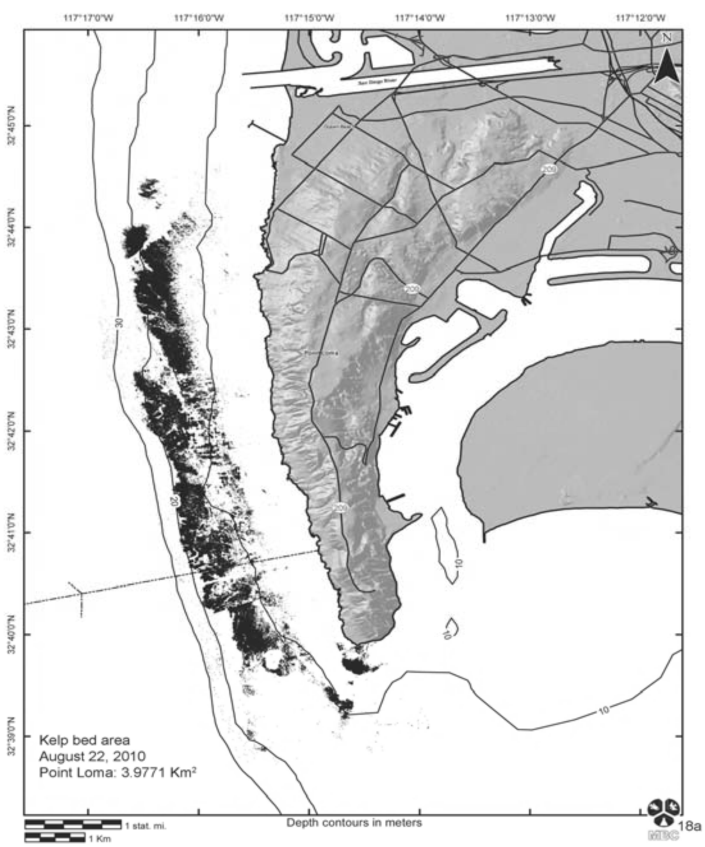

117° 17'
16'
15'
14'
San Diego Bay
32° 42'
41'
40'
39'
Point Loma
90
Kelp bed area
Point Loma: 1.7673 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MBC
18


San Diego Bay
N
Point Loma
Kelp bed area
Point Loma: 3.6162 Km²
December 14, 2007
Depth contours in meters
18

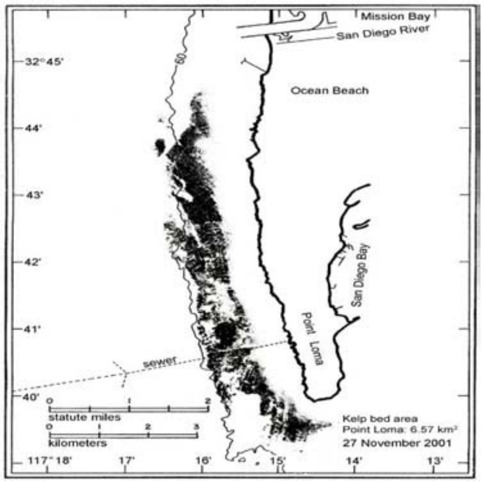

San Diego Bay
N
Point Loma
Kelp bed area
Point Loma: 6.6231 Km²
December 31, 2008
Depth contours in meters
18

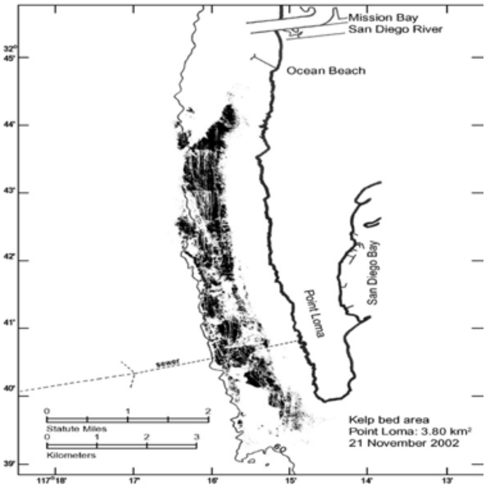


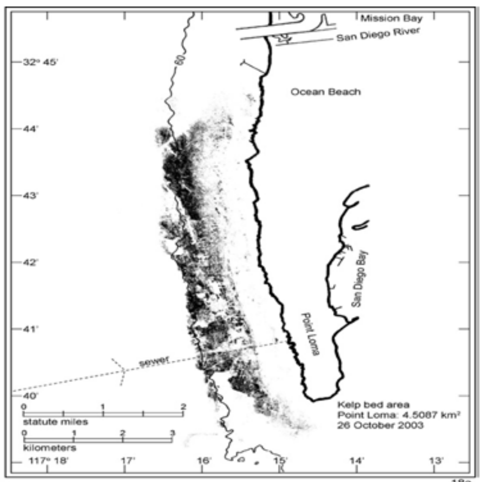
117°17'0"W
117°16'0"W
117°15'0"W
117°14'0"W
117°13'0"W
117°12'0"W
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
30
20
10
Kelp bed area
June 4, 2009
Point Loma: 4.9086 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18a



117°17'0"W
117°16'0"W
117°15'0"W
117°14'0"W
117°13'0"W
117°12'0"W
32°45'0"N
32°44'0"N
32°43'0"N
32°42'0"N
32°41'0"N
32°40'0"N
32°39'0"N
N
30
20
10
Kelp bed area
August 22, 2010
Point Loma: 3.9771 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
18a







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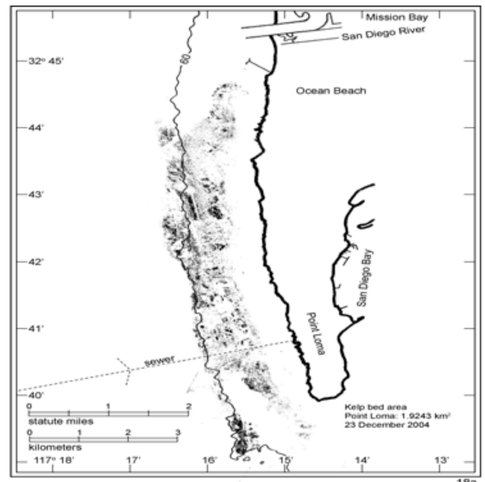

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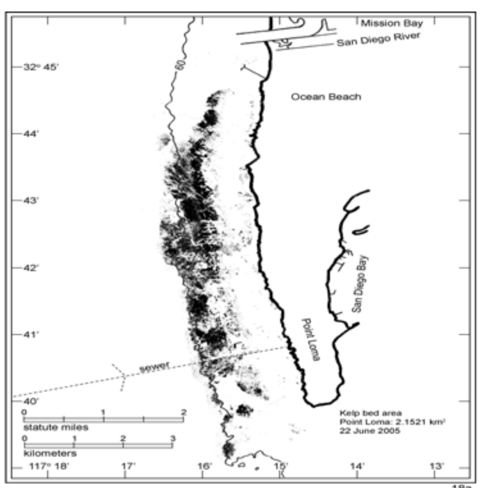

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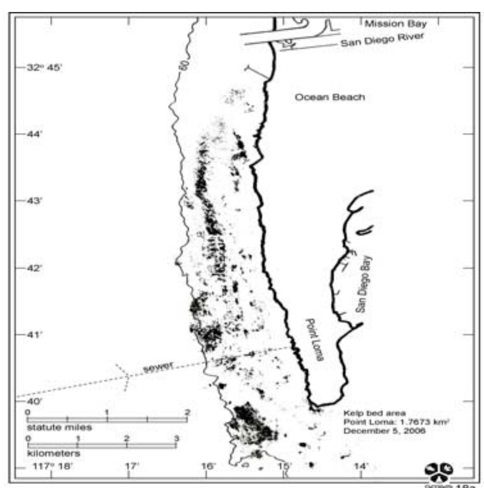

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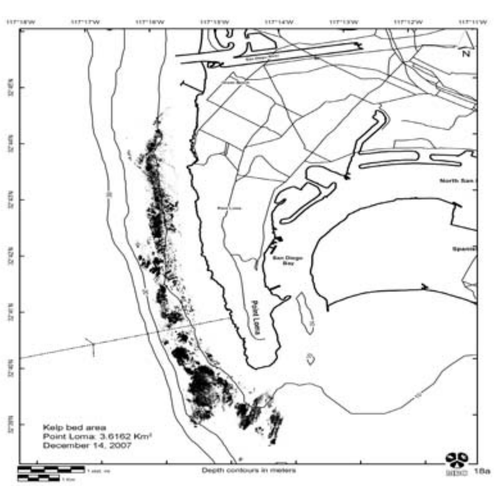

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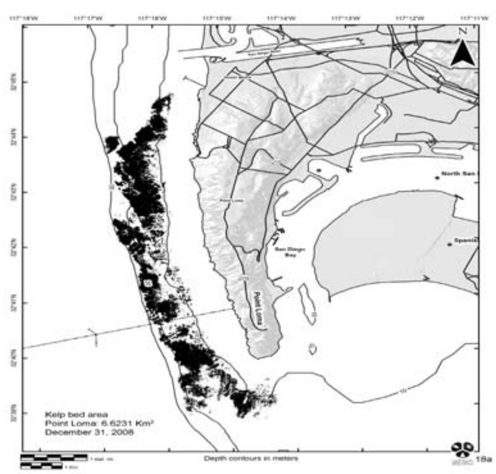

