Status of the Kelp Beds in 2017:

Ventura, Los Angeles, Orange, and San Diego Counties

Prepared for the Central Region Kelp Survey Consortium

and

Region Nine Kelp Survey Consortium

MBC Aquatic Sciences

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EXECUTIVE SUMMARY

Giant kelp beds have been mapped quarterly off Ventura, Los Angeles, Orange, and San Diego counties for both the Central Region (CRKSC) and Region Nine Kelp Survey Consortiums (RNKSC). The CRKSC was formed in 2003 as a result of regulations from the Los Angeles Regional Water Quality Control Board (LARWQCB). The program was based on the long-established RNKSC that formed in 1983 as a result of regulations promulgated by the San Diego Regional Water Quality Control Board (SDRWQCB). When combined, the two organizations provide continuous and synoptic monitoring for approximately 355 kilometers (km) of the 435-km coastline of the Southern California Bight (SCB), from Ventura Harbor to the Mexican Border. The annual reports from 2010 through 2016 are available online at:

https://www.mbcaquatic.com/reports/southern-california-bight-regional-aerial-kelp-surveys

Aerial imaging surveys of the giant kelp beds were conducted by MBC *Applied Environmental Sciences* (MBC) on March 27, June 27, September 26, and December 27, 2017. Digital color and color infrared photos were taken of the Central Region and Region Nine coastlines during each survey. (The airspace off North Island Naval Air Station and Coronado was restricted during the December survey, but this area does not support giant kelp.) These photos were then processed and the kelp depicted on each photo was transferred to base maps to facilitate intra-annual comparisons for ease of analysis (Appendices A, D, and E). Vessel surveys of the Region Nine kelp beds were conducted on December 19-20, 2017, and January 15, 2018. In addition to visual observations of the surface canopy and subsurface kelp, more detailed in-water surveys were conducted by biologist-divers at the Del Mar and Agua Hedionda kelp beds.

MONITORING QUESTIONS

One of the objectives of the CRKSC and RNKSC programs is to answer basic monitoring questions regarding the status of kelp beds within the two regions:

1. What is the maximum areal extent of the coastal kelp bed canopies each year?
    - Central Region - maximum total kelp canopy covered 4.881 km^2 in 2017;
    - Region Nine - maximum total kelp canopy covered 3.277 km^2 in 2017.
2. What is the variability of the coastal kelp bed canopy over time?
    - Central Region:
        - maximum total kelp canopy increased in size in 2017 by 2.6% (from 4.757 km^2 to 4.881 km^2);
        - 9 kelp beds increased in size (including Las Tunas, which reappeared in 2017);
        - 12 kelp beds decreased in size;
    - Region 9:
        - maximum total kelp canopy decreased in size in 2017 by 36.2% (from 5.134 km^2 to 3.277 km^2);
        - 7 kelp beds increased in size (including North Carlsbad and Carlsbad State Beach, which reappeared in 2017);

        - o 13 kelp beds decreased in size (including Imperial Beach, which disappeared in 2017).

3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
    - Central Region
        - o no beds disappeared in 2017 that had been visible in 2016;
        - o 5 beds continued not to be visible in 2017, 2 that disappeared in 2015 (La Costa and Las Flores), 1 that disappeared in 2016 (Topanga), and 2 that have been absent historically (Horseshoe and Huntington Flats);
    - Region Nine
        - o 1 bed disappeared in 2017 that had been visible in 2016 (Imperial Beach);
        - o 4 beds continued not to be visible in 2017, 2 that disappeared in 2014 (Santa Margarita and Torrey Pines) and 2 that disappeared in 2016 (Agua Hedionda and Del Mar).
    - factors that could contribute to the disappearance of kelp beds in the Central Region and Region Nine include high water temperatures, low nutrient availability, excessive turbidity, reduced upwelling, strong wave action, amount of rainfall, and phytoplankton blooms/toxin production.
4. Are new kelp beds forming?
    - Central Region
        - o 1 bed reappeared in 2017, following a one-year absence in 2016 (Las Tunas);
    - Region 9
        - o 2 beds reappeared in 2017, following a one-year absence in 2016 (North Carlsbad and Carlsbad State Beach).
        - o the North Carlsbad kelp bed has been present every year since 2001, with the exception of 2006 and 2016;
        - o the Carlsbad State Beach kelp bed has been present every year since 2000, with the exception of 2005, 2006, and 2016.

CENTRAL REGION RESULTS

In 2017, 21 kelp beds displayed surface canopy, compared to 20 kelp beds with surface canopy in 2016 (one kelp bed reappeared in 2017, the Las Tunas bed). Of these 21 kelp beds, 12 decreased in size, while 9 increased in size. The total amount of kelp canopy in the CRKSC region increased by 2.6% (from 4.757 km^2 in 2016 to 4.881 km^2 in 2017). The largest beds in the CRKSC region are three of the Palos Verdes kelp beds, with the largest being Palos Verdes IV (Flat Rock to Palos Verdes Point) at 1.0482 km^2) (Panel A in Figure 3). The Palos Verdes I, II, III, and IV kelp beds and the Cabrillo kelp bed accounted for 73.7% (3.181 km^2) of the total CRKSC kelp coverage. The largest increase in size in 2017 was observed at Palos Verdes I kelp bed (Point Inspiration to Cabrillo), which increased by 53.1%), while the greatest decline was observed at the Malibu Point kelp bed, which decreased by 97.1%. Two kelp beds (Leo Carrillo and Cabrillo) reached their maximum size recorded since CRKSC surveys began in 2003. In 2017, nine kelp beds were at or above 40% of their historic maximum size, while six kelp beds were at less than 10% of their historic maximum size. There is no indication that wastewater treatment plant ocean discharges are impacting the health of kelp beds in the Central Region.

REGION NINE RESULTS

In 2017, 19 kelp beds displayed surface canopy, compared to 18 kelp beds with surface canopy in 2016. Two kelp beds (North Carlsbad and Carlsbad State Beach) reappeared in 2017, while one kelp bed (Imperial Beach) disappeared. Nearly twice as many kelp beds decreased in size than increased in size (13 versus 7). The total amount of kelp canopy in the RNKSC region declined by 36.2% (from 5.134 km^2 in 2016 to 3.277 km^2 in 2017). The largest beds in the RNKSC region are the La Jolla and Point Loma kelp beds, with Point Loma being the largest (1.784 km^2). These two large kelp beds accounted for 75.8% (2.481 km^2) of the total RNKSC kelp coverage in 2017. The largest increase in size was observed at the Encina Power Plant kelp bed (+177.8%), while the greatest decline was observed at the Capistrano Beach kelp bed (-96.7%). Only one kelp bed (North Laguna Beach) was above 40% of its historic maximum size, while 11 kelp beds were at less than 10% of their historic maximum size and five more were at less than 15% of the historic maximum.

CONCLUSIONS

In the Central Region, the total combined kelp surface canopy increased slightly (by 1.9%) in 2017. However, more individual beds decreased in size than increased in size. Ten kelp beds exceeded 40% of their historical maximum size, including three beds that reached the highest level recorded since surveys began in 2003, while only six kelp beds declined to less than 10% of their maximum size. The total kelp coverage in the Central Region has been at or above the long-term average every year for the past 10 years, although for the past three years it has been 18 to 27% below the high level recorded in 2009 (6.406 km^2).

In Region Nine, the total kelp coverage decreased by 36.2% in 2017, continuing the decline that began in 2014. After peaking at a size of 17.064 km^2 in 2013, the kelp bed area has decreased by 80.8% over the past four years. Twice as many individual kelp beds decreased in size than increased in 2017. Only one kelp bed exceeded 40% of the historical maximum, while 11 kelp beds declined to less than 10% of their maximum size.

Water temperatures throughout the CRKSC and RNKSC areas generally were warmer than average throughout all of 2017, particularly from January through March, and October through December. However, there were occasional periods of cooler than normal water temperatures in both regions, likely associated with upwelling events, from April through August. Daily SST values in both areas rarely fell below 14ºC, a threshold below which nutrient availability is much greater than at higher water temperatures. Based on relatively low NQ Index scores, nutrient availability remained below average in most CRKSC and RNKSC areas in 2017, as has been the case since 2013. Upwelling was strong, particularly in April and June, which may have produced higher nutrient availability in certain areas.

I - INTRODUCTION

Giant kelp (*Macrocystis pyrifera*) beds along most of the southern California mainland coast have been mapped quarterly by the Central Region Kelp Survey Consortium (CRKSC) since 2003 and by the Region Nine Kelp Survey Consortium (RNKSC) since 1983. The CRKSC and RNKSC participants agreed that the monitoring programs would be methodologically based upon aerial kelp surveys that were conducted since 1967 by the late Dr. Wheeler J. North. Since 2003, the two consortia monitoring programs have provided continuous coverage of the kelp beds along approximately 354 of the 435 km (220 of the 270 miles) of the southern California mainland coast from Ventura Harbor to the U.S./Mexico Border.

I.1 - CENTRAL REGION KELP BEDS

The CRKSC program area extends from Ventura Harbor (also referred to as Ventura Marina) in Ventura County south to Abalone Point in northern Laguna Beach in Orange County, and recognizes 26 designated existing or historic kelp beds (Figure 1), including 3 (Sunset, Horseshoe, and Huntington Flats) that have been missing or greatly reduced since the first half of the 20^{th} century (MBC 2004*a*–2012*a*). The kelp surrounding the breakwaters of the Ports of Los Angeles and Long Beach (POLA-POLB) was added as a designated kelp bed in the CRKSC surveys upon realization in 2005 that considerable giant kelp was present in the Ports. Several additional kelp beds associated with harbors, marinas, or hard substrate also are surveyed. The largest kelp beds in the Central Region usually are found off the Palos Verdes Peninsula. There are 14 major ocean outfalls located within the geographical range of the CRKSC (Figure 1).

I.2 - REGION NINE KELP BEDS

The RNKSC program area extends from Abalone Point in northern Laguna Beach (Orange County) to the U.S./Mexico Border to the south, and recognizes 24 existing or historic kelp beds (Figure 2). Several additional kelp beds associated with harbors, marinas, or hard substrate also are surveyed. Region Nine supports what are usually the two largest kelp beds in southern California: the La Jolla, and the Point Loma kelp beds. There are 8 major ocean outfalls (including three that are shared by two different agencies) located within the geographical range of the RNKSC (Figure 2).

I.3 - KELP BIOLOGY

If spores and suitable rocky substrate are available, giant kelp can quickly colonize surfaces and grow within a wide range of environmental conditions. Giant kelp grows rapidly and becomes reproductive in less than one year. Its population dynamics are largely driven by changes in the oceanographic environment. If not removed prematurely by storms or grazers, large vegetative fronds eventually produce a terminal blade, stop growing, and senesce. Individual fronds usually live no more than four to nine months, and individual plants can live up to approximately nine years [Schiel & Foster, 2015]. Detailed information on kelp biology is presented in Appendix B.

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

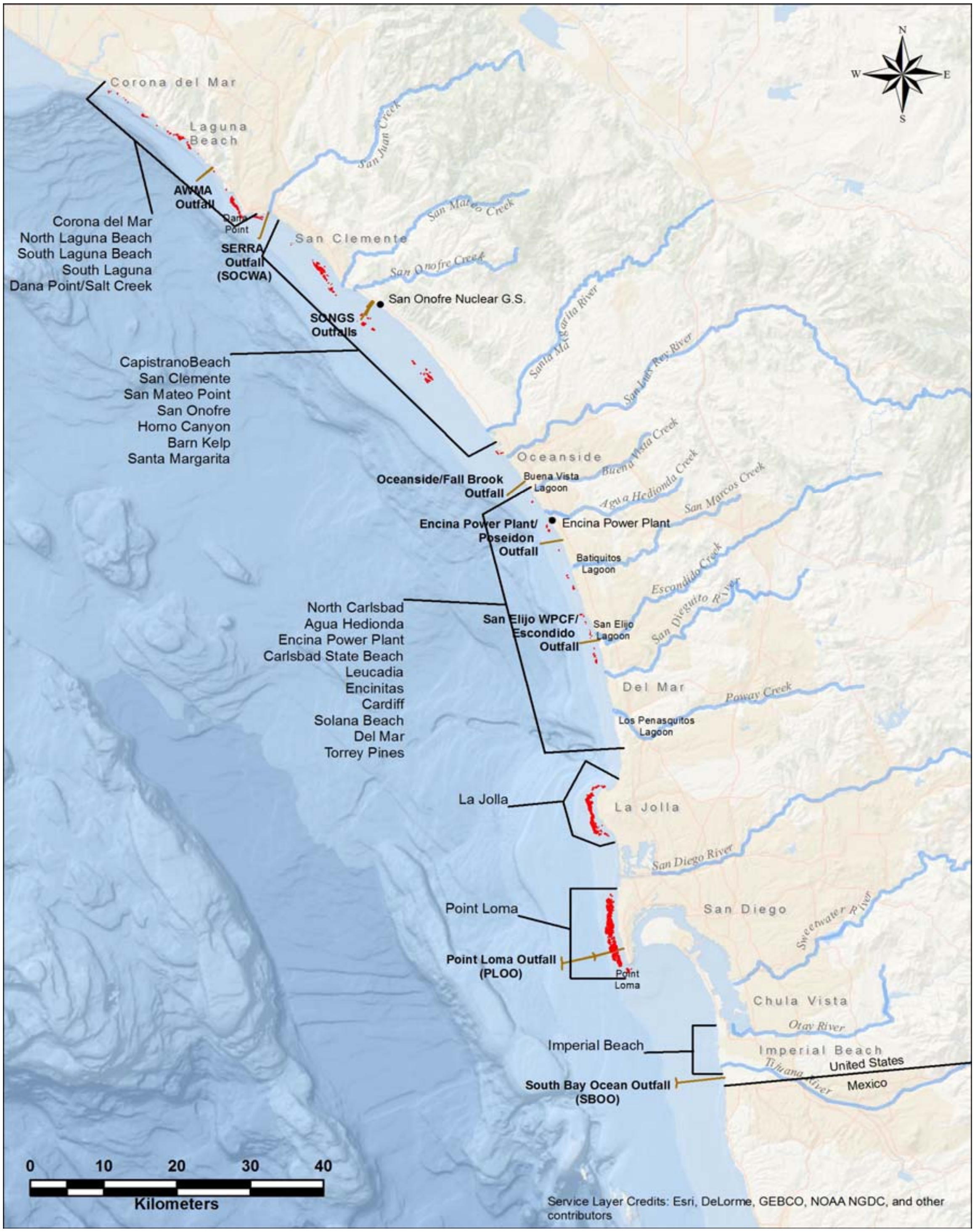


Figure 2. Ocean discharges and kelp beds located within Region Nine kelp survey area.

II - MATERIALS AND METHODS

II.1 - KELP DATA COLLECTION

II.1.A - AERIAL SURVEYS

Beginning in the early-1960s, the surface area of coastal kelp beds was calculated by aerial photography by the late Dr. Wheeler J. North of the California Institute of Technology, and later by MBC using a methodology that followed that of Dr. North's, because it provided a consistent approach to determining kelp bed size (North 2001). MBC has used this methodology for the Region Nine surveys since inception of the program in 1983, and for surveys for the CRKSC since initiation in 2003.

In 2017, Ecoscan conducted quarterly overflights of the coastline for the CRKSC and RNKSC from Ventura Harbor (Ventura County) to the U.S./Mexico border. Direct downward-looking photographs of the kelp beds were taken from an aircraft modified by Ecoscan Resource Data to facilitate aerial photography. Approximately 400 high-contrast digital color and infrared photos were taken during each survey. Prior to each survey, the flight crew assesses the weather, marine conditions, and sun angle to schedule surveys on optimum dates. The pilot targets the following:

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

Aerial surveys were flown on March 27, June 27, September 26, and December 27, 2017 (Table 1). During the June 27th overflight, cloudy conditions obscured the coastline from Leucadia south to Imperial Beach and no images of the kelp beds could be recorded. Due to continued cloud cover over the next few weeks, it was impossible to complete the southern portion of the RNKSC survey for the second quarter. The flight path and data sheets from each quarterly aerial survey are included in Appendix D. The photographs from each aerial survey are contained in Appendix E.

II.1.B - VESSEL SURVEYS

Once per survey year, typically targeted in December, a vessel survey is conducted of all of the RNKSC kelp beds. The vessel survey for the 2017 survey year was conducted on December 19 (Santa Margarita to Imperial Beach) and December 20 (North Laguna Beach to Dana Point Harbor, and Corona del Mar), 2017, and January 15, 2018 (Capistrano Beach to Barn Kelp). During each vessel survey, biologists visually located the main canopies (or during poor years by latitude and longitude coordinates of the last remaining canopy).

Visual observations of the surface canopy included:

- Extent and density of the bed;
- Tissue color: ranges from pale yellow (indicating poor nutrient uptake) to dark brown (indicating good nutrient intake);
- Frond length on the surface;

- Presence/absence of apical meristem (scimitar = growing tips);
- Extent of encrustations of hydroids or bryozoans;
- Sedimentation on blades;
- Any evidence of disease, such as holes or black rot; and
- Composition of fronds: young, mature, or senile.

The presence of subsurface kelp also was recorded via visual observations and fathometer readings. During the 2017 vessel surveys, more detailed in-water surveys were conducted by biologist-divers at the Del Mar and Agua Hedionda kelp beds. Field data sheets from the vessel surveys are included in Appendix D.

Table 1. Kelp bed overflights in 2017.

Quarter	Target Date	Actual Date	Comments
1st Quarter	**January to March 2017**	March 29, 2017	Excellent conditions.
2nd Quarter	**April to June 2017**	June 27, 2017	Cloudy. Kelp beds obscured from Leucadia south to Imperial Beach (no photographs).
3rd Quarter	**July to September 2017**	September 26, 2017	Good conditions.
4th Quarter	**October to December 2017**	December 27, 2017	Excellent conditions.

II.2 - KELP DATA ANALYSIS

All photographs were reviewed after each overflight and the canopy surface area of each kelp bed was ranked in size by subjectively comparing the extent of canopy coverage shown in the photographs to the average historical bed size and photographs from previous surveys (Tables 2 and 3). The ranking scale ranged from 0 for no kelp, 0.5 for minimal kelp, 1 for well below average kelp, 1.5 for somewhat below average kelp, 2 for below average kelp, 2.5 for average kelp, 3 for above average kelp, 3.5 for somewhat above average kelp, and 4 for well above average kelp. These rankings allow the archiving of the quarterly survey slides for later retrieval and assembly of a digitized photo-mosaic of each kelp bed that represents the greatest areal extent for each survey year. Individual beds in the composite were selected for detailed evaluation and the surface area of all visible kelp canopies in each distinct kelp bed was calculated.

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

The “Average Bed Area Per Year” (ABAPY) was plotted with results from individual beds to compare canopy sizes and patterns of growth/decline to averages for particular regions. Those regions were: the northern and central portions of the Central Region, including California Fish and Wildlife kelp lease beds 15, 16, and 17 upcoast from Palos Verdes (Figure 34); lease bed 9 in Orange County (Figure 34); and lease beds 5, 6, 7, and 8 in San Diego County (Figure 35). Kelp beds off Palos Verdes (lease beds 13 and 14, Figure 34), La Jolla (lease bed 4, Figure 35), and Point Loma (lease beds 2 and 3, Figure 35) were treated separately because they are typically much larger beds which would dominate the ABAPY if included with the other much smaller beds and may react differently than the other beds within their regions. Each ABAPY was calculated by summing the annual canopy estimates for the relevant beds during each year, and dividing the total by the number of beds included.

Table 2. Rankings assigned to kelp beds from aerial photographs from 2017 Central Region surveys between Ventura Harbor and Newport / Irvine Coast.