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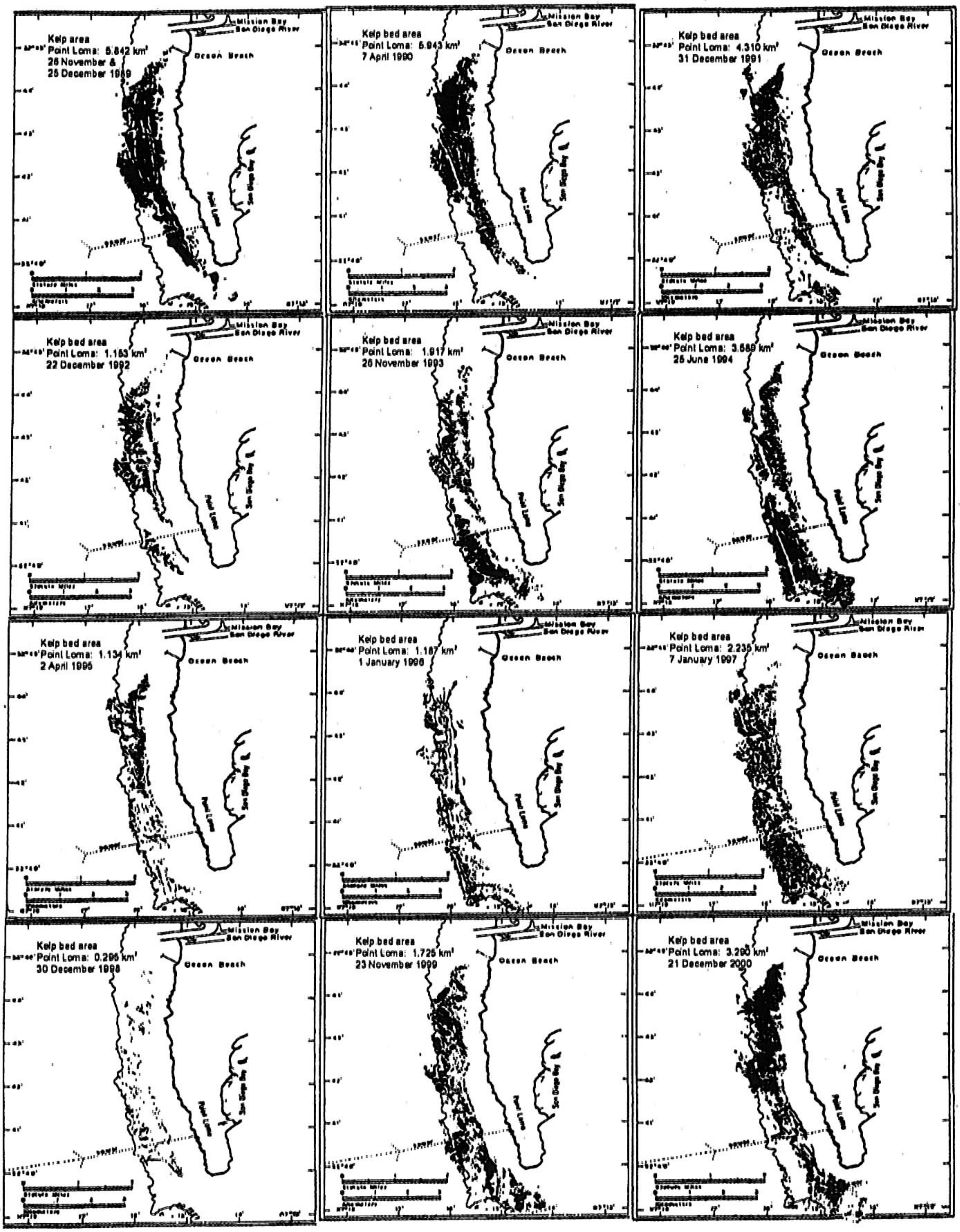
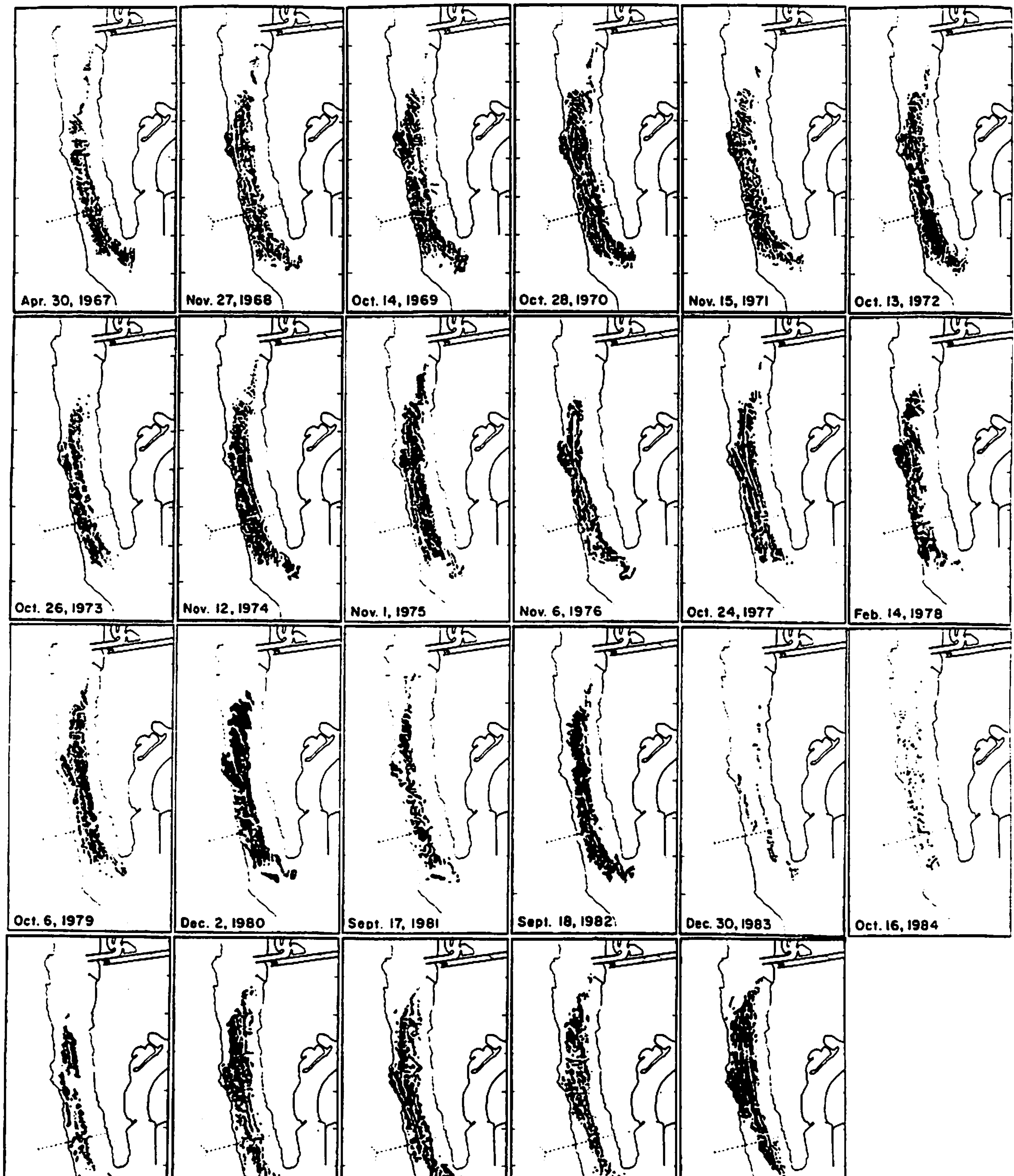
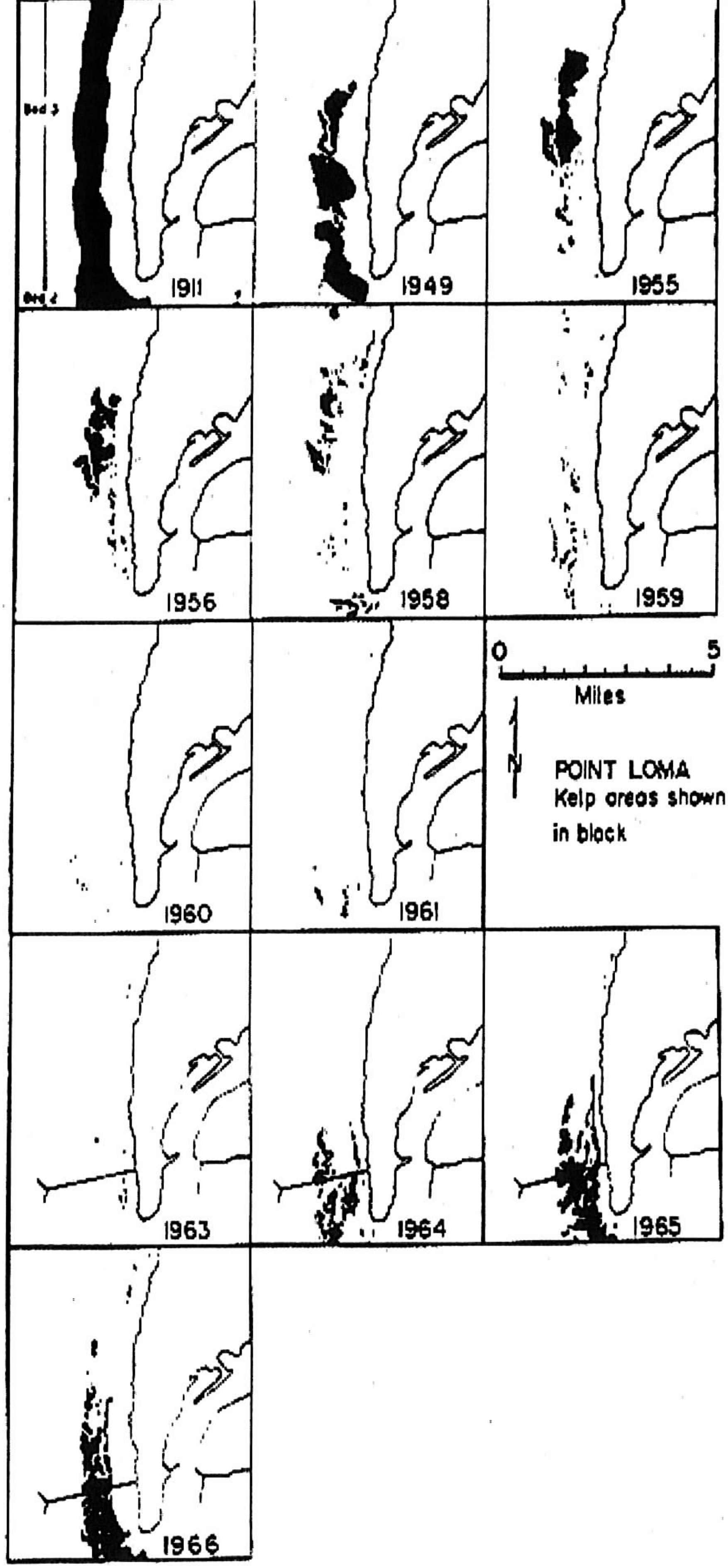
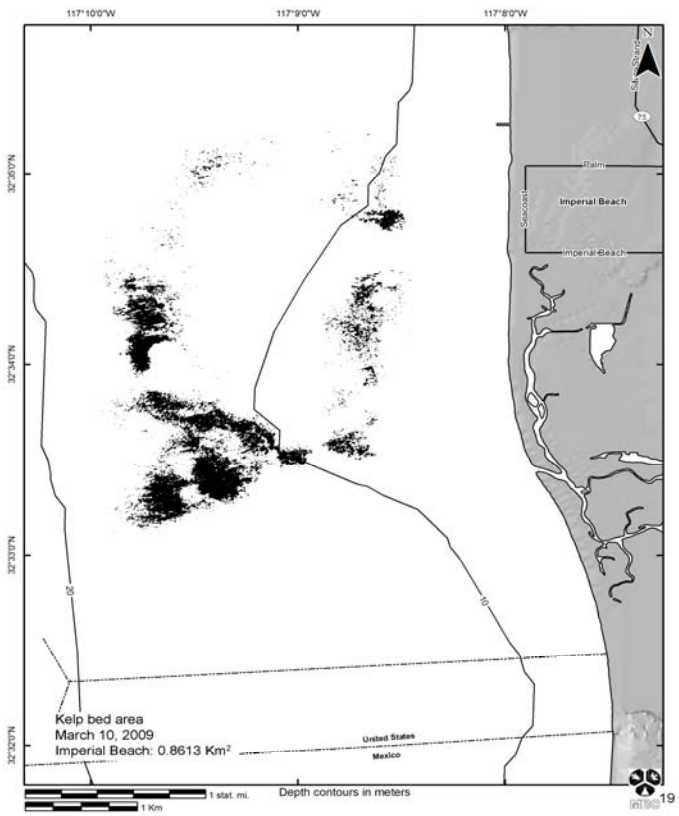

Kelp area
Point Loma: 5.842 km²
26 November &
25 December 1989
Kelp bed area
Point Loma: 5.943 km²
7 April 1990
Kelp bed area
Point Loma: 4.310 km²
31 December 1991
Kelp bed area
Point Loma: 1.153 km²
22 December 1992
Kelp bed area
Point Loma: 1.917 km²
26 November 1993
Kelp bed area
Point Loma: 3.589 km²
25 June 1994
Kelp bed area
Point Loma: 1.134 km²
2 April 1995
Kelp bed area
Point Loma: 1.187 km²
1 January 1996
Kelp bed area
Point Loma: 2.235 km²
7 January 1997
Kelp bed area
Point Loma: 0.295 km²
30 December 1998
Kelp bed area
Point Loma: 1.725 km²
23 November 1999
Kelp bed area
Point Loma: 3.290 km²
21 December 2000
Mission Bay
San Diego River
Ocean Beach
Point Loma
San Diego Bay
Statute Miles
Kilometers

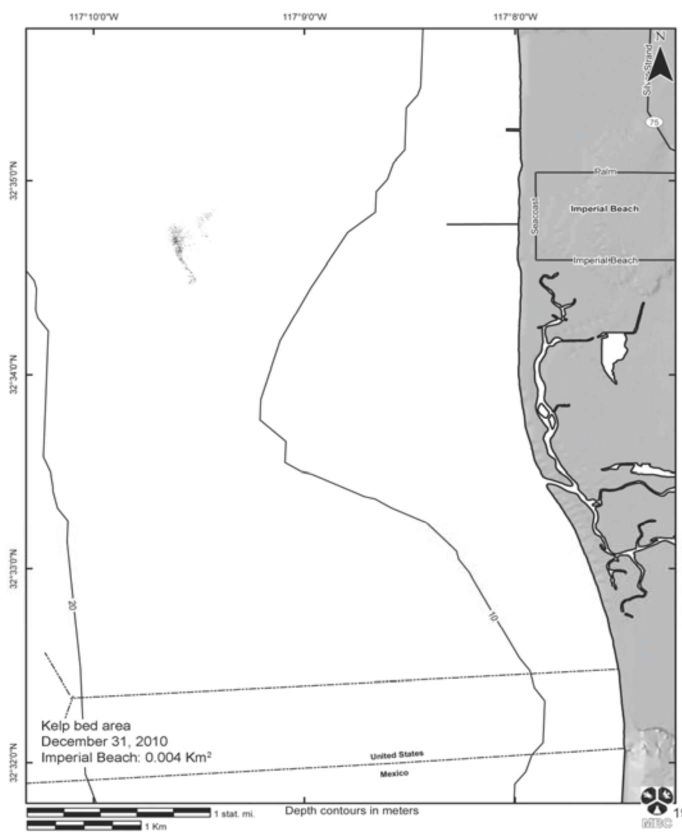


Historical charts of Pt Loma kelp from 1967 to 1989.

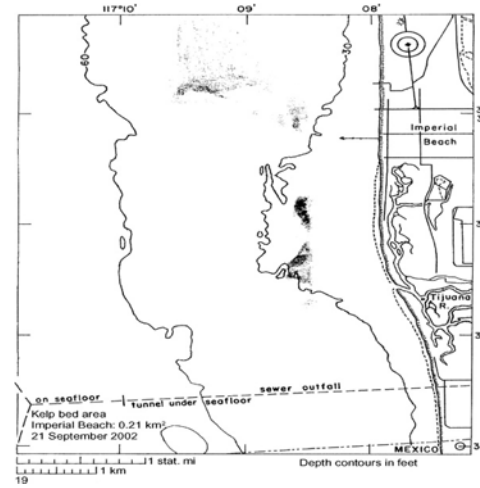


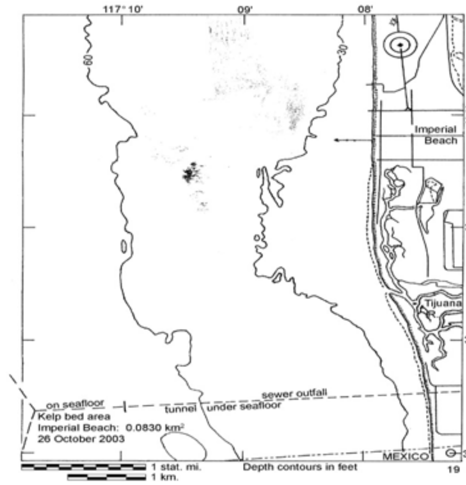
Historical charts of Pt Loma kelp from 1911 to 1989.
The years 1963 through 1965 were sketched from oblique
photos provided by Kelco Company.

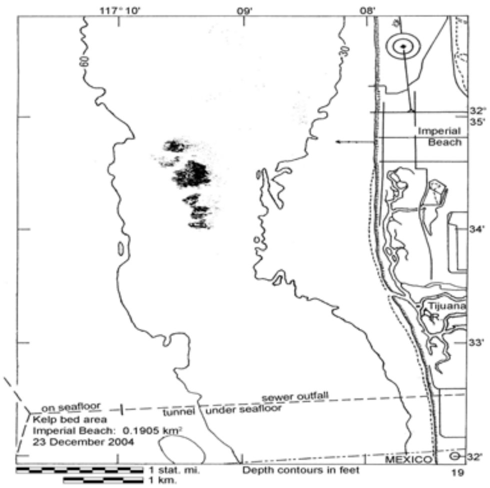

117°10'0"W
117°9'0"W
117°8'0"W
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
N
Silver Strand
75
Palm
Seacoast
Imperial Beach
Imperial Beach
20
10
Kelp bed area
March 10, 2009
Imperial Beach: 0.8613 Km²
United States
Mexico
1 stat. mi.
1 Km
Depth contours in meters
19

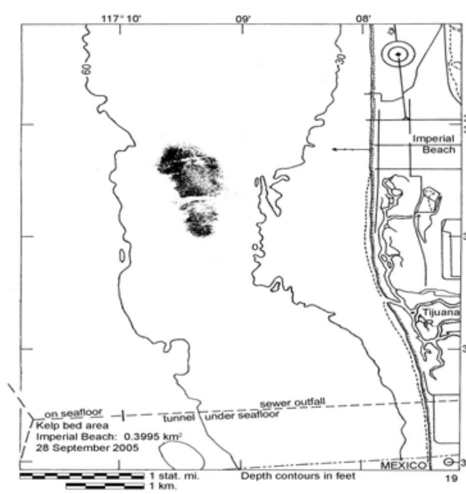

117°10'0"W
117°9'0"W
117°8'0"W
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
N
Silver Strand
75
Palm
Seacoast
Imperial Beach
Imperial Beach
20
10
Kelp bed area
December 31, 2010
Imperial Beach: 0.004 Km²
United States
Mexico
1 stat. mi.
1 Km
Depth contours in meters
19


117° 10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
sewer outfall
on seafloor
tunnel under seafloor
Kelp bed area
Imperial Beach: 0.08 km²
27 November 2001
1 stat. mi.
1 km.
Depth contours in feet
MEXICO
32'
19

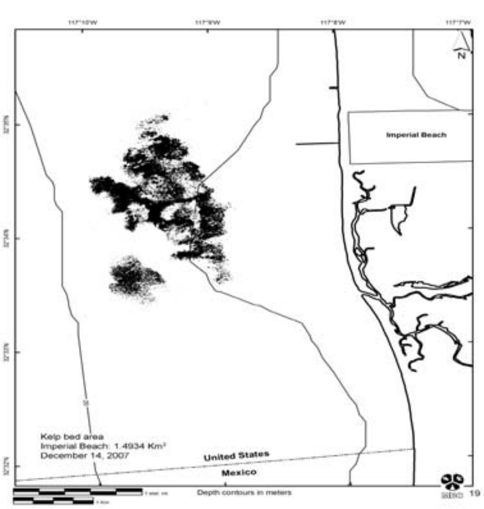

117°10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
on seafloor
Tunnel under seafloor
sewer outfall
Kelp bed area
Imperial Beach: 0.21 km²
21 September 2002
1 stat. mi
1 km
Depth contours in feet
MEXICO
32'
19

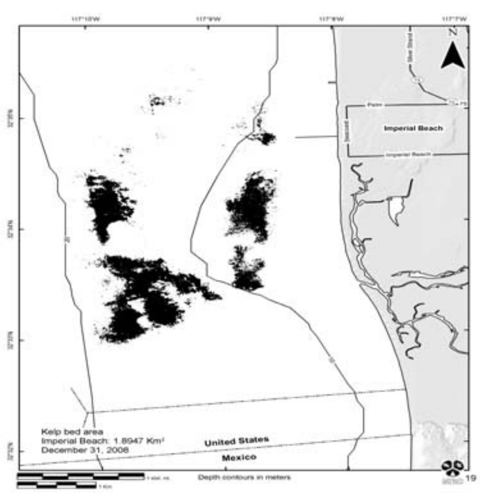

117° 10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
sewer outfall
on seafloor
tunnel under seafloor
Kelp bed area
Imperial Beach: 0.0830 km²
26 October 2003
1 stat. mi.
1 km.
Depth contours in feet
MEXICO
32'
19

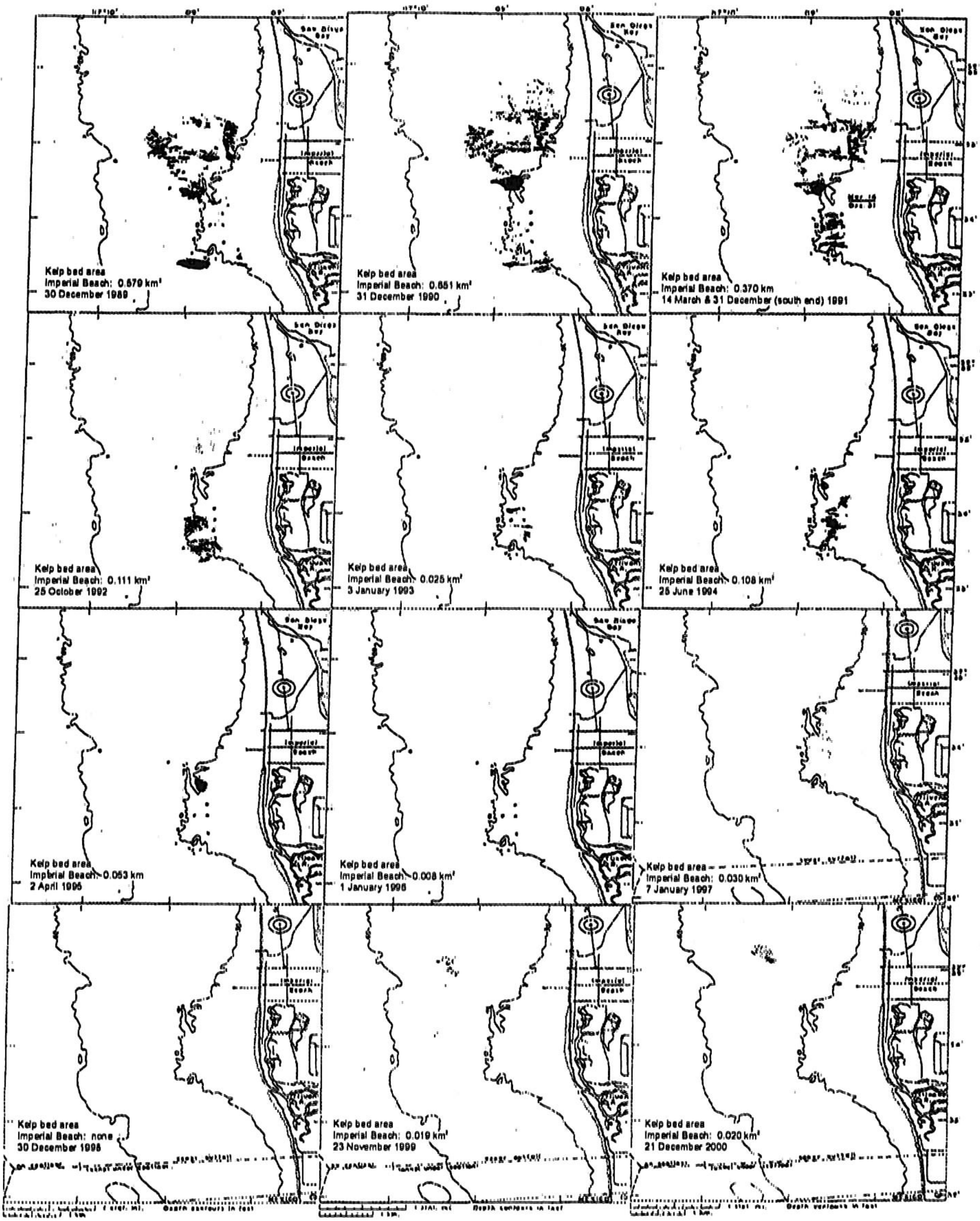

117° 10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
sewer outfall
on seafloor
tunnel under seafloor
Kelp bed area
Imperial Beach: 0.1905 km²
23 December 2004
1 stat. mi.
1 km.
Depth contours in feet
MEXICO
32'
19


117° 10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
sewer outfall
on seafloor
tunnel under seafloor
Kelp bed area
Imperial Beach: 0.3995 km²
28 September 2005
1 stat. mi.
1 km.
Depth contours in feet
MEXICO
32'
19