	2017 Surveys			
Kelp Beds	**29 March**	**27 June**	**26 September**	**27 December**
Ventura Harbor *	—	2.0	0.5	0.5
Channel Islands *	—	2.5	NI	—
Port Hueneme *	2.0	3.0	NI	1.0
Deer Creek	1.5	2.5	2.0	3.0
Leo Carrillo	2.0	3.0	2.0	2.5
Nicolas Canyon	1.5	2.5	0.5	2.0
El Pescador/La Piedra	2.0	1.5	0.5	2.0
Lechuza Kelp	1.0	1.5	0.5	3.0
Point Dume	—	1.5	0.5	2.5
Paradise Cove	—	1.5	0.5	2.5
Escondido Wash	1.5	0.5	—	1.5
Latigo Canyon	1.5	0.5	—	1.5
Puerco/Amarillo	—	1.0	—	0.5
Malibu Pt.	1.0	—	—	0.5
La Costa	—	—	—	—
Las Flores	—	—	—	—
Big Rock	—	—	—	0.5
Las Tunas	—	—	—	0.5
Topanga	—	—	—	—
Sunset	0.5	—	—	—
Marina Del Rey *	0.5	0.5	1.0	0.5
Hyperion Pipeline *	—	—	—	—
Redondo Breakwater *	1.0	0.5	1.0	0.5
Malaga Cove - PV Point (IV)	2.5	3.0	1.0	2.5
PV Point - Point Vicente (III)	2.0	3.5	3.0	3.0
Point Vicente - Inspiration Point (II)	1.5	3.5	3.0	3.0
Inspiration Point - Point Fermin (I)	NI	2.0	1.5	3.5
Cabrillo	1.0	2.0	3.0	3.0
LB/LA Harbor and Breakwaters	1.5	3.0	2.5	2.5
Horseshoe Kelp	—	—	—	—
Huntington Flats	—	—	—	—
Newport Harbor *	1.0	1.0	1.0	1.0
Corona Del Mar	2.5	1.0	—	2.0
North Laguna Beach	3.0	3.5	0.5	1.0

Ranking values: 0.5 = trace or very small amount of kelp present; 1 = well below average;
1.5 = somewhat below average; 2 = below average; 2.5 = average;
3 = above average; 3.5 = somewhat above average; and 4 = well above average.
* = not a designated kelp bed

Table 3. Rankings assigned to kelp beds from aerial photographs surveys from 2017 Region Nine surveys between Newport / Irvine Coast and Imperial Beach.

	2017 Surveys			
Kelp Beds	29 March	27 June	26 September	27 December
Newport Harbor *	1.0	1.0	1.0	1.0
Corona del Mar	2.5	1.0	—	2.0
No. Laguna Beach	3.0	3.5	0.5	1.0
So. Laguna Beach	2.5	2.5	0.5	2.0
South Laguna	2.5	2.5	2.5	—
Salt Creek-Dana Point	—	—	—	2.0
Dana Marina *	0.5	—	—	0.5
Capistrano Beach	0.5	—	—	—
San Clemente	3.0	2.5	0.5	3.0
San Mateo Point	—	1.0	—	0.5
San Onofre	2.5	2.5	0.5	1.5
Pendleton Reefs *	—	—	—	—
Horno Canyon	—	1.5	—	0.5
Barn Kelp	2.5	2.5	—	2.0
Santa Margarita	—	—	—	—
Oceanside Harbor *	—	—	0.5	—
North Carlsbad	0.5	—	—	—
Agua Hedionda	—	—	—	—
Encina Power Plant	2.0	1.5	—	1.5
Carlsbad State Beach	0.5	NI	—	—
North Leucadia	0.5	NI	—	—
Central Leucadia	—	NI	—	0.5
South Leucadia	—	NI	—	—
Encinitas	—	NI	—	0.5
Cardiff	1.0	NI	—	—
Solana Beach	1.5	NI	—	0.5
Del Mar	—	NI	—	—
Torrey Pines Park	—	NI	—	—
La Jolla Upper	—	NI	0.5	1.5
La Jolla Lower	—	NI	0.5	1.5
Point Loma Upper	2.0	NI	0.5	2.5
Point Loma Lower	2.0	NI	0.5	2.5
Imperial Beach	NI	NI	—	—

Ranking values: 0.5 = trace or very small amount of kelp present; 1 = well below average;
1.5 = somewhat below average; 2 = below average; 2.5 = average;
3 = above average; 3.5 = somewhat above average; and 4 = well above average.
* = not a designated kelp bed

III - RESULTS

III.1 - 2017 KELP CANOPY SUMMARY

III.1.A - MONITORING QUESTIONS

One of the objectives of the CRKSC and RNKSC programs is to answer several basic monitoring questions regarding the status of kelp beds within the two regions:

1. What is the maximum areal extent of the coastal kelp bed canopies each year?
   - Central Region: maximum total kelp canopy covered 4.881 km^2 in 2017;
   - Region Nine: maximum total kelp canopy covered 3.277 km^2 in 2017.
2. What is the variability of the coastal kelp bed canopy over time?
   - Central Region:
     - maximum total kelp canopy increased in size in 2017 by 2.6% (from 4.757 km^2 to 4.881 km^2);
     - 9 kelp beds increased in size (including Las Tunas, which reappeared in 2017);
     - 12 kelp beds decreased in size;
   - Region 9:
     - maximum total kelp canopy decreased in size in 2017 by 36.2% (from 5.134 km^2 to 3.277 km^2);
     - 7 kelp beds increased in size (including North Carlsbad and Carlsbad State Beach, which reappeared in 2017);
     - 13 kelp beds decreased in size (including Imperial Beach, which disappeared in 2017).
3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
   - Central Region
     - no beds disappeared in 2017 that had been visible in 2016;
     - 5 beds continued not to be visible in 2017, 2 that disappeared in 2015 (La Costa and Las Flores), 1 that disappeared in 2016 (Topanga), and 2 that have been absent historically (Horseshoe and Huntington Flats);
   - Region 9
     - 1 bed disappeared in 2017 that had been visible in 2016 (Imperial Beach);
     - 4 beds continued not to be visible in 2017, 2 that disappeared in 2014 (Santa Margarita and Torrey Pines) and 2 that disappeared in 2016 (Agua Hedionda and Del Mar).
     - factors that could contribute to the disappearance of kelp beds in the Central Region and Region Nine include high water temperatures, low nutrient availability, excessive turbidity, reduced upwelling, strong wave action, amount of rainfall, and phytoplankton blooms/toxin production.

4. Are new kelp beds forming?
   - Central Region
     - 1 bed reappeared in 2017, following a one-year absence in 2016 (Las Tunas);
     - the Las Tunas kelp bed generally has been relatively small in size, but has been present every year since 2003 with the exception of 2006 and 2016.
   - Region 9
     - 2 beds reappeared in 2017, following a one-year absence in 2016 (North Carlsbad and Carlsbad State Beach);
     - the North Carlsbad kelp bed has been present every year since 2001, with the exception of 2006 and 2016;
     - the Carlsbad State Beach kelp bed has been present every year since 2000, with the exception of 2005, 2006, and 2016.

III.1.B - CENTRAL REGION RESULTS

Most of the kelp beds in the CRKSC region attained maximum surface canopy area for the year during either the June or December surveys (Table 2). However, a few kelp beds were at their maximum during the March or September surveys. In 2017, 21 kelp beds displayed surface canopy, compared to 20 kelp beds with surface canopy in 2016 (one kelp bed reappeared in 2017, Las Tunas). Of these 21 kelp beds, 12 decreased in size in 2017, while 9 increased in size (Panel C on Figure 3). The total amount of kelp canopy in the CRKSC region increased by 2.6% (from 4.757 km^2 in 2016 to 4.881 km^2 in 2017). The largest beds in the CRKSC region are three of the Palos Verdes kelp beds, with the largest being Palos Verdes IV (Flat Rock to Palos Verdes Point) at 1.0482 km^2 (Panel A on Figure 3). The Palos Verdes I, II, III, and IV kelp beds and the Cabrillo kelp bed accounted for 73.7% (3.181 km^2) of the total CRKSC kelp coverage in 2017. The largest increase in size was observed at the Palos Verdes I bed (Point Inspiration to Cabrillo) kelp bed (+53.1%), while the greatest decline was observed at the Malibu Point kelp bed (-97.1%). Two kelp beds (Leo Carrillo and Cabrillo) reached their maximum size recorded since CRKSC surveys began in 2003. In 2017, nine kelp beds were at or above 40% of their historic maximum size, while six kelp beds were at less than 10% of their historic maximum size (Panel B on Figure 3).

Maps showing the areal extent of CRKSC canopy coverage in 2017 are provided in Appendix A. Tables displaying the historical canopy coverage for the Central Region (2003 through 2017) are included in Appendix B.3. Delineation of each kelp bed area is presented from upcoast to downcoast in Appendix D, which utilizes the aerial extent of the kelp beds in 2013 as a reference point to facilitate comparisons. Kelp coverage that year was relatively high in both regions, and smaller beds at La Costa, Santa Margarita, and Torrey Pines were visible. The aerial photographs taken during each of the four quarterly overflights in 2017 are included in Appendix E.

III.1.C - REGION NINE RESULTS

Most of the kelp beds in the RNKSC region attained maximum surface canopy area for the year during either the March or December surveys (Table 3). However, a few kelp beds were at their maximum during the June surveys. In 2017, 19 kelp beds displayed surface canopy, compared to 18 kelp beds with surface canopy in 2016, including 2 kelp beds that reappeared in 2017 (North Carlsbad and Carlsbad State Beach), and 1 kelp bed that disappeared (Imperial Beach). Nearly twice as many kelp beds decreased in size as increased in size (13 versus 7)

(Panel C on Figure 3). The total amount of kelp canopy in the RNKSC region declined by 36.2% in 2017 (from 5.134 km^2 in 2016 to 3.277 km^2 in 2017). The largest beds in the RNKSC region are the La Jolla and Point Loma kelp beds, with Point Loma being the largest (1.784 km^2) (Panel on A Figure 3). These two large kelp beds accounted for 75.8% (2.481 km^2) of the total RNKSC kelp coverage in 2017. The largest increase in size was observed at the Encina Power Plant kelp bed (+177.8%), while the greatest decline was observed at the Capistrano Beach kelp bed (-96.7%). Only one kelp bed (North Laguna Beach) was above 40% of its historic maximum size, while 11 kelp beds were at less than 10% of their historic maximum size and five more were at less than 15% of the historic maximum (Panel B on Figure 3).

Maps showing the areal extent of RNKSC canopy coverage in 2017 are provided in Appendix A. Tables displaying the historical canopy coverage for Region Nine (1983 through 2017) are included in Appendix B.4. Delineation of each kelp bed area in Appendix D. Aerial photographs taken during the four quarterly overflights in 2017 are included in Appendix E.

III.2 - SIZE OF KELP BEDS IN THE CENTRAL REGION

The following is a synopsis of the status of each of the 26 designated individual kelp beds in the CRKSC Region during the 2017 survey year based upon the quarterly surveys. Information also is presented on several other areas where kelp beds were observed. The comparison of canopy coverage between 2016 and 2017 for each kelp bed is presented in Table 4. Historical canopy coverage since 1911 is presented in Appendix B.3.

III.2.A - VENTURA HARBOR TO POINT MUGU STATE PARK

None of the kelp beds located from Ventura Harbor to Point Mugu are designated kelp beds within the Central Region, due to their small size. There was a small amount of kelp growing along the breakwaters of Ventura Harbor (0.007 km^2), Channel Islands Harbor (0.010 km^2), and Port Hueneme (0.010 km^2) in 2017 (Appendices A.1, A.4, and A.5). The amount of kelp at Ventura Harbor was the same in 2017 as in 2016, while there was a slight increase at Channel Islands Harbor in 2017 and a slight decrease at Port Hueneme. No kelp was noted offshore of the Mandalay and Ormond Beach Generating Stations (Appendices A.2, A.3, A.5, and A.6), and no kelp was visible between Port Hueneme and Deer Creek (Appendices A.5 through A.10).

III.2.B - POINT MUGU TO POINT DUME

Three of the five kelp beds increased substantially in 2017, one decreased substantially, and one decreased slightly.

Deer Creek. This kelp bed increased in size from 0.087 km^2 in 2016 to 0.105 km^2 in 2017 (an increase of 20.7%) (Table 4). The canopy area in 2017 was 84.5% of the maximum recorded in 2015 (Figure 3, Appendix B.3).

The Deer Creek kelp canopy (Appendix A.10) was compared to the ABAPY of the northern and central portions of the Central Region (average of the 17 kelp beds located in Fish and Wildlife kelp harvest lease areas 15, 16, and 17) to determine whether it was responding synoptically with other beds (Figure 4). Although the ABAPY decreased by 13.0% over the past year, the Deer Creek kelp bed increased in size by 20.7% in 2017. Although it is under the peak recorded in 2015 (0.124 km^2), the canopy area has remained high for the past five years (2013 through 2017) following a low in 2012 (blue line on Figure 4, Table 7).

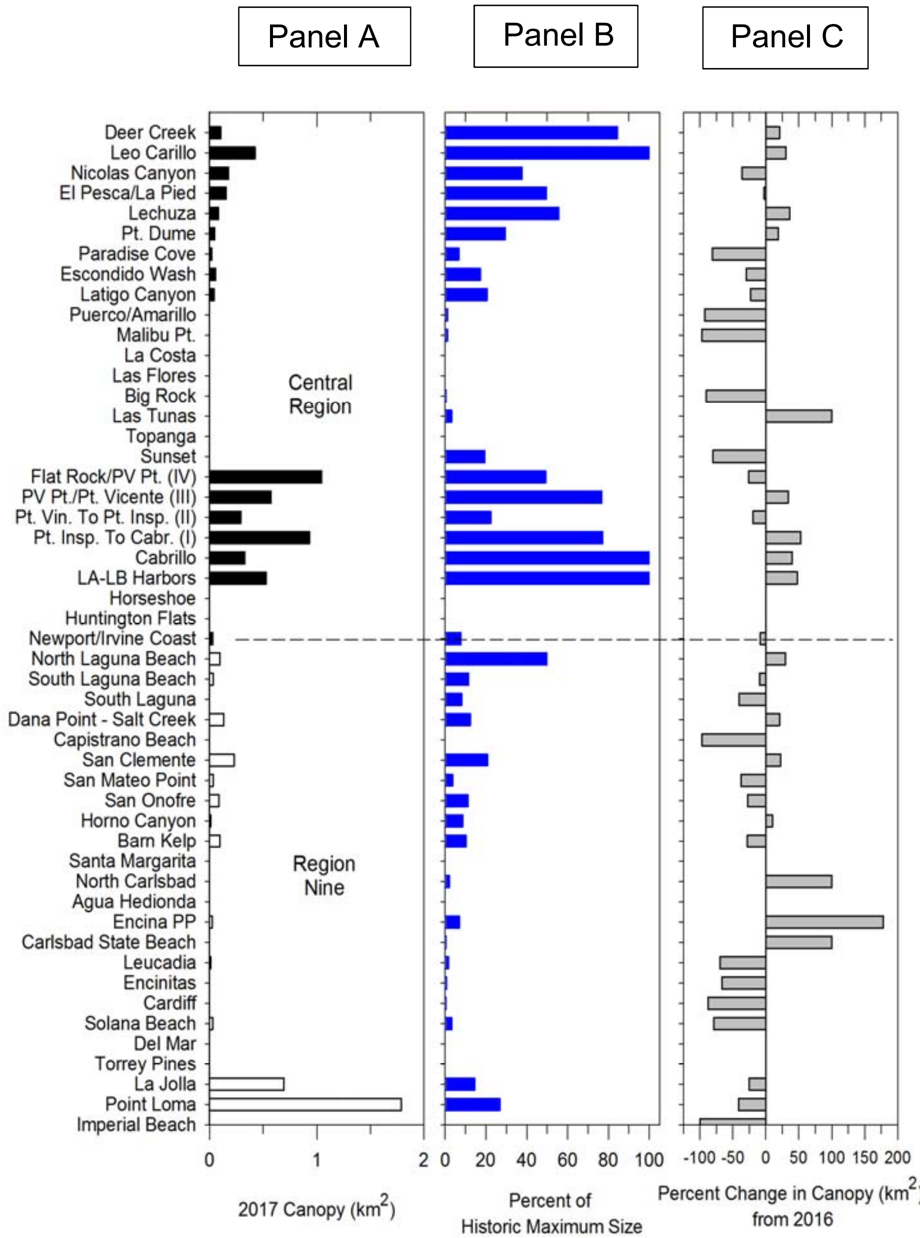


Figure 3. Summary of Central Region and Region Nine kelp canopy coverage in 2017.

Leo Carrillo. This kelp bed increased in size from 0.326 km^2 in 2016 to 0.426 km^2 in 2017 (an increase of 30.7%) (Table 4). The canopy area in 2017 was the maximum recorded since the CRKSC surveys began in 2003 (Figure 3, Appendix B.3).

The Leo Carrillo kelp canopy (Appendix A.11) increased substantially in size in 2017 (an increase of 30.7%), despite the 13.0% decrease in the ABAPY for northern and central Los Angeles County (green line on Figure 4). Leo Carrillo was the largest kelp bed in the northern and central Los Angeles County area in 2017, as was the case in 2015 and 2016 (Table 7).

Nicolas Canyon. This kelp bed decreased in size from 0.279 km^2 in 2016 to 0.179 km^2 in 2017 (a decrease of 35.8%) (Table 4). The canopy area in 2017 was 37.8% of the maximum recorded in 2007 (Figure 3, Appendix B.3).

The decline in the size of the Nicolas Canyon kelp bed in 2017 was even greater than the overall decrease of the ABAPY (35.8% compared to 13.0%). With a sharp decline from the 2015 level (0.347 km^2), the 2017 canopy areas was the lowest recorded since 2011 (purple line on Figure 4, Table 7). However, it still remained the second largest kelp bed within the northern and central Los Angeles County area (Appendix A.12).

El Pescador/La Piedra. This kelp bed decreased in size from 0.160 km^2 in 2016 to 0.156 km^2 in 2016 (a decrease of 2.5%) (Table 4). The canopy area in 2017 was 49.7% of the maximum recorded in 2004 (Figure 3. Appendix B.3).

The slight decrease in size of the El Pescador/La Piedra kelp canopy (Appendix A.12 and A.13) was less than the 13.0 decrease of the ABAPY. However, this kelp bed remains well below the extent of canopy (0.236-0.246 km^2) recorded in 2013 through 2015 (red line on Figure 4, Table 7).

Lechuza. This kelp bed increased in size from 0.063 km^2 in 2016 to 0.086 km^2 in 2017 (an increase of 36.5%) (Table 4). The canopy area in 2017 was 55.8% of the maximum recorded in 2013 (Figure 3, Appendix B.3).

The Lechuza kelp canopy increased substantially in size in 2017 (an increase of 36.5%), despite the 13.0% decrease in the ABAPY for northern and central Los Angeles County (Figure 4). However, this kelp bed still remains well below the peak (0.154 km^2) recorded in 2013 (orange line on Figure 4, Table 7). Lechuza (Appendix A.13) is the smallest of the five kelp beds located between Point Mugu and Point Dume.

III.2.C - POINT DUME TO MALIBU POINT

All six kelp beds were fairly small in 2017. Five of the six kelp beds decreased substantially, while one bed increased in size.

Point Dume. This kelp bed increased in size from 0.042 km^2 in 2016 to 0.050 km^2 in 2017 (an increase of 19.0%) (Table 4). The canopy area in 2017 was 29.6% of the maximum recorded in 2015 (Figure 3, Appendix B.3).

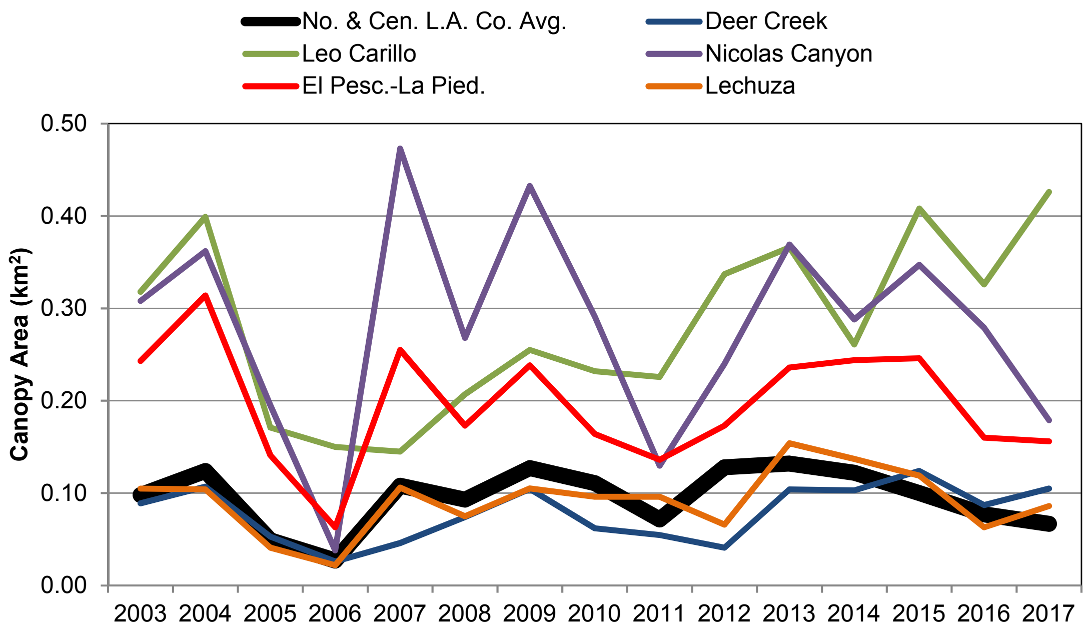


Figure 4. Comparisons between the average Northern and Central Los Angeles County ABAPY and canopy coverage from Point Mugu through Point Dume from 2003 through 2017.