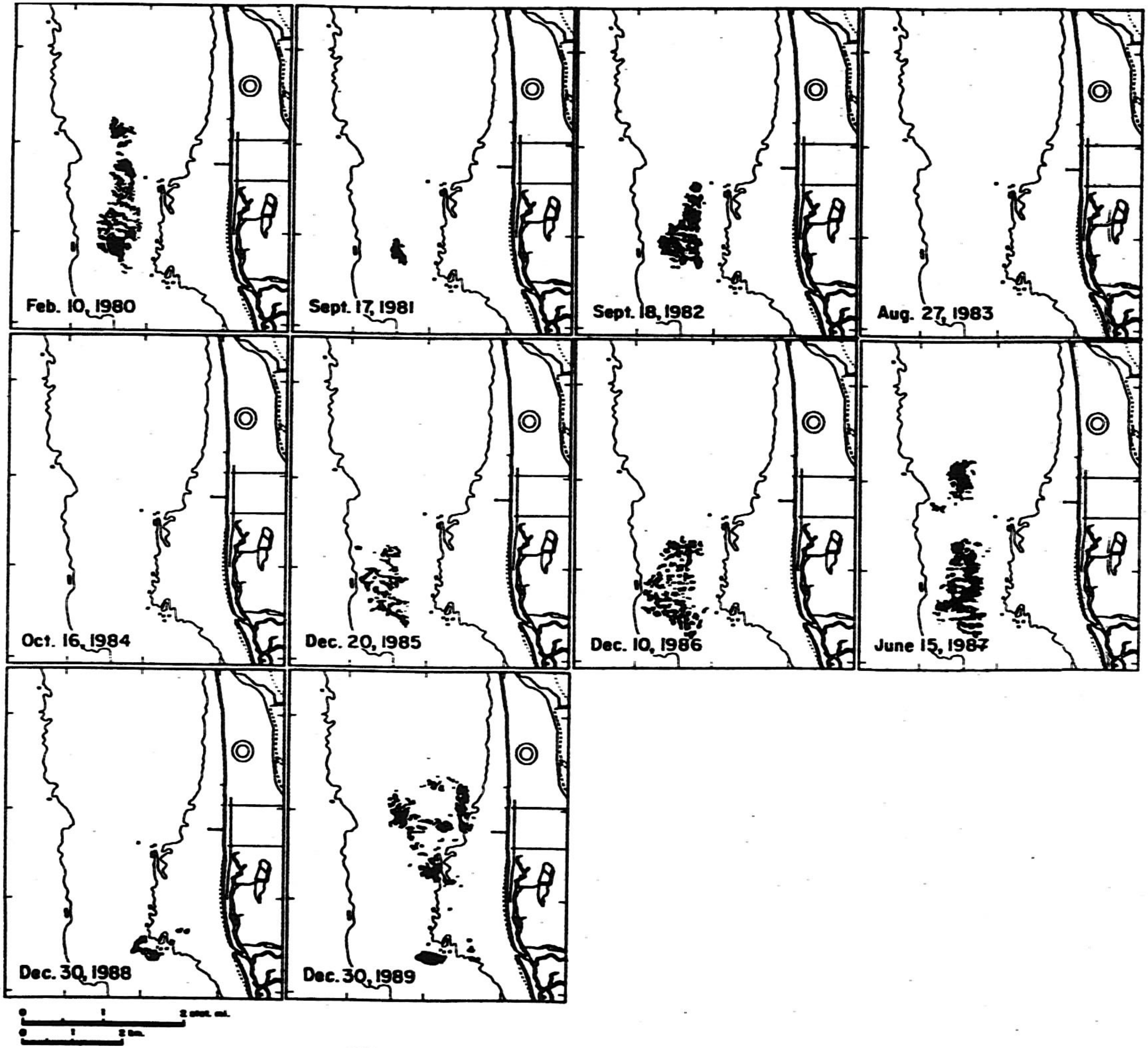

117° 10'
09'
08'
60
30
32°
35'
Imperial
Beach
34'
Tijuana
R.
33'
sewer outfall
on seafloor
tunnel under seafloor
Kelp bed area
Imperial Beach: 0.4002 km²
December 5, 2006
1 stat. mi.
1 km.
Depth contours in feet
MEXI
32'
MBC
19


117°10'W
117°9'W
117°8'W
117°7'W
N
Imperial Beach
Kelp bed area
Imperial Beach: 1.4934 Km²
December 14, 2007
United States
Mexico
Depth contours in meters
19

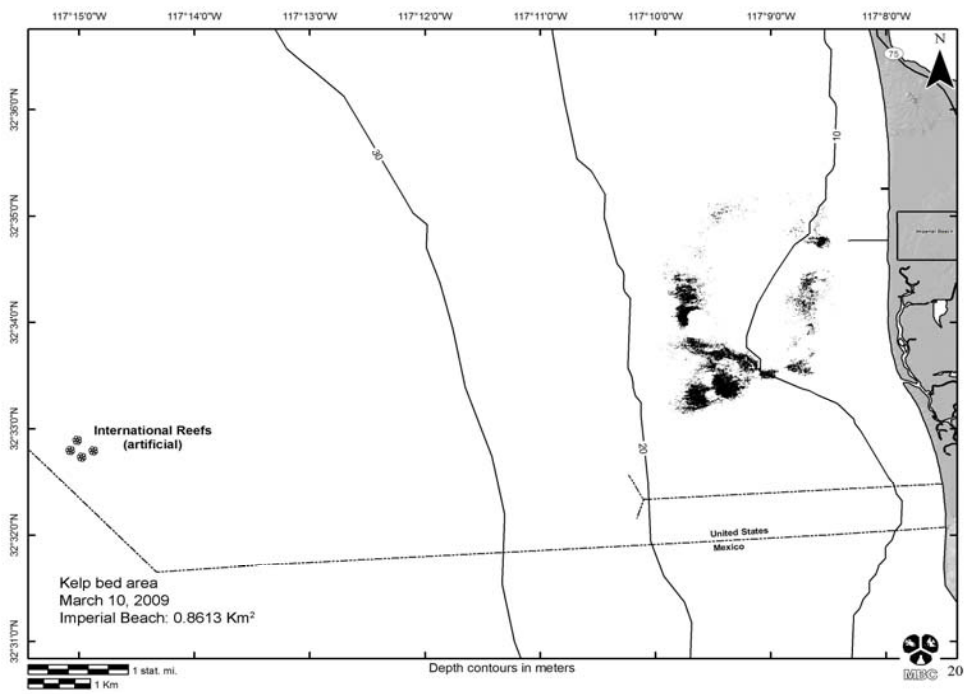

117°10'W
117°9'W
117°8'W
117°7'W
N
Imperial Beach
Kelp bed area
Imperial Beach: 1.8947 Km²
December 31, 2008
United States
Mexico
Depth contours in meters
19

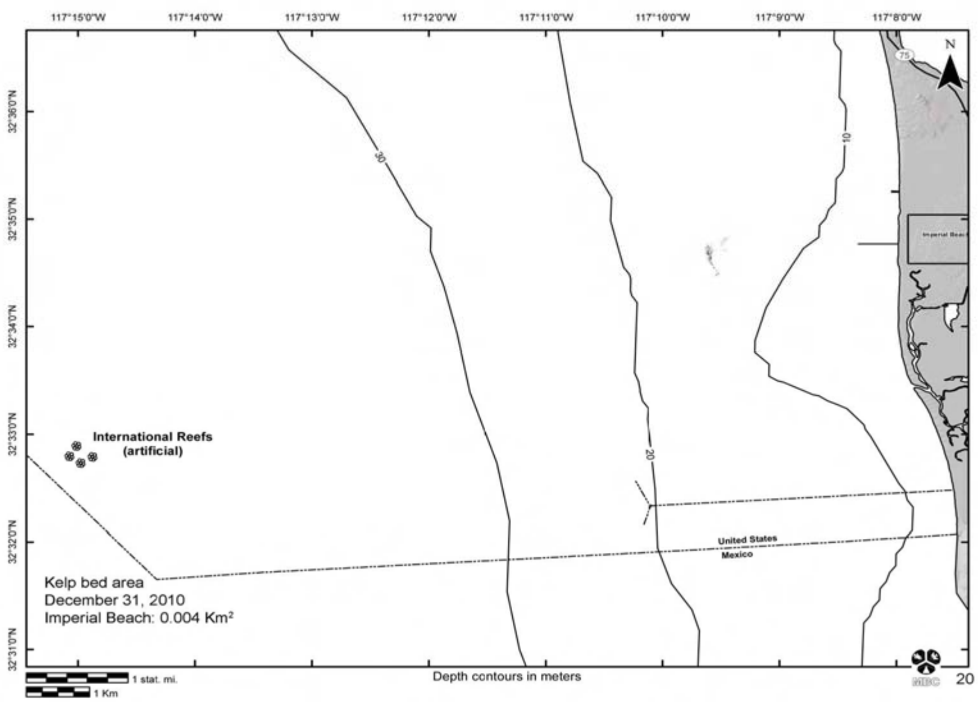


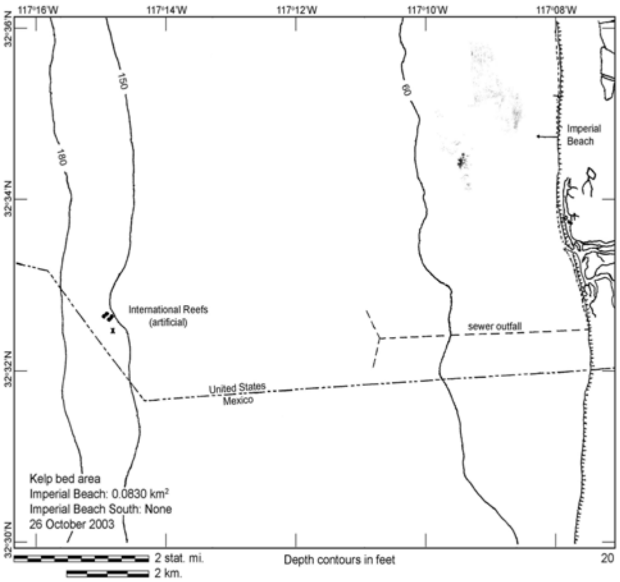
San Diego Bay
Imperial Beach
Tijuana
Kelp bed area
Imperial Beach: 0.579 km^2
30 December 1989
Kelp bed area
Imperial Beach: 0.651 km^2
31 December 1990
Kelp bed area
Imperial Beach: 0.370 km
14 March & 31 December (south end) 1991
Kelp bed area
Imperial Beach: 0.111 km^2
25 October 1992
Kelp bed area
Imperial Beach: 0.025 km^2
3 January 1993
Kelp bed area
Imperial Beach: 0.108 km^2
28 June 1994
Kelp bed area
Imperial Beach: 0.053 km
2 April 1995
Kelp bed area
Imperial Beach: 0.008 km^2
1 January 1996
Kelp bed area
Imperial Beach: 0.030 km^2
7 January 1997
Kelp bed area
Imperial Beach: none
30 December 1998
Kelp bed area
Imperial Beach: 0.019 km^2
23 November 1999
Kelp bed area
Imperial Beach: 0.020 km^2
21 December 2000
sewer outfall
Depth contours in feet

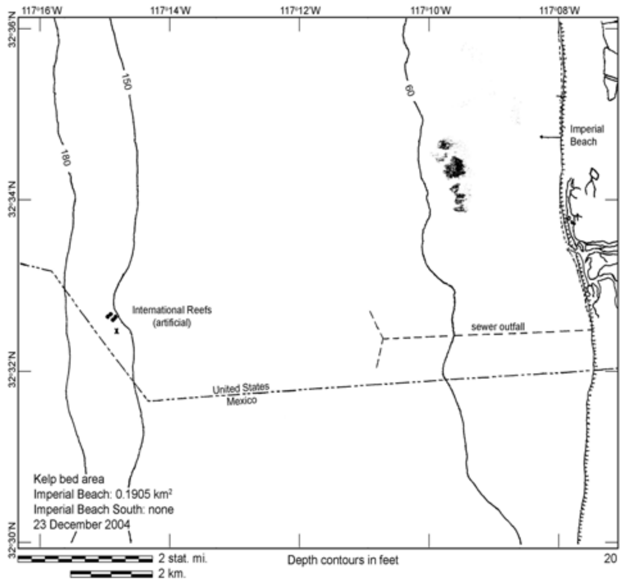


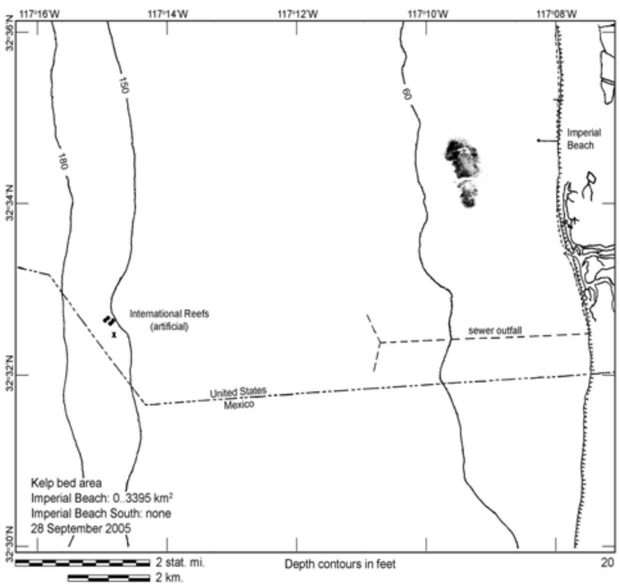
Historical charts of Imperial Beach from 1980 to 1989.

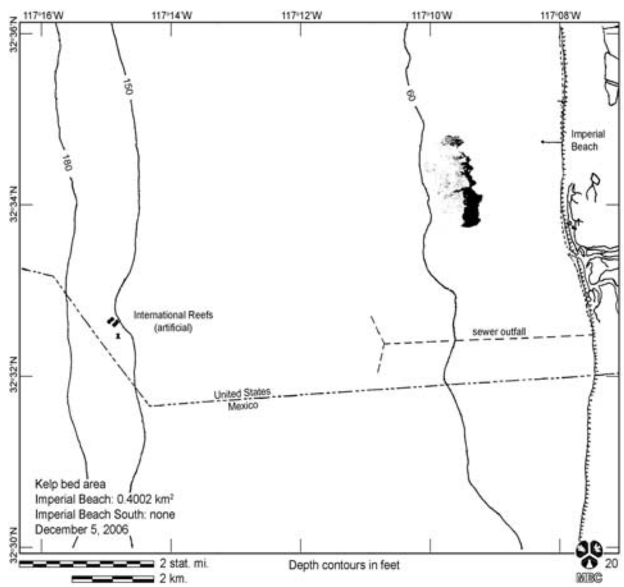

117°15'0"W
117°14'0"W
117°13'0"W
117°12'0"W
117°11'0"W
117°10'0"W
117°9'0"W
117°8'0"W
32°36'0"N
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
32°31'0"N
N
30
20
10
International Reefs
(artificial)
United States
Mexico
Kelp bed area
March 10, 2009
Imperial Beach: 0.8613 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
20

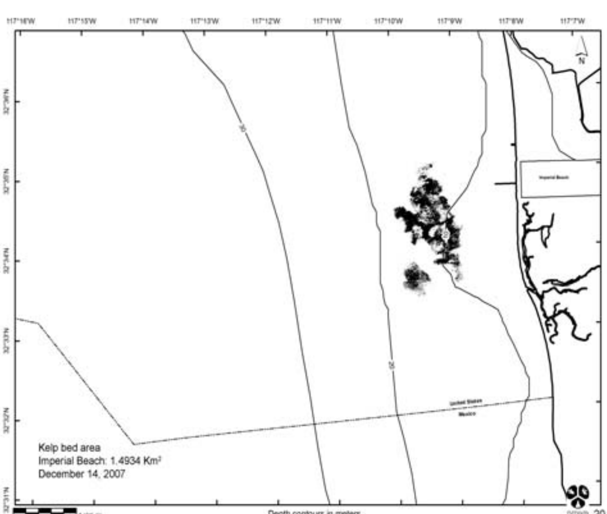

117°15'0"W
117°14'0"W
117°13'0"W
117°12'0"W
117°11'0"W
117°10'0"W
117°9'0"W
117°8'0"W
32°36'0"N
32°35'0"N
32°34'0"N
32°33'0"N
32°32'0"N
32°31'0"N
N
30
20
10
International Reefs
(artificial)
United States
Mexico
Kelp bed area
December 31, 2010
Imperial Beach: 0.004 Km²
1 stat. mi.
1 Km
Depth contours in meters
MBC
20

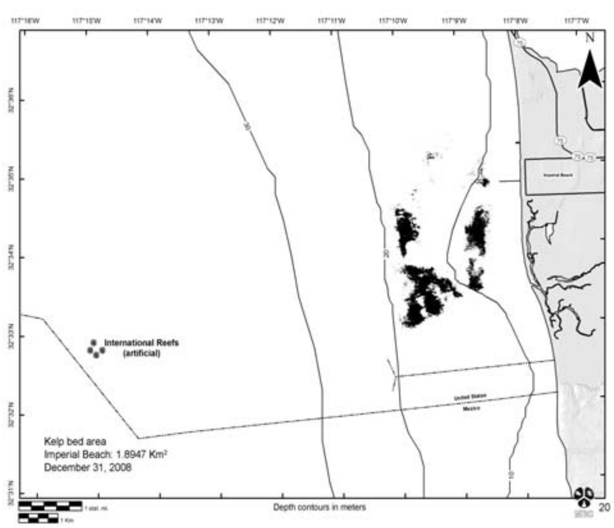

117°16'W
117°14'W
117°12'W
117°10'W
117°08'W
32°36'N
32°34'N
32°32'N
32°30'N
150
180
60
Imperial Beach
International Reefs (artificial)
sewer outfall
United States
Mexico
Kelp bed area
Imperial Beach: 0.0830 km²
Imperial Beach South: None
26 October 2003
2 stat. mi.
2 km.
Depth contours in feet
20


117°16'W
117°14'W
117°12'W
117°10'W
117°08'W
32°36'N
32°34'N
32°32'N
32°30'N
150
180
60
Imperial Beach
International Reefs (artificial)
sewer outfall
United States
Mexico
Kelp bed area
Imperial Beach: 0.1905 km²
Imperial Beach South: none
23 December 2004
2 stat. mi.
2 km.
Depth contours in feet
20


117°16'W
117°14'W
117°12'W
117°10'W
117°08'W
32°36'N
32°34'N
32°32'N
32°30'N
150
180
60
Imperial Beach
International Reefs (artificial)
sewer outfall
United States
Mexico
Kelp bed area
Imperial Beach: 0..3395 km²
Imperial Beach South: none
28 September 2005
2 stat. mi.
2 km.
Depth contours in feet
20


117°16'W
117°14'W
117°12'W
117°10'W
117°08'W
32°36'N
32°34'N
32°32'N
32°30'N
150
180
60
Imperial Beach
International Reefs (artificial)
sewer outfall
United States
Mexico
Kelp bed area
Imperial Beach: 0.4002 km²
Imperial Beach South: none
December 5, 2006
2 stat. mi.
2 km.
Depth contours in feet
20
MBC


117°16'W
117°15'W
117°14'W
117°13'W
117°12'W
117°11'W
117°10'W
117°9'W
117°8'W
117°7'W
Imperial Beach
United States
Mexico
Kelp bed area
Imperial Beach: 1.4934 Km²
December 14, 2007
Depth contours in meters
MBC
20


117°16'W
117°15'W
117°14'W
117°13'W
117°12'W
117°11'W
117°10'W
117°9'W
117°8'W
117°7'W
N
Imperial Beach
International Reefs (artificial)
United States
Mexico
Kelp bed area
Imperial Beach: 1.8947 Km²
December 31, 2008
Depth contours in meters
MBC
20

APPENDIX C

Flight Data Reports

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:**	3/2010
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	3/28/2010
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	4/2010

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - March 28, 2010**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	**Acquisition Processing Analysis Presentation**	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**March 28, 2010**			
	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:	3-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1445-1615
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.5' (-) to 1.5' (+) 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 showed a significant increase in surface extent from that observed in the December 2009 survey.
Imagery Quality/ Comments	Excellent Lens Note	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. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ______________________ Bob Van Wagenen, Director

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

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:**	6/2010
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	8/22/2010
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	8/2010

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - August 22, 2010**
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 22, 2010**			
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:	3-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1505-1630
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.0' (+) to 2.5' (+) 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 throughout and at maximium summer 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)

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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:**	10/2010
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	11/4/2010
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	11/2010

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - November 4, 2010**
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:		**November 4, 2010**			
	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:	4-6 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1500-1630
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.1' (-) to 1.2' (+) 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 throughout and at or near maximium summer 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)

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Signed: ______________________ Bob Van Wagenen, Director

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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:**	12/2010
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/31/2010
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	1/2011

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - December 31, 2010**
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 31, 2010**			
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:	1150-1306
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.2' (-) to 0.8' (-) 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 throughout and substantially larger than normal winter extent. Water sedimentation near drainages slightly reduced kelp/water contrast.
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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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 - Aprin 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)

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Signed: ______________________ Bob Van Wagenen, Director