The Point Dume kelp canopy (Appendix A.14) increased by 19.0% despite the 13.0 % decrease in the ABAPY for northern and central Los Angeles County (red line on Figure 5). Even with the 2017 increase, the size of the Point Dume kelp bed still is much lower than the 2015 level (0.169 km^2) (Figure 5, Table 7).

Paradise Cove. This kelp bed decreased in size from 0.127 km^2 in 2016 to 0.024 km^2 in 2017 (a decrease of 81.1%) (Table 4). The canopy area in 2017 was 6.9% of the maximum recorded in 2012 (Figure 3, Appendix B.3).

The 81.1% decline in canopy size at Paradise Cove (Appendix A.14) in 2017 was much greater than the 13.0% decrease in the ABAPY (green line on Figure 5). This is the lowest level ever recorded since the CRKSC surveys began in 2003, continuing the decline observed over the past several years from the peak level (0.346 km^2) recorded in 2012 (Figure 5, Appendix B.3).

Escondido Wash. This kelp bed decreased in size from 0.084 km^2 in 2016 to 0.059 km^2 in 2017 (a decrease of 29.8%) (Table 4). The canopy area in 2017 was 17.4% of the maximum recorded in 2007 (Figure 3, Appendix B.3).

The Escondido Wash kelp canopy (Appendix A.15) decreased approximately twice as much in 2017 as the 13.0 decline in the ABAPY (purple line on Figure 5). This continues the decline from the 2014 level of 0.241 km^2 (Figure 5).

Table 4. Canopy coverage of the Central Region kelp beds from Deer Creek to Newport/Irvine Coast during 2016 and 2017.

Kelp Bed	2016 (km^2)	2017 (km^2)	Percentage Difference
Deer Creek	0.087	0.105	+20.7
Leo Carrillo	0.326	0.426	+30.7
Nicolas Canyon	0.279	0.179	-35.8
El Pescador/La Piedra	0.160	0.156	-2.5
Lechuza	0.063	0.086	+36.5
Pt. Dume	0.042	0.050	+19.0
Paradise Cove	0.127	0.024	-81.1
Escondido Wash	0.084	0.059	-29.8
Latigo Canyon	0.057	0.044	-22.8
Puerco/Amarillo	0.027	0.002	-92.6
Malibu Pt.	0.035	0.001	-97.1
La Costa	–	–	no change
Las Flores	–	–	no change
Big Rock	0.001	0.0001	-90.0
Las Tunas	–	0.001	reappeared
Topanga	–	–	no change
Sunset	0.015	0.003	-80.0
Malaga Cove to Palos Verdes Point (IV)	1.420	1.048	-26.2
Palos Verdes Point to Point Vicente (III)	0.430	0.576	+34.0
Point Vicente to Point Inspiration (II)	0.366	0.294	-19.7

Table 4 (continued)

Kelp Bed	2016 (km^2)	2017 (km^2)	Percentage Difference
Point Inspiration to Cabrillo (I)	**0.610**	**0.934**	**+53.1**
Cabrillo	**0.235**	**0.329**	**+40.0**
Port of Los Angeles/Port of Long Beach Harbor	**0.359**	**0.530**	**+47.6**
Horseshoe	–	–	**no change**
Huntington Flats	–	–	**no change**
Newport-Irvine Coast	**0.036**	**0.033**	**-8.3**

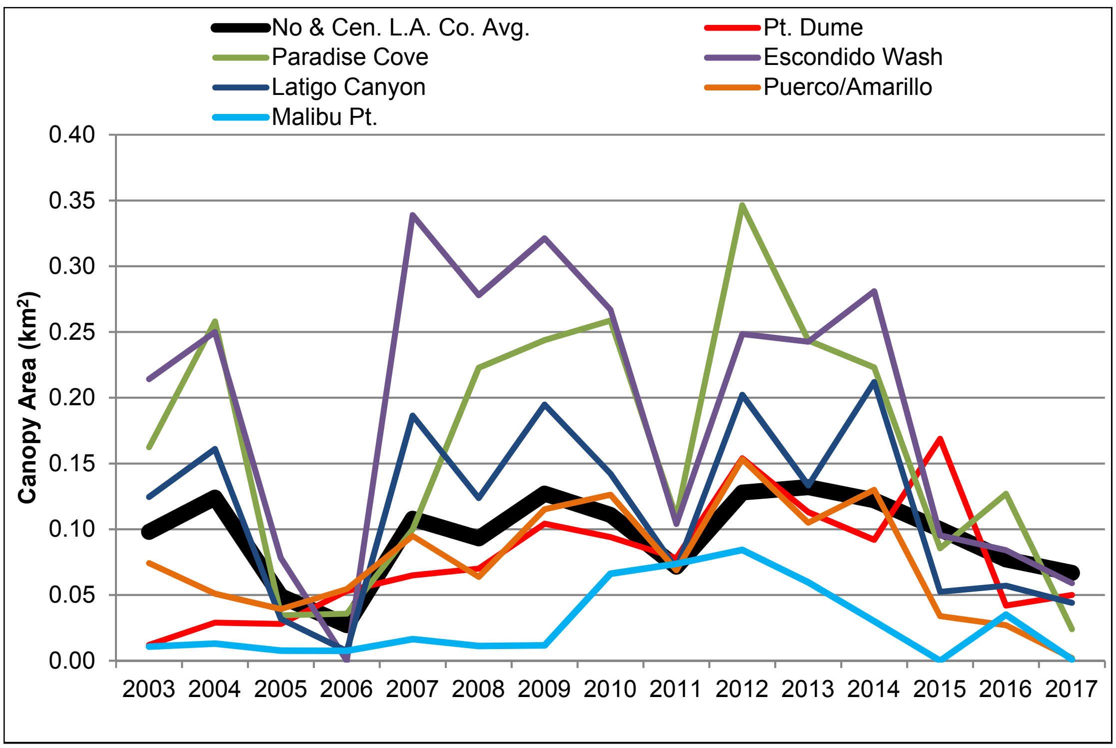


Figure 5. Comparisons between the average Northern and Central Los Angeles County ABAPY and canopy coverage from Point Dume to Malibu Point from 2003 through 2017.

Latigo Canyon. This kelp bed decreased in size from 0.057 km^2 in 2016 to 0.044 km^2 in 2017 (a decrease of 22.8%) (Table 4). The canopy area in 2017 was 20.7% of the maximum recorded in 2014 (Figure 3, Appendix B.3).

The 22.8% decrease in the size of the Latigo Canyon kelp canopy (Appendix A.15) in 2017 was greater than the 13% decrease in the ABAPY (blue line on Figure 5). This continues the decline from the peak level recorded in 2014 (0.212 km^2).

Puerco/Amarillo. This kelp bed decreased in size from 0.274 km^2 in 2016 to 0.002 km^2 in 2017 (a decrease of 92.6%) (Table 4). The canopy area in 2017 was only 1.3% of the maximum recorded in 2012 (Figure 3, Appendix B.3).

The 92.6% decrease in the size of the Puerco/Amarillo kelp canopy (Appendix A.16) in 2017 was much greater than the 13% decrease in the ABAPY (orange line on Figure 5). With this substantial decline (the second largest percentage reduction in canopy area in the Central Region), the Puerco/Amarillo kelp bed nearly disappeared in 2017, falling to the lowest level recorded since the CRKSC surveys began in 2003 (Figure 5, Appendix B.3).

Malibu Point. This kelp bed decreased in size from 0.035 km^2 in 2016 to 0.001 km^2 in 2017 (a decrease of 97.1%) (Table 4). The canopy area in 2017 only 1.2% of the maximum recorded in 2012 (Figure 3, Appendix B.3).

The 97.1% decrease in the size of the Malibu Point kelp canopy (Appendix A.17) in 2017 was much greater than the 13% decrease in the ABAPY (turquoise line on Figure 5). With this substantial decline (the largest percent reduction in canopy area in the Central Region), the Malibu Point kelp bed nearly disappeared in 2017 (Figure 5), as was the case with the adjacent Puerco/Amarillo kelp bed.

III.2.D - MALIBU POINT TO SANTA MONICA PIER

The six kelp beds from La Costa to Sunset are usually among the smallest beds in the Central Region. All were very small or not visible in 2017.

La Costa. This kelp bed was not observed in 2016, nor was it visible in 2017 (Table 4).

The La Costa kelp bed (Appendix A.18) only has been present in half the years since 2003 (Figure 6). In 2012, it reappeared (0.003 km^2), the largest size recorded in 10 years of monitoring. It remained at that size in 2013, but decreased in size in 2014 and has been absent since 2015 (turquoise line on Figure 6, Appendix B.3).

Las Flores. This kelp bed also was not observed in 2016, nor was it visible in 2017 (Table 4).

The Las Flores kelp bed (Appendix A.18) reached its maximum size in 2012, but canopy size decreased until the kelp bed disappeared in 2015, and it has not reappeared (red line on Figure 6).

Big Rock. This kelp bed decreased in size from 0.001 m^2 in 2016 to 0.0001 km^2 in 2017 (a decrease of 90.0%) (Table 4). The canopy area in 2017 was only 0.6% of the maximum recorded in 2012 (Figure 3, Appendix B.3).

In 2012, the kelp bed at Big Rock (Appendix A.19) reached its largest size (0.018 km^2) since the inception of the CRKSC program (Figure 6, Appendix B.3). The Big Rock kelp bed remained near this size in 2013, but has declined every year since and virtually disappeared in 2017 (green line on Figure 6).