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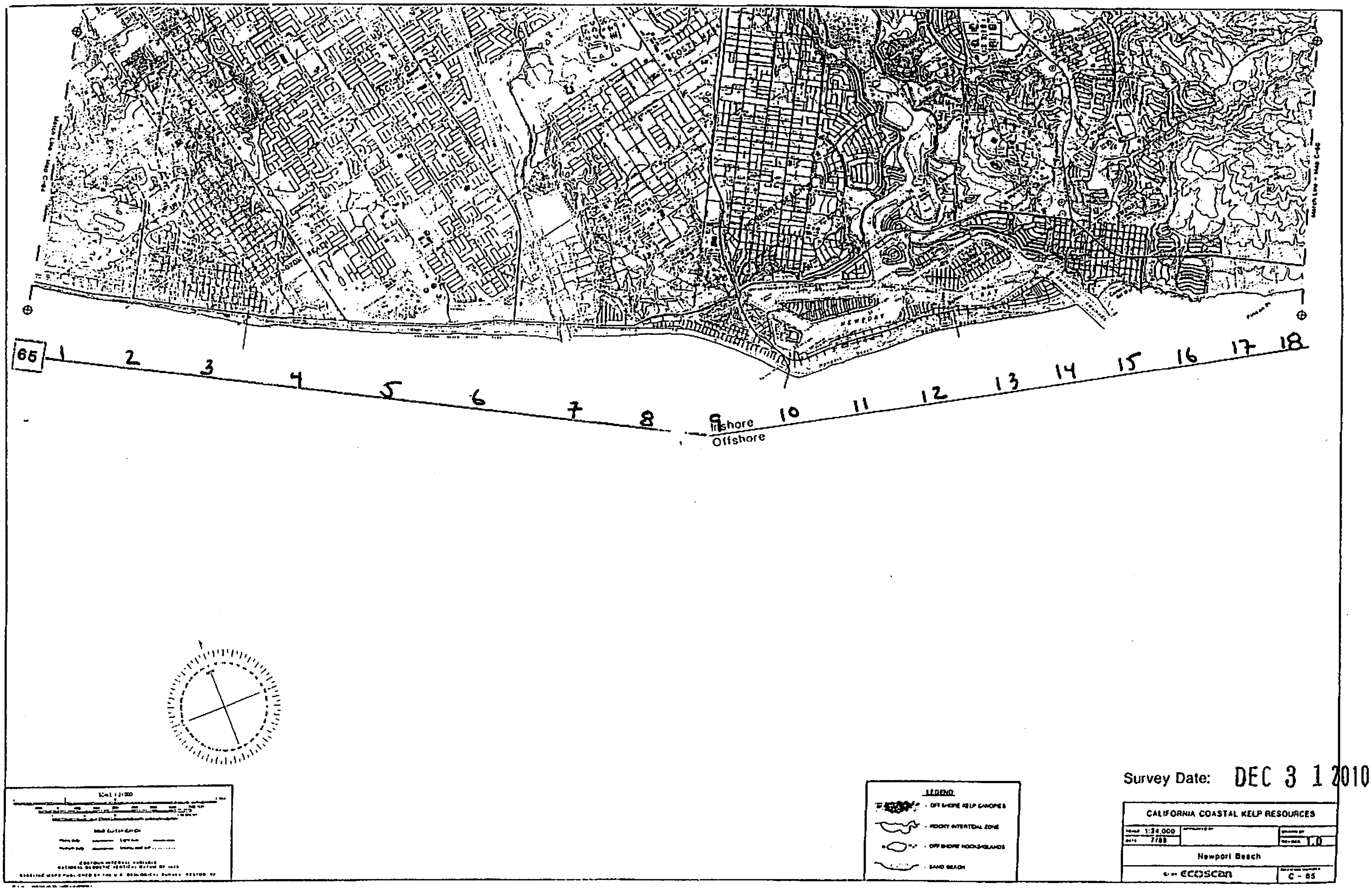
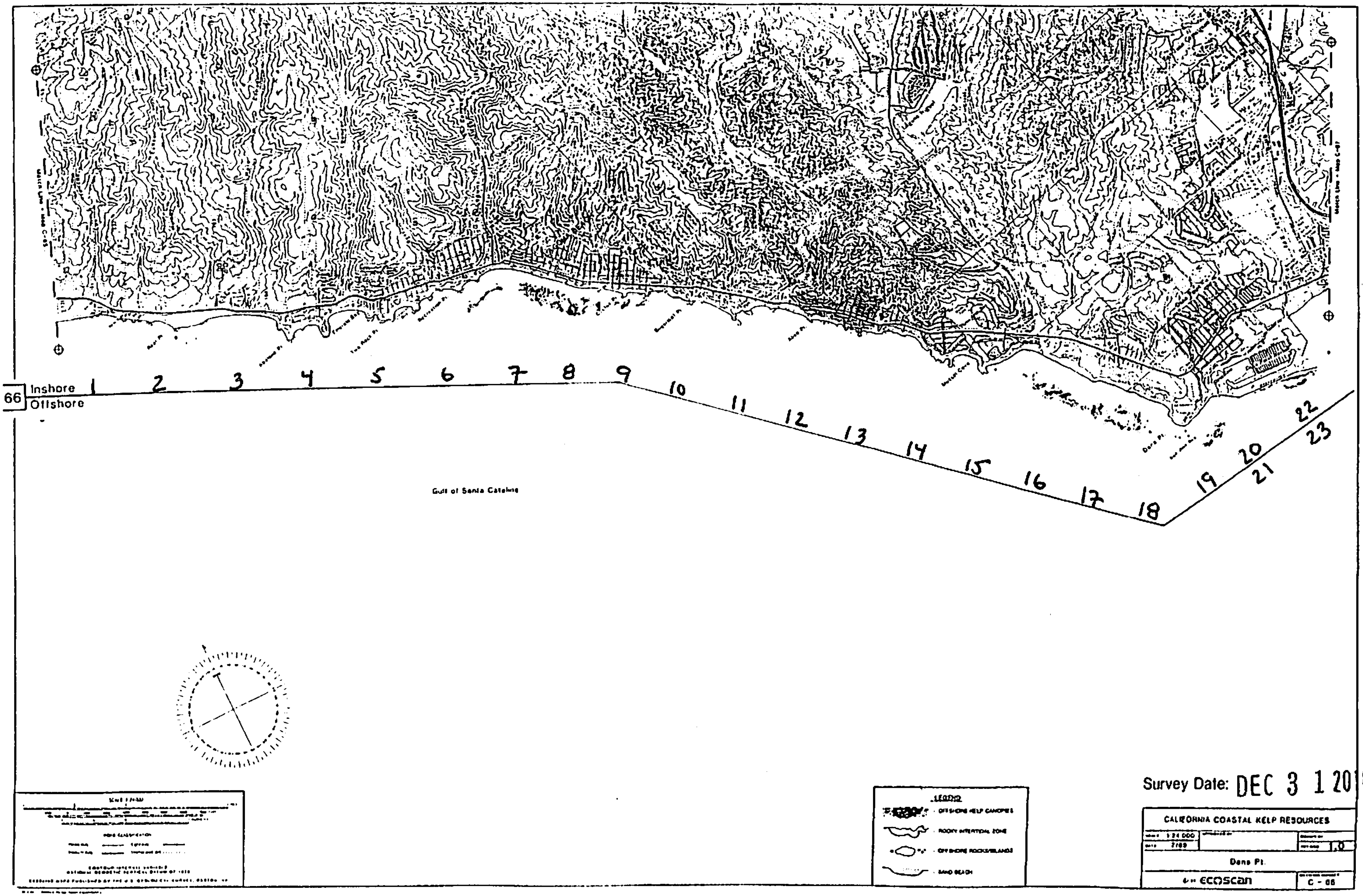
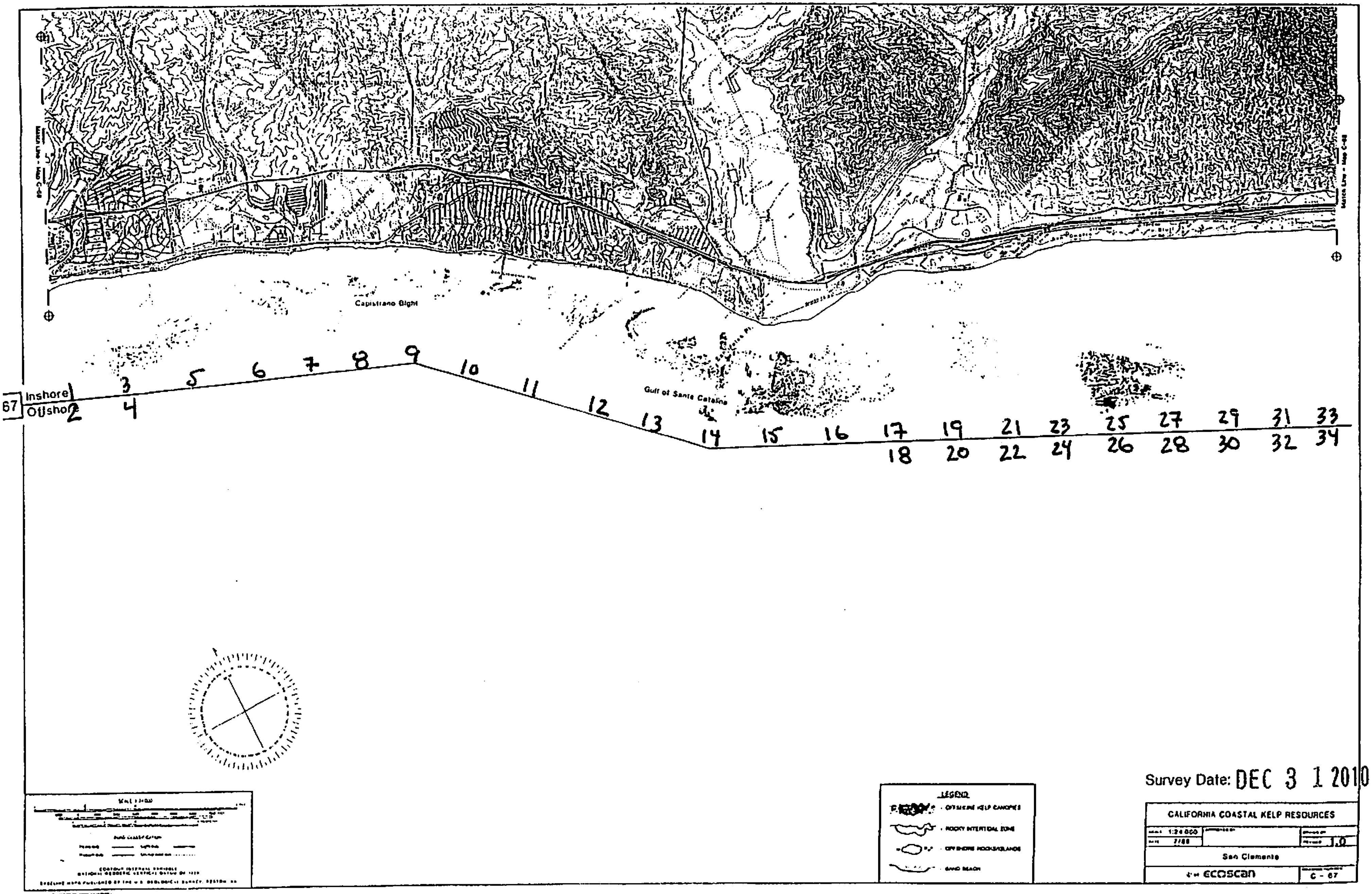
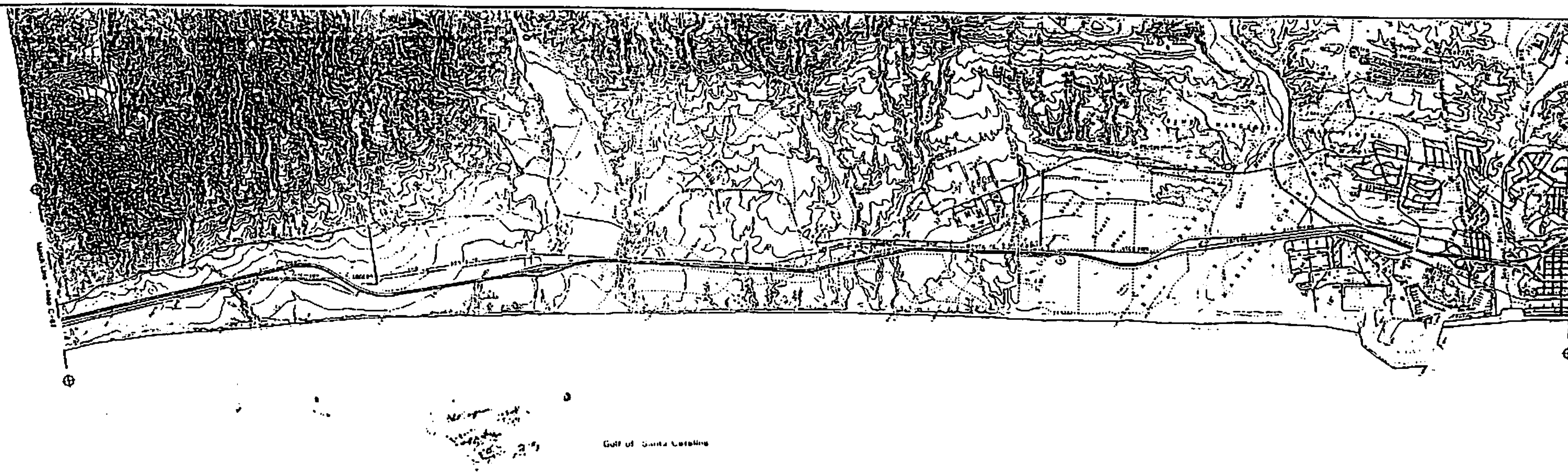


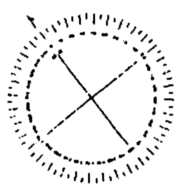
65
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Inshore
Offshore
NEWPORT
LEGEND
OFF SHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFF SHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 3 1 2010
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Newport Beach
ecoscan
C - 65


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 23
Gulf of Santa Catalina
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 3 1 2010
CALIFORNIA COASTAL KELP RESOURCES
1:24 000
7/89
1.0
Dana Pt.
ecoscan
C - 05


67
Inshore
Offshore
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
Capistrano Bight
Gulf of Santa Catalina
Survey Date: DEC 3 1 2010
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24000
7/88
1.0
San Clemente
ecoscan
C - 67