Las Tunas. This kelp bed was not visible in 2016, but reappeared in 2017 at 0.001 km^2 (Table 4). The canopy area in 2017 was only 3.3% of the maximum recorded in 2012 (Figure 3, Appendix B.3).

Las Tunas kelp bed canopy size (Appendix A.19) reached 0.030 km^2 in 2012, the largest size recorded since the CRKSC surveys began in 2003 (Figure 6, Appendix B.3). Subsequent declines resulted in its disappearance in 2016, but it reappeared at a very small size in 2017 (purple line on Figure 6).

Topanga. This kelp bed also was not observed in 2016, nor was it visible in 2017 (Table 4).

Topanga kelp bed (Appendix A.20) reached its maximum size in 2010 at 0.052 km^2. However, it decreased in size from 2012 until its disappearance in 2016 (Figure 6). It did not reappear in 2017 (blue line on Figure 6, Appendix B.3).

Sunset. This kelp bed decreased in size from 0.015 km^2 in 2016 to 0.003 km^2 in 2017 (a decrease of 80.0%) (Table 4). The canopy area in 2017 was 19.6% of the maximum recorded in 2016 (Figure 3, Appendix B.3).

The Sunset kelp bed (Appendix A.20, A.21 and A.22) was not observed in any of the CRKSC surveys from 2003 through 2008, but has been present every year since (Figure 6, Appendix B.3), reaching the maximum size of 0.015 km^2 in 2016 (since the CRKSC surveys began in 2003). With the substantial decline in 2017, the Sunset kelp bed is at its smallest size since it reappeared in 2009 (orange line on Figure 6).

III.2.E - SANTA MONICA PIER TO REDONDO BEACH BREAKWATER

None of the kelp beds located from Santa Monica Pier to the Redondo Beach Breakwater are designated kelp beds within the Central Region, due to their small size.

Santa Monica Pier to King Harbor. No kelp was seen between the two harbors along the Hyperion Treatment Plant outfall pipeline, offshore the Scattergood and El Segundo Generating Stations, Chevron Oil Refinery, Manhattan or Hermosa Beach, or the Redondo Beach Generating Station in 2016 (Appendices A.23 through A.27).

Kelp was observed along the Marina del Rey Harbor breakwaters (Appendix A.23) in 2017 (0.016 km^2), an increase from 2016 (0.008) km^2).

Redondo Beach Breakwater to Malaga Cove, Torrance. Kelp was observed along the Redondo breakwater at King Harbor (Appendix A27) in 2017 (0.006 km^2), a decrease compared to 2016 (0.016 km^2). No kelp was seen between King Harbor and Malaga Cove at the Palos Verdes Peninsula (Appendices A.27, A.28).

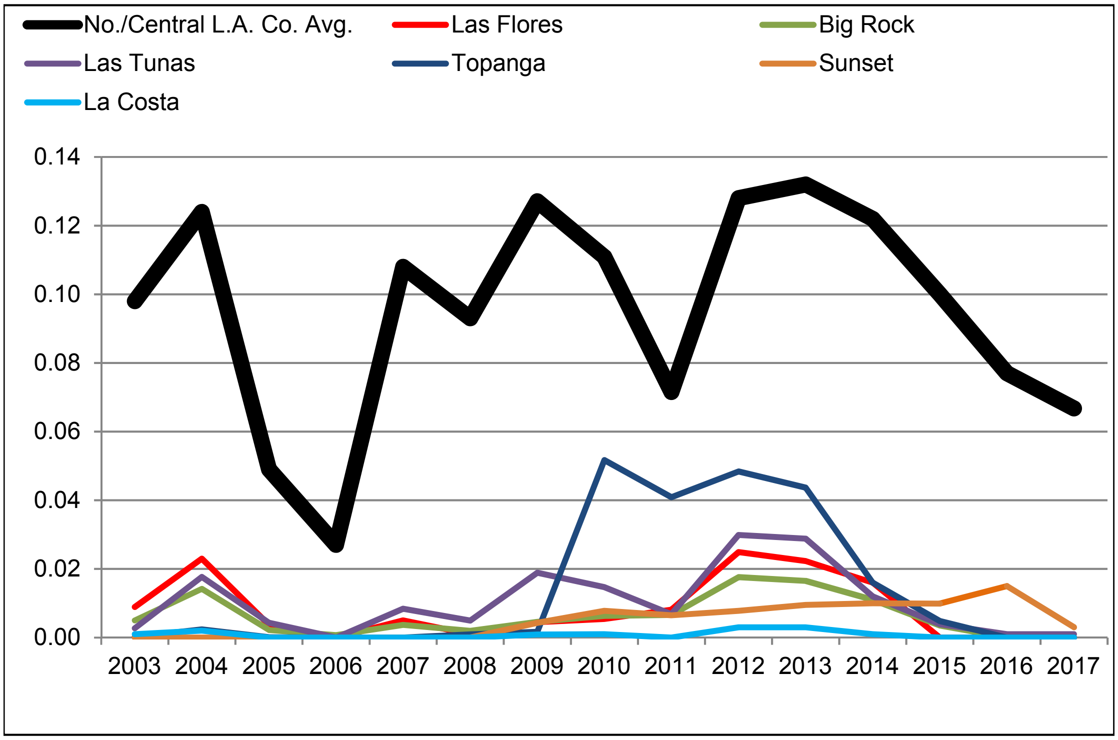


Figure 6. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverage from Las Flores to Sunset from 2003 through 2017.

III.2.F - MALAGA COVE TO POINT FERMIN

Palos Verdes IV. This kelp bed decreased in size from 1.420 km^2 in 2016 to 1.048 km^2 in 2017 (a decrease of 26.2%) (Table 4). The canopy area in 2017 was 49.4% of the maximum recorded in 2009 (Figure 3, Appendix B.3).

The Palos Verdes IV kelp bed includes the area from Flat Rock to Palos Verdes Point (Appendix A.28). In 2015, the PV-IV bed increased more than four-fold to its largest size since 2009, corresponding to an increase in the ABAPY for the Palos Verdes and Cabrillo kelp beds (red line on Figure 7). The ABAPY remained at the same level for 2016 and 2017, but after remaining approximately the same size in 2016, the Palos Verdes IV bed declined considerably in size in 2017 (Figure 7).

Palos Verdes III. This kelp bed increased in size from 0.430 km^2 in 2016 to 0.576 km^2 in 2017 (an increase of 34.0%) (Table 4). The canopy area in 2017 was 76.8% of the maximum recorded in 2015 (Figure 7, Appendix B.3).

The Palos Verdes III kelp bed includes the area from Palos Verdes Point to Point Vicente (Appendix A.29). In 2015, the PV-III kelp bed reached the maximum size recorded since the CRKSC surveys began in 2003, corresponding to an increase in the ABAPY (green line on Figure 7, Appendix B.3). This bed declined considerably in size in 2016, then increased considerably in 2017, even though the ABAPY was relatively constant from 2015 through 2017.

Palos Verdes II. This kelp bed decreased in size from 0.366 km^2 in 2016 to 0.294 km^2 in 2017 (a decrease of 19.7%) (Table 4). The canopy area in 2017 was 22.5% of the maximum recorded in 2009 (Figure 3, Appendix B.3).

The Palos Verdes II kelp bed includes the kelp from Point Vicente to Inspiration Point (Appendix A.29). The Palos Verdes II kelp bed followed a pattern similar to the Palos Verdes IV kelp bed, increasing to a large size in 2015 and maintaining that level in 2016, before declining considerably in 2017 (purple line on Figure 7), even though the ABAPY remained relatively constant.

Palos Verdes I. This kelp bed increased in size from 0.610 km^2 in 2016 to 0.934 km^2 in 2017 (an increase of 53.1%) (Table 4). The canopy area in 2017 was 77.3% of the maximum recorded in 2002 (Figure 3, Appendix B.3).

The Palos Verdes I kelp bed includes the area from Inspiration Point to Point Fermin (Appendix A.30 and A.31). Unlike the other Palos Verdes kelp beds, Palos Verdes I did not experience a large increase in size in 2015, when the ABAPY increased (blue line on Figure 7). Although the ABAPY was relatively unchanged in 2016 and 2017, the Palos Verdes I kelp bed increased considerably in size during both of these years.

III.2.G - POINT FERMIN TO NEWPORT BEACH

Cabrillo. This kelp bed increased in size from 0.235 km^2 in 2016 to 0.329 km^2 in 2017 (an increase of 40.0%) (Table 4). The canopy area in 2017 was the maximum recorded since the CRKSC surveys began in 2003 (Figure 3, Appendix B.3).

The Cabrillo kelp bed includes the area east of Point Fermin up to and including the western end of the San Pedro Breakwater (Appendix A.31). Although the ABAPY was relatively constant from 2015 through 2017, the Cabrillo kelp bed increased considerably in size in 2016 and again in 2017 (orange line on Figure 7). The 2016 canopy area was the largest recorded since CRKSC surveys began in 2003, and this was exceeded by 77% in 2017 (Table 7, Appendix B.3).

Los Angeles and Long Beach Harbors (POLA/POLB). Kelp coverage increased in size from 0.359 km^2 in 2016 to 0.504 km^2 in 2017 (an increase of 47.6%) (Table 4). The canopy area in 2017 was the maximum recorded since 2005 (Figure 3, Appendix B.3).

Kelp grows along the POLA/POLB breakwaters, on the armored edges of the outer harbors, and extends into the inner harbors in some places (Appendices A.31 through A.33). This kelp was not adequately considered in CRKSC reports before 2005, but it has been measured on a yearly basis since. The existence of these beds was known for some time, but the extent was not thought to be great. In response to growing curiosity as to the extent of the kelp in the Port Complex, it was requested that the overflight photographs for the third quarterly survey in 2005 (28 September 2005) include the entire outer harbors. Analysis revealed a narrow band of dense kelp (0.147 km^2) on both the inside and outside of the riprap. Only a small portion of the berths in the southern part of the Port Complex was included in the photographs, and it was suggested that the outer harbor be included in future overflights. The more inclusive survey of the harbor complex in 2006 measured 0.494 km^2 of giant kelp on the inner and outer breakwaters (Appendix B.3). Due to reports of kelp along a number of the inner breakwaters, the entire Port Complex was photographed and surveyed by biologists to determine whether the algae in the infrared photographs was giant kelp, feather boa kelp (*Egregia menziesii*), and/or *Sargassum* spp. The visual inspection of the growth along the breakwaters and within the confines of the Ports confirmed that the major portion was giant kelp. Diver surveys in the Ports in 2013 and 2014 confirmed that *Macrocystis* was estimated to comprise more than95% of the kelp coverage, with *Egregia menziesii* comprising less than5% (MBC and Merkel 2016).