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



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

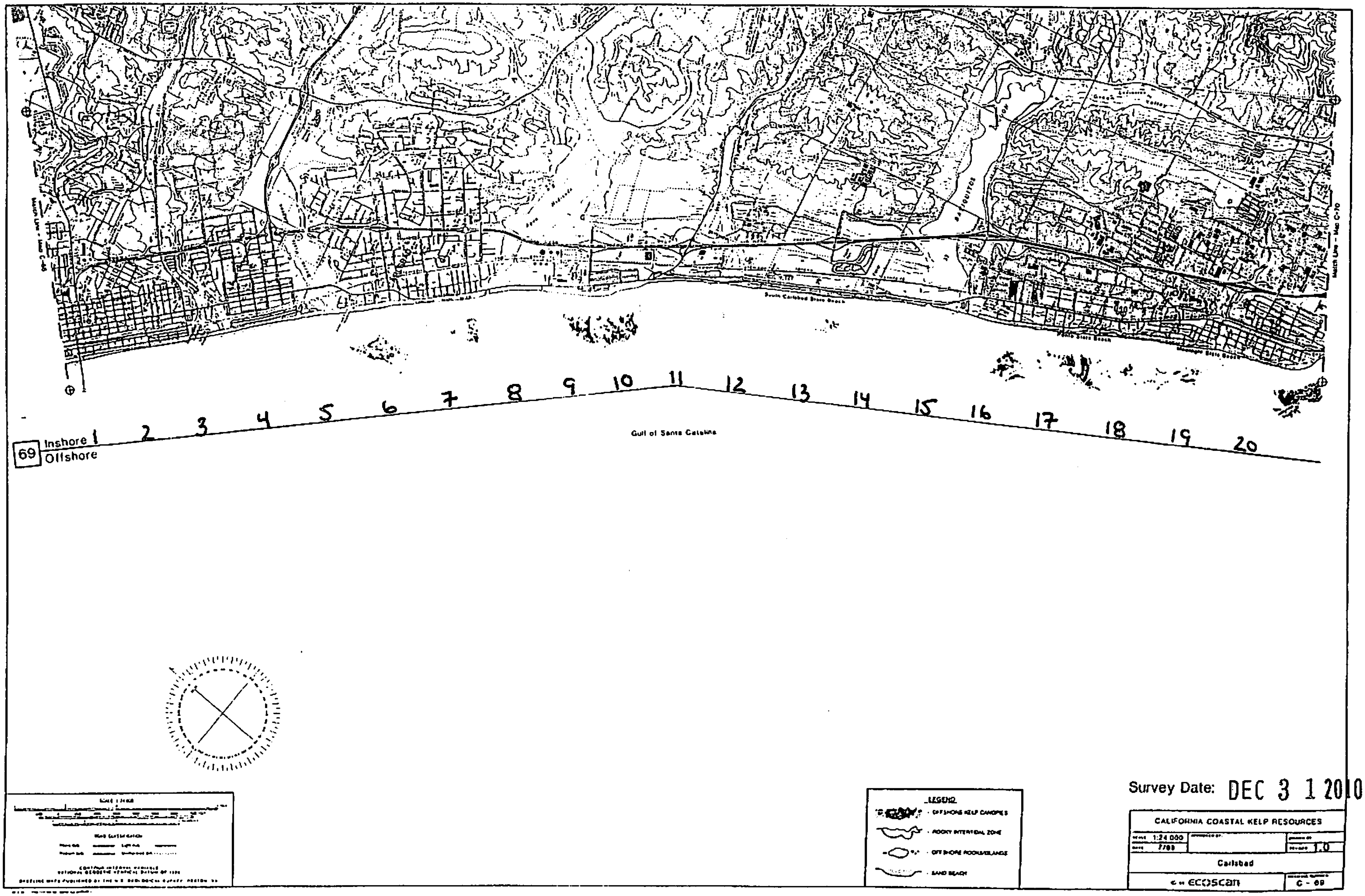
Survey Date: DEC 3 1 2010

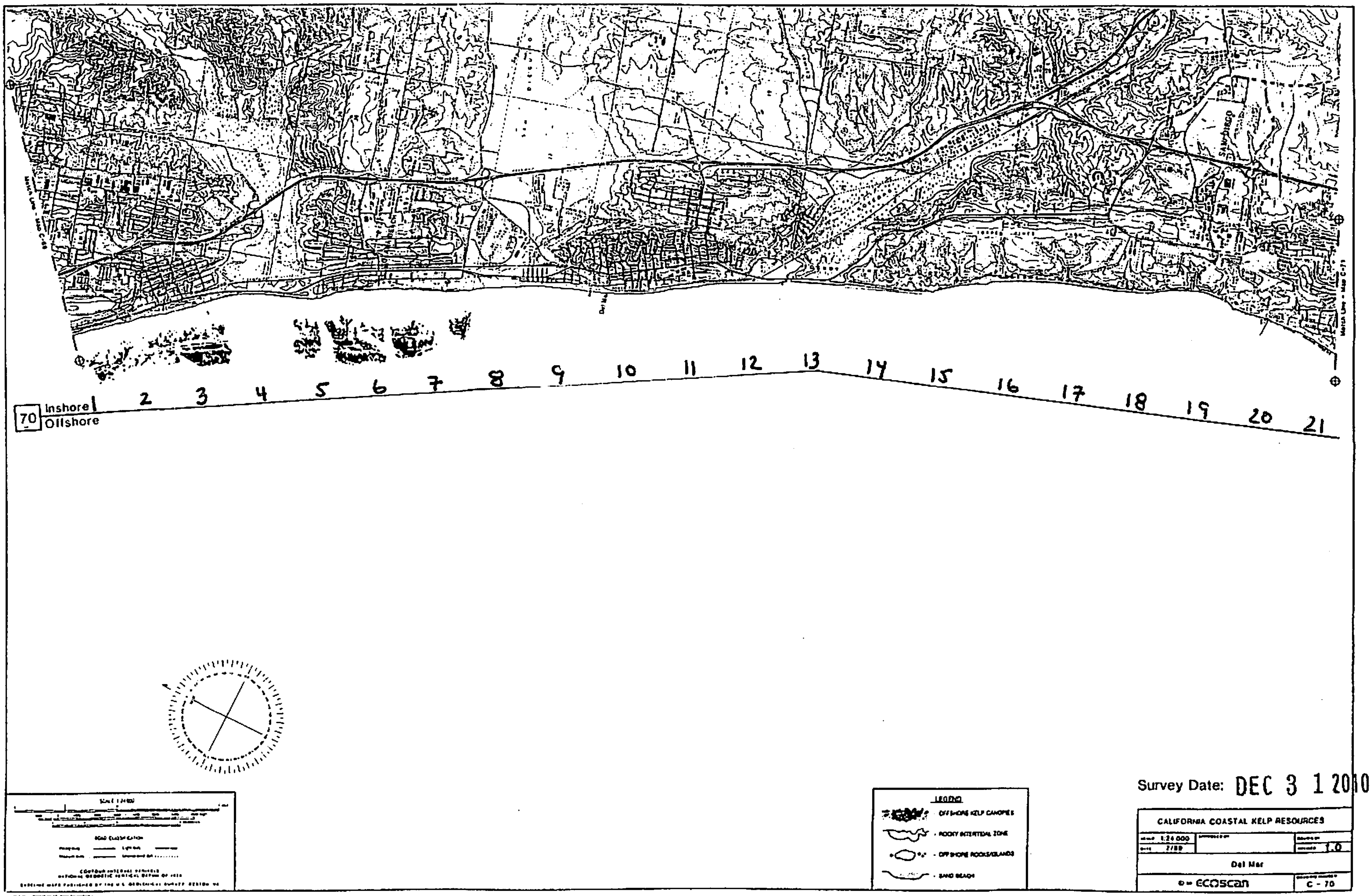
CALIFORNIA COASTAL KELP RESOURCES

1:24,000 | 7/89 | 1.0

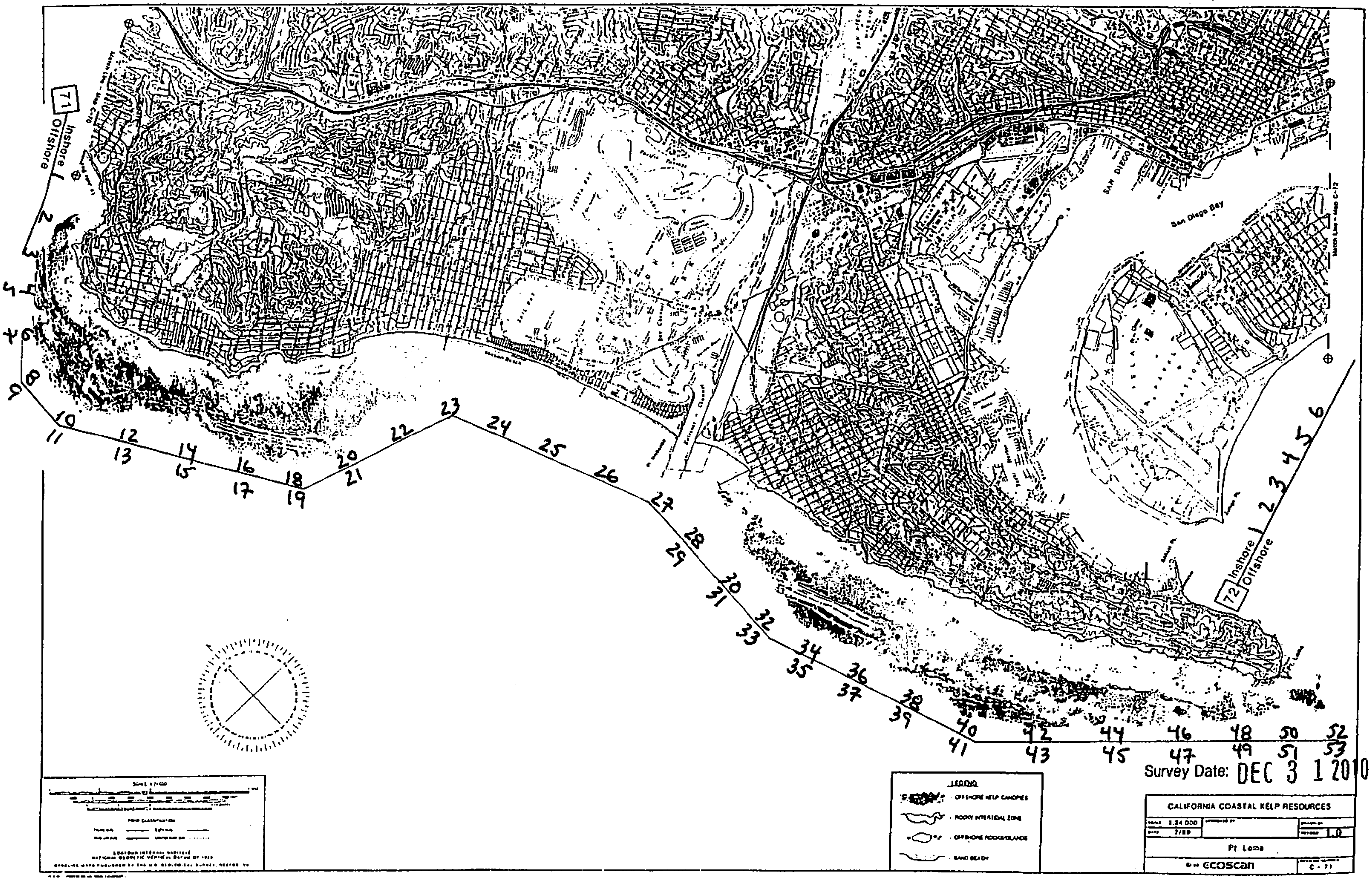
Camp Pendelton

ECOSCAN | C - 68


Inshore
Offshore
69
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Gulf of Santa Catalina
South Carlsbad State Beach
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 3 1 2010
CALIFORNIA COASTAL KELP RESOURCES
1:24 000
7/89
1.0
Carlsbad
ecoscan
C - 69



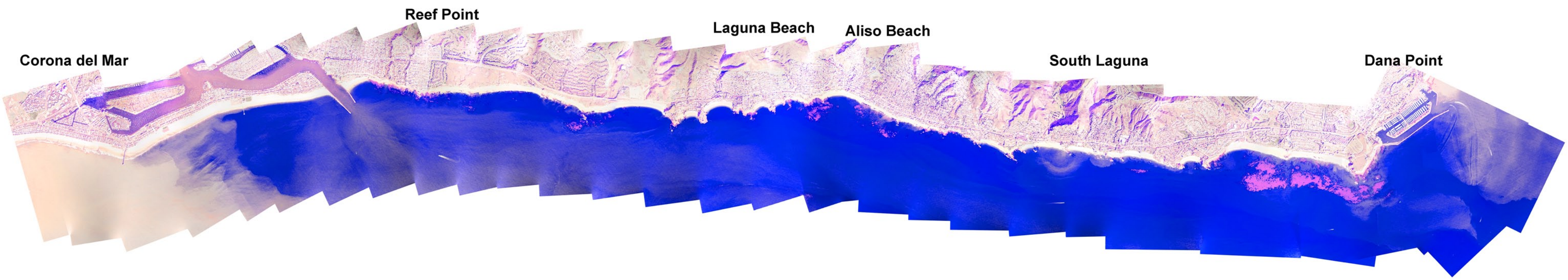
70
Inshore
Offshore
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Del Mar
SAN DIEGO
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
Survey Date: DEC 3 1 2010
CALIFORNIA COASTAL KELP RESOURCES
1:24 000
7/89
1.0
Del Mar
ECOSCAN
C - 70

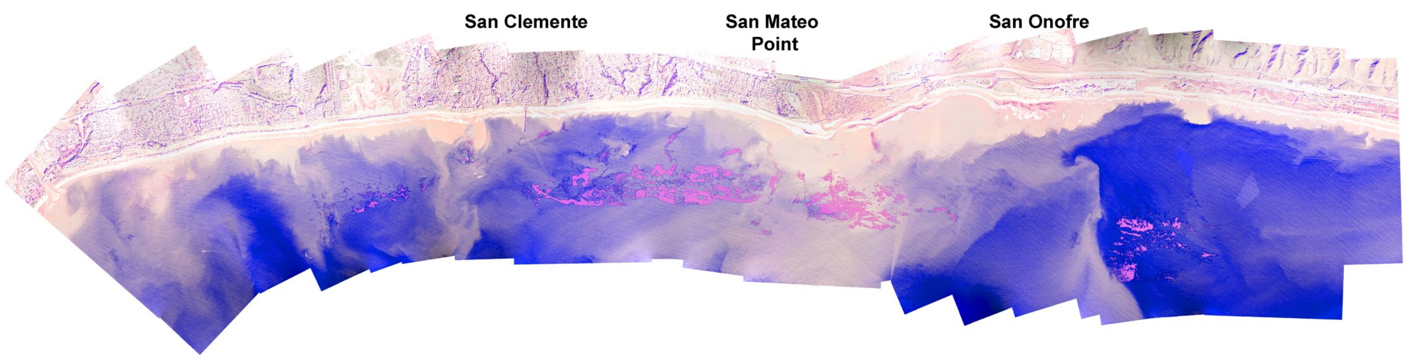

71 Inshore Offshore
72 Inshore Offshore
San Diego Bay
SAN DIEGO
Survey Date: DEC 3 1 2010
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Pt. Loma
ECOSCAN
C-71