Although the ABAPY for the Palos Verdes/Cabrillo area was similar in 2016 and 2017 (only increased slightly in 2017), the POLA/POLB kelp canopy increased considerably in 2017, exceeding the previous maximum size recorded in 2006 (turquoise line on Figure 7, Appendix B.3).

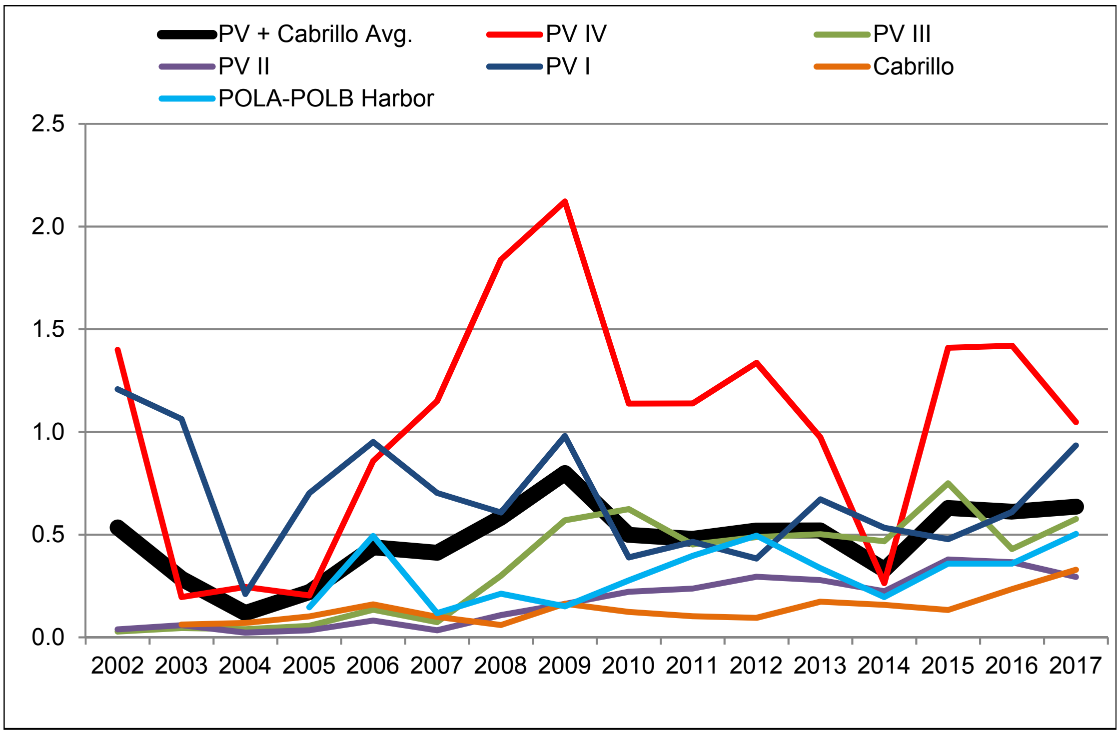


Figure 7. Comparisons between the average Palos Verdes and Cabrillo ABAPY and canopy coverage of the kelp beds off Palos Verdes and POLA/POLB Harbor from 2002 through 2017.

Horseshoe Kelp. This bed was not observed in 2017, nor was it visible in 2016 (Table 4).

In fact, no giant kelp canopy has formed at the site of Horseshoe kelp (Appendix A.35) in more than 60 years. Subsurface kelp has been observed at this location; in 2004, the kelp *Pterygophora californica* was photographed growing at depths of 20 to30 m (Wong et al. 2012). *Pterygophora* is present in dense stands on a considerable portion of the hard substrate in the region. The approximate location of this site is 10 km south of the Angel's Gate, the entrance to the POLA.

Huntington Flats. This bed (Appendices A.37 and A.38) was not observed in 2017, nor was it visible in 2016 (Table 4).

No kelp canopy has been observed in this area since the CRKSC surveys started in 2003 (Appendix B.3).

Huntington Flats to Newport Harbor. No kelp was observed from Huntington Flats to Newport Harbor (which includes the area offshore of the Huntington Beach Generating Station and Orange County Sanitation District outfalls) in 2016 (Appendices A.36 through A.40, D.8, and E.5). However, narrow bands of kelp were visible on the Newport Harbor jetties during all four quarterly surveys in 2017 (0.002 km^2) (Appendix A.40) (note: not considered to be one of the 26 designated kelp beds within the CRKSC, due to its small size).

III.2.H - NEWPORT BEACH TO ABALONE POINT, LAGUNA BEACH

Newport/Irvine Coast. This kelp bed decreased in size from 0.036 km^2 in 2016 to 0.033 km^2 in 2017 (a decrease of 8.3%) (Table 4). The canopy area in 2017 was 7.9% of the maximum recorded in 2011 (Figure 3, Appendix B.3).

Downcoast from Newport Harbor, giant kelp grows in a number of small beds (collectively called the Newport/Irvine Coast kelp bed (Appendices A.41 and A.42), and referred to in some reports as the Corona del Mar kelp bed). The canopy area of this kelp bed was quite large from 2011 through 2014, but decreased considerably from 2015 through 2017 (red line on Figure 8). In 2017, the canopy area was the lowest since 2005 (Appendix B.3). This corresponds to the sharp decrease in the Orange County ABAPY from 2015 through 2017 (Figure 8).

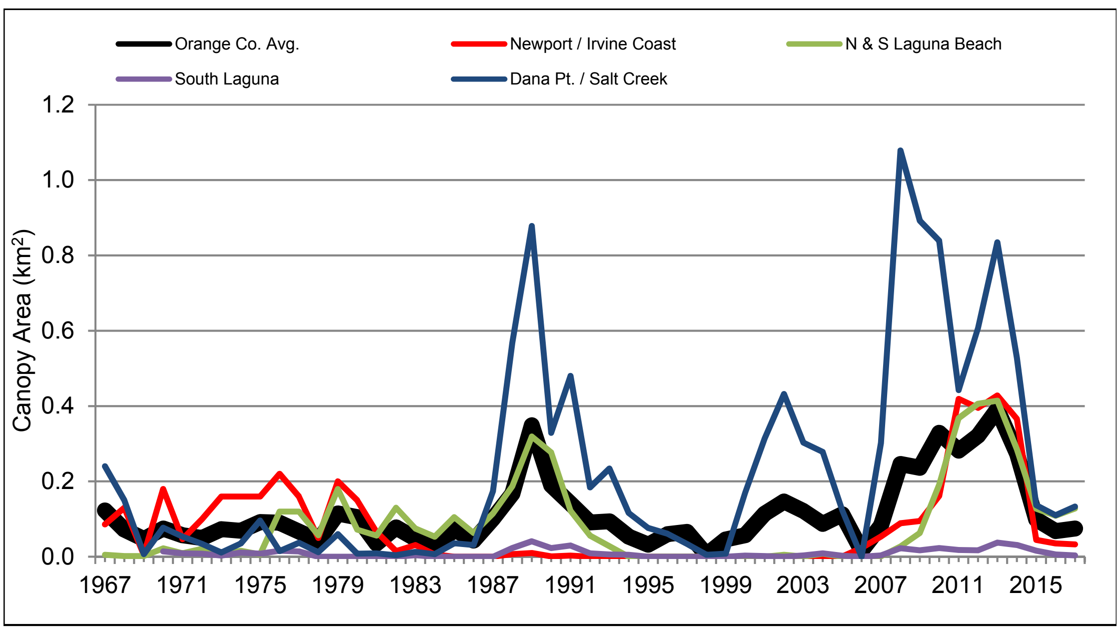


Figure 8. Comparisons between the average Orange County ABAPY and the canopy coverage of the kelp beds from Newport/Irvine Coast to Dana Point/Salt Creek from 1967 through 2017.

III.3 - SIZE OF KELP BEDS IN REGION NINE

The following is a synopsis of the status of each of the 24 designated individual kelp beds in the Region Nine during the 2017 survey year based upon the quarterly surveys. Information also is presented on several other areas where kelp beds were present. The comparison of canopy coverage between 2016 and 2017 for each kelp bed is presented in Table 5. Historical canopy coverage since 1911 is presented in Appendix B.4. Visual observations of the kelp beds are recorded in Table 6 (based on vessel surveys conducted in December 2017 and January 2018). Observations from diver surveys at the Del Mar and Agua Hedionda kelp bed areas also are presented.

III.3.A - ABALONE POINT TO CAPISTRANO BEACH

There are five kelp beds located between Abalone Point and Capistrano Beach. In 2017, two of the beds increased in size, while three decreased (Table 5).

North Laguna Beach/South Laguna Beach. The North Laguna Beach kelp bed increased in size 0.074 km^2 in 2016 to 0.096 km^2 in 2017 (an increase of 7.5%) (Table 5). The canopy area in 2017 was 50.0% of the maximum recorded in 2012 (Figure 3, Appendix B.4). The South Laguna Beach kelp bed decreased in size from 0.035 km^2 in 2016 to 0.032 km^2 in 2017 (a decrease of 9.4%). The canopy area in 2017 was 11.7% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

The Laguna Beach beds were not visible until about 2006 when they reappeared as a result of restoration efforts. Based upon the combined annual total kelp canopy coverage, the total area calculated at these two areas in 2013 (0.415 km^2) was the largest on record. However, canopy declined each year thereafter through 2016. However, the two kelp beds increased from a combined total of 0.109 km^2 in 2016 to 0.128 km^2 in 2017 (green line on Figure 8), similar to the increase in the Orange County ABAPY.