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
Match Line - Map C-71
Survey Date: DEC 3 1 2010
CALIFORNIA COASTAL KELP RESOURCES
1:24,000
7/89
1.0
Imperial Beach
ECOSCAN
C - 72
LEGEND
OFFSHORE KELP CANOPIES
ROCKY INTERTIDAL ZONE
OFFSHORE ROCKS/ISLANDS
SAND BEACH
ROAD CLASSIFICATION
CONTOUR INTERVAL VARIABLE

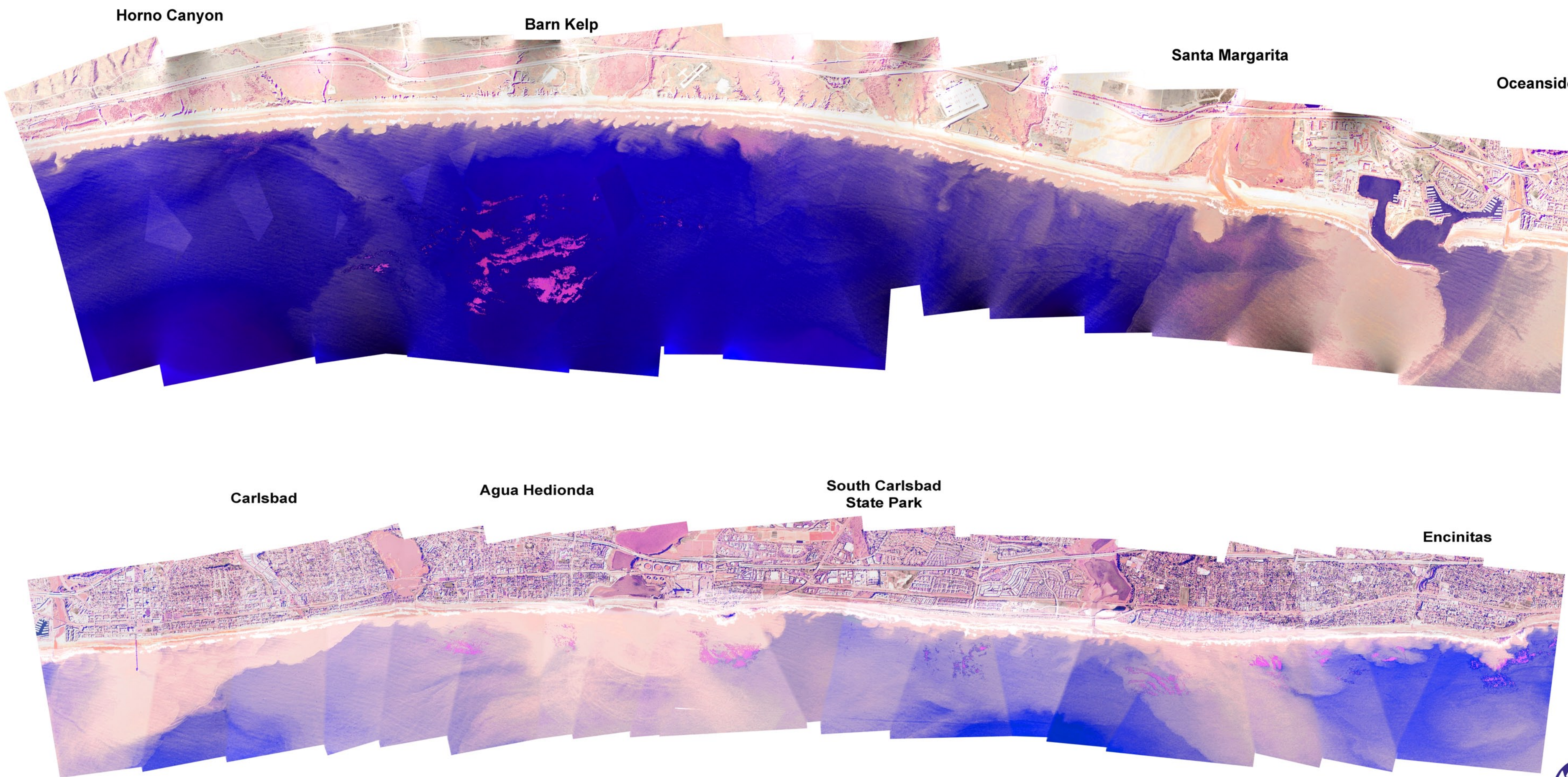
APPENDIX D

Kelp Canopy Aerial Photographs



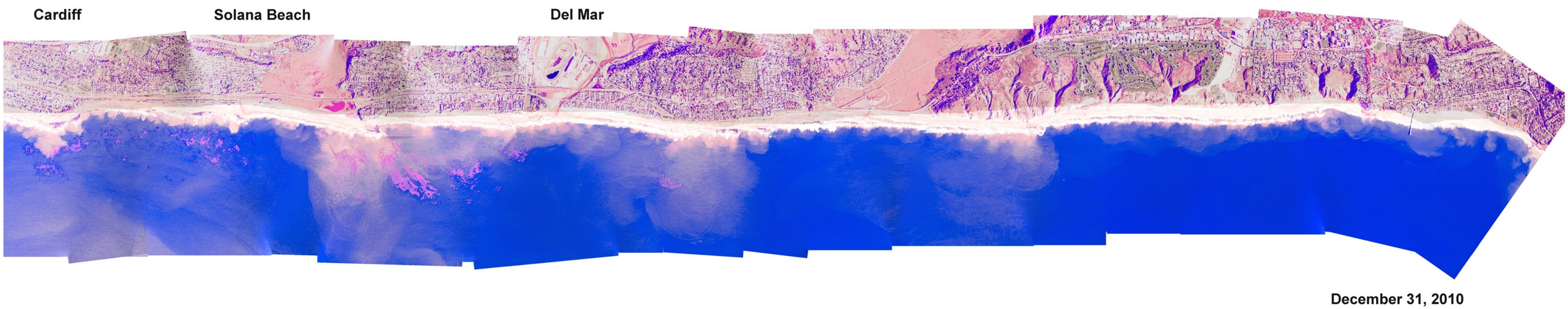


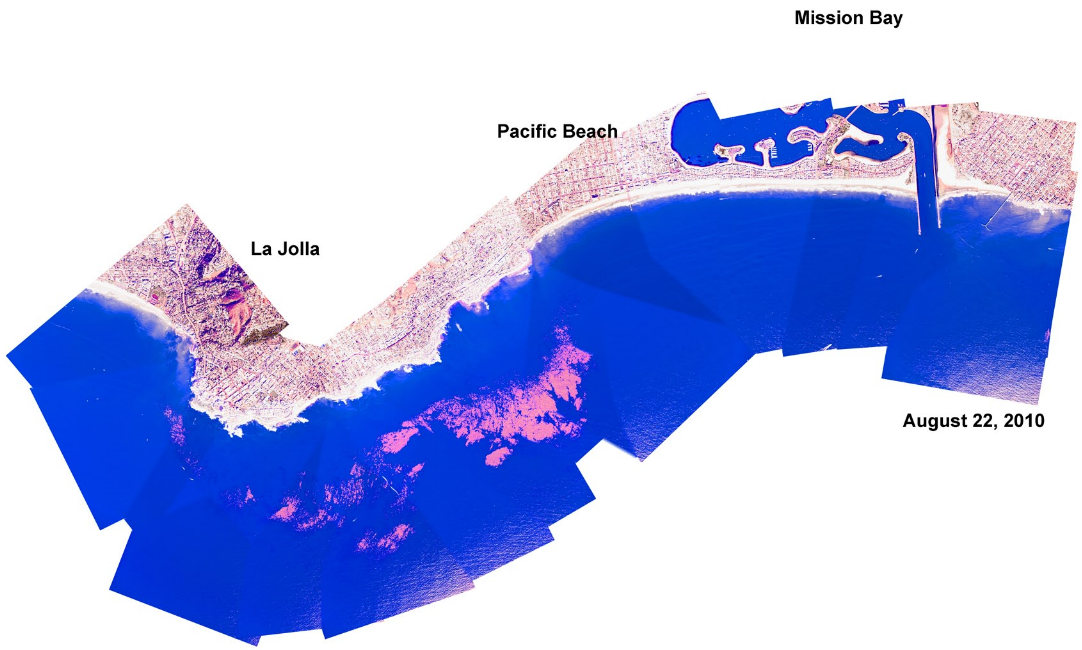
December 31, 2010



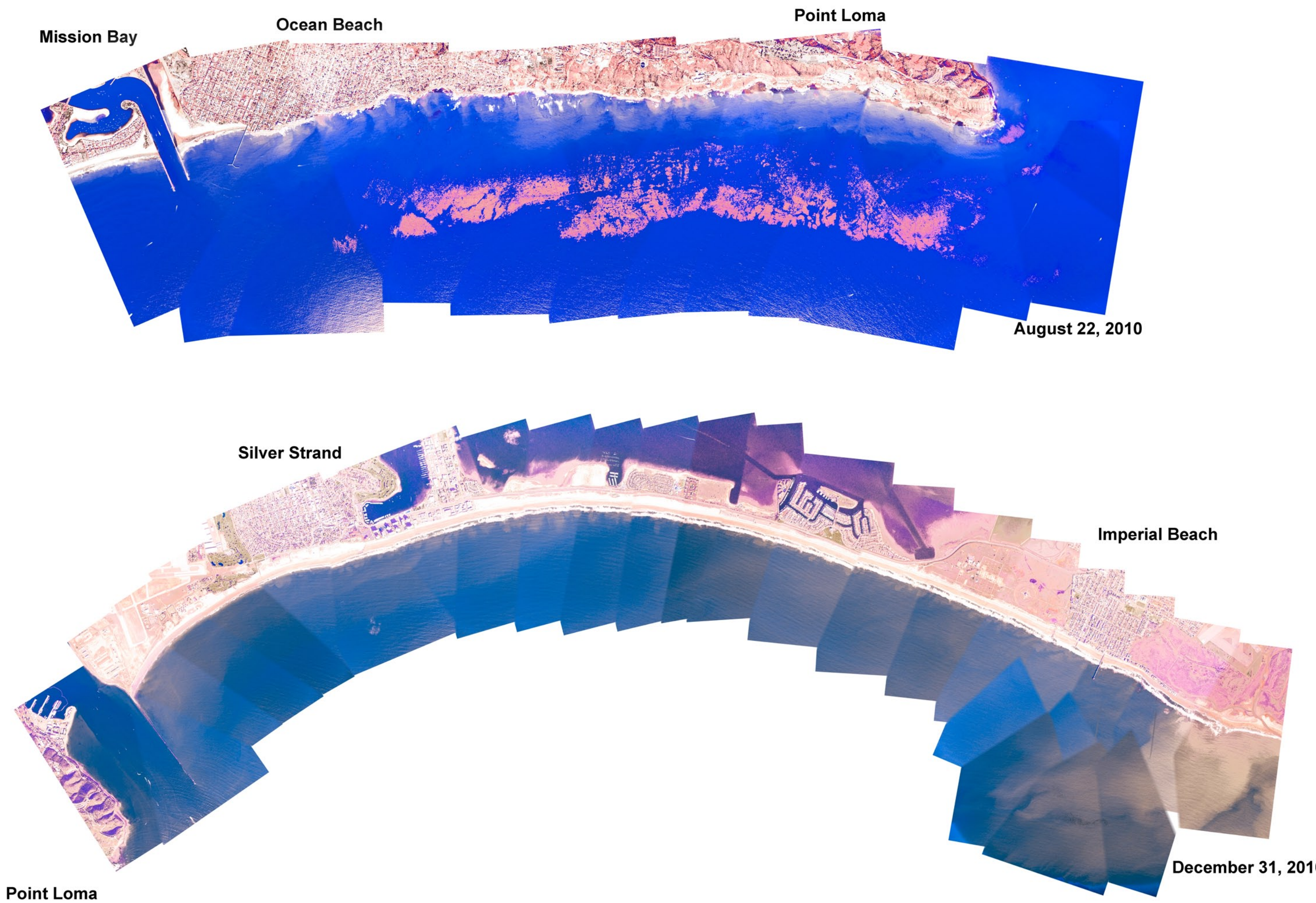
December 31, 2010

MBC


Cardiff
Solana Beach
Del Mar
December 31, 2010


Mission Bay
Pacific Beach
La Jolla
August 22, 2010

MBC


Mission Bay
Ocean Beach
Point Loma
August 22, 2010
Silver Strand
Imperial Beach
Point Loma
December 31, 2010