During the 2017 vessel survey (Table 6), the North Laguna Beach surface canopy was medium in area and measured approximately 100 by 30 meters. No subsurface kelp was visible on the fathometer. Tissue color was 80% dark yellow and 20% light yellow, with 5% apical blades and the fronds had medium to heavy encrustation. The kelp bed was composed of approximately 5% senile, 10% mature, and 85% young fronds. The South Laguna Beach surface canopy was thick and measured approximately 500 by 100 meters. Lots of subsurface kelp was visible on the fathometer. Tissue color was 60% dark yellow and 40% light yellow, with 30% apical blades and the fronds had medium encrustation. The kelp bed was composed of approximately 5% senile, 25% mature, and 70% young fronds.

South Laguna. This kelp bed decreased in size from 0.006 km^2 in 2016 to 0.003 km^2 in 2017 (a decrease of 50.0%) (Table 5). The canopy area in 2017 was 7.3% of the maximum recorded in 1989 (Figure 3, Appendix B.4).

In 2013, the South Laguna kelp bed more than doubled in size from 2012, and it reached its largest extent since 1989 (Appendix B.4). However, this kelp bed has declined since, nearly disappearing in 2017 (purple line on Figure 8). The South Laguna kelp bed was much smaller than the ABAPY during most years, and canopy size at this site has not trended well with the ABAPY (Appendix A.45).

During the 2017 vessel survey, sparse kelp was observed over a 10 to 20 x 0.25 meter area. The tissue was medium yellow and approximately 80% of the fronds were mature, with medium to heavy encrustation. Sporadic subsurface kelp was visible on the fathometer (Table 6).

Dana Point/Salt Creek. This kelp bed increased in size from 0.110 km^2 in 2016 to 0.133 km^2 in 2017 (an increase of 20.9%) (Table 5). The canopy area in 2017 was 12.5% of the maximum recorded in 2008 (Figure 8, Appendix B.4).

The canopy at Dana Point/Salt Creek (Appendix A.46) has fluctuated greatly since 1986. Large canopy areas were observed in 1989, 2002, 2008, and 2013. However, extremely small canopy size was recorded in 1986, 1998, 1999, and 2006 (when the kelp bed disappeared) (Appendix B.4). From 2015 to 2017, this kelp bed has remained at a relatively small size (blue line on Figure 8), corresponding to low ABAPY levels for the Orange County average.

During the 2017 vessel survey (Table 6), the Dana Point/Salt Creek surface canopy was scattered and measured approximately 100 by 150 meters. Lots of subsurface kelp was visible on the fathometer out to a depth of about 60 feet. Tissue color was medium yellow, with 50% apical blades, and the fronds had little to no encrustation. The kelp bed was composed of 100% young fronds.

Some kelp (0.004 km^2) was observed along the breakwaters in Dana Point Harbor (Appendix A.47) in 2017. This represented a decrease of 50% from 2016 (0.004 km^2). This is not a designated kelp bed, due to its small size.

Capistrano Beach. This kelp bed decreased in size from 0.012 km^2 in 2016 to 0.0004 km^2 in 2017 (a decrease of 96.7%) (Table 5). The canopy area in 2017 was 1.7% of the maximum recorded in 1989 (Figure 9, Appendix B.4).

The Capistrano Beach kelp bed (Appendices A.47 and A.48) nearly disappeared in 2017 (blue line on Figure 9). The Capistrano Beach bed declined substantially in size in 2017 despite the slight increase in the ABAPY.

During the 2017 vessel survey, scattered kelp was observed with approximately 5% coverage close to shore in an area of approximately 100 by 150 meters. The tissue was light and medium yellow, with 5% apical blades and 75% encrustation. Approximately 30% of the fronds were senile, 65% mature, and 5% young. More subsurface kelp was visible on the fathometer than the amount observed in the surface canopy (Table 6).

Table 5. Canopy coverage of the Central Region kelp beds from Laguna Beach to Imperial Beach during 2016 and 2017.

Kelp Bed	2016 (km^2)	2017 (km^2)	Percentage Difference
North Laguna Beach	**0.074**	**0.096**	**+29.7**
South Laguna Beach	**0.035**	**0.032**	**-9.4**
South Laguna	**0.006**	**0.003**	**-50.0**
Dana Point/Salt Creek	**0.110**	**0.133**	**+20.9**
Capistrano Beach	**0.012**	**0.0004**	**-96.7**
San Clemente	**0.187**	**0.229**	**+22.5**
San Mateo Point	**0.053**	**0.033**	**-37.7**
San Onofre	**0.120**	**0.087**	**-27.5**
Horno Canyon	**0.010**	**0.011**	**+10.0**
Barn Kelp	**0.133**	**0.096**	**-27.8**
Santa Margarita	–	–	**no change**
North Carlsbad	–	**0.004**	**reappeared**
Agua Hedionda	–	–	**no change**
Encina Power Plant	**0.009**	**0.025**	**+177.8**
Carlsbad State Beach	–	**0.001**	**reappeared**
Leucadia	**0.033**	**0.010**	**-69.7**
Encinitas	**0.009**	**0.003**	**-66.7**
Cardiff	**0.024**	**0.003**	**-87.5**
Solana Beach	**0.138**	**0.029**	**-79.0**
Del Mar	–	–	**no change**

Table 5 (continued)

Kelp Bed	2016 (km²)	2017 (km²)	Percentage Difference
Torrey Pines	–	–	**no change**
La Jolla	**0.927**	**0.694**	**-25.1**
Point Loma	**3.037**	**1.787**	**-41.2**
Imperial Beach	**0.217**	–	**disappeared**
TOTAL	**5.134**	**3.276**	**-36.2**

Table 6. Visual observations of RNKSC kelp beds during 2017 vessel surveys.

Kelp Bed	Surface Canopy		Subsurface Kelp
	Extent	Appearance	
North Laguna Beach	medium 100 m x 30 m	80% dark yellow, 20% light yellow; 5% senile, 10% mature, 85% young; medium to heavy encrustation 5% apical blades	
South Laguna Beach	Thick 100 m x 500 m	60% dark yellow, 40% light yellow 5% senile, 25% mature, 70% young medium encrustation 30% apical blades	lots of subsurface kelp
South Laguna	sparse 10 to 20 m x 0.25 miles	medium yellow 80% mature medium to heavy encrustation	sporadic
Dana Point/Salt Creek	scattered 100 m x 150 m	medium yellow 100% young no to little encrustation 50% apical blades	lots of subsurface kelp, out to 60-ft depth
Dana Point Harbor	None		None
Capistrano Beach	scattered (@ 5% coverage), close to shore 100 m x 150 m	light and medium yellow 30% senile, 65% mature, 5% young 75% encrustation 5% apical blades	More subsurface than in surface canopy
San Clemente	medium (@ 70% coverage) 150 m x 150 m	medium yellow 5% senile, 90% mature, 5% young 70% encrustation	all apical blades subsurface (new young stipes)
San Mateo Point	medium (@ 50% coverage) 200 m x 1 km	medium yellow 5% senile, 85% mature, 10% young 10% encrustation 15% apical blades	most apical blades subsurface
San Onofre	medium (@ 65% coverage) 150 m x 150 m	medium yellow 10% senile, 70% mature, 20% young 40% encrustation 15% apical blades	most apical blades subsurface

Table 6 (continued)

Pendleton Reefs	none		none
Horno Canyon	none		none
Barn Kelp	Scattered (@ 50% coverage) 200 m x 100 m	medium yellow 10% senile, 70% mature, 20% young Slight/medium encrustation (@40% blades) 10% apical blades	younger apical blades subsurface
Santa Margarita	none		none
North Carlsbad	none		lots of subsurface kelp, @ 40% new growth
Agua Hedionda	none		See discussion of dive survey results
Encina Power Plant	none		lots of subsurface kelp; 90% senile/mature, 10% young
Carlsbad State Beach	none		lots of subsurface kelp (90% senile/mature,10% young)
Leucadia-north	none		none
Leucadia-central	none		sparse patches (10 x 100 m, mostly senile)
Leucadia-south	none		none
Encinitas	sparse and scattered	medium yellow 5% senile, 92% mature, 3% young heavy encrustation 1% apical blades	medium amount
Cardiff	Medium 100 m x 100 m	50% dark yellow, 50% light yellow 5% senile, 45% mature, 50% young light encrustation 5% apical blades	lots of subsurface kelp
Solana Beach	Several patches, medium 100 m x 100 m for two areas, half that for third area	90% medium yellow, 10% dark yellow 95% mature, 5% young medium to heavy encrustation 2% apical blades	lots of subsurface kelp
Del Mar	none		See discussion of dive survey results
Torrey Pines	none		none
La Jolla North	sparse, @ 180 m wide	medium yellow 5% senile, 85% mature, 10% young light encrustation no apical blades	visible subsurface kelp
La Jolla South	Extensive near shore	70% pale yellow, 30% dark yellow 10% senile, 50% mature, 40% young heavy encrustation on old growth some apical blades	some subsurface kelp
Point Loma North	Solid canopy 100 m wide	20% light yellow, 80% dark yellow 2% senile, 8% mature, 90% young 50% encrustation 2% apical blades	subsurface at 65-ft depth, but none deeper
Point Loma South	Solid canopy 150 m wide x @ 0.5 km alongshore (linked to Point Loma North	gold dark yellow 5% mature, 95% young some encrustation 5% apical blades	subsurface at 55-ft depth, but none deeper
Imperial Beach	none		none

III.3.B - SAN CLEMENTE TO SAN ONOFRE

Three kelp beds are located between San Clemente and San Onofre. One bed increased in size in 2017, while the other two decreased (Table 5).

San Clemente. This kelp bed increased in size from 0.187 km^2 in 2016 to 0.229 km^2 in 2017 (an increase of 22.5%) (Table 5). The canopy area in 2017 was 20.9% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

After increasing in size for seven consecutive years (from 0.014 km^2 in 2006 to 1.097 km^2 in 2013, a 99% increase), the canopy coverage of this reef decreased by 83% from 2013 to 2016, with 46% canopy loss from 2015 to 2016 (Appendix B.4). Although the Orange County ABAPY increased only slightly between 2016 and 2017, the San Clemente kelp canopy increased considerably in size in 2017 (purple line on Figure 9).

During the 2017 vessel survey (Table 6), the San Clemente surface canopy was medium in area (approximately 70% coverage) and measured approximately 150 by 150 meters. Tissue color was medium yellow and the fronds had approximately 70% encrustation. The kelp bed was composed of approximately 5% senile, 90% mature, and 5% young fronds. All apical blades (new young stipes) were located in subsurface areas.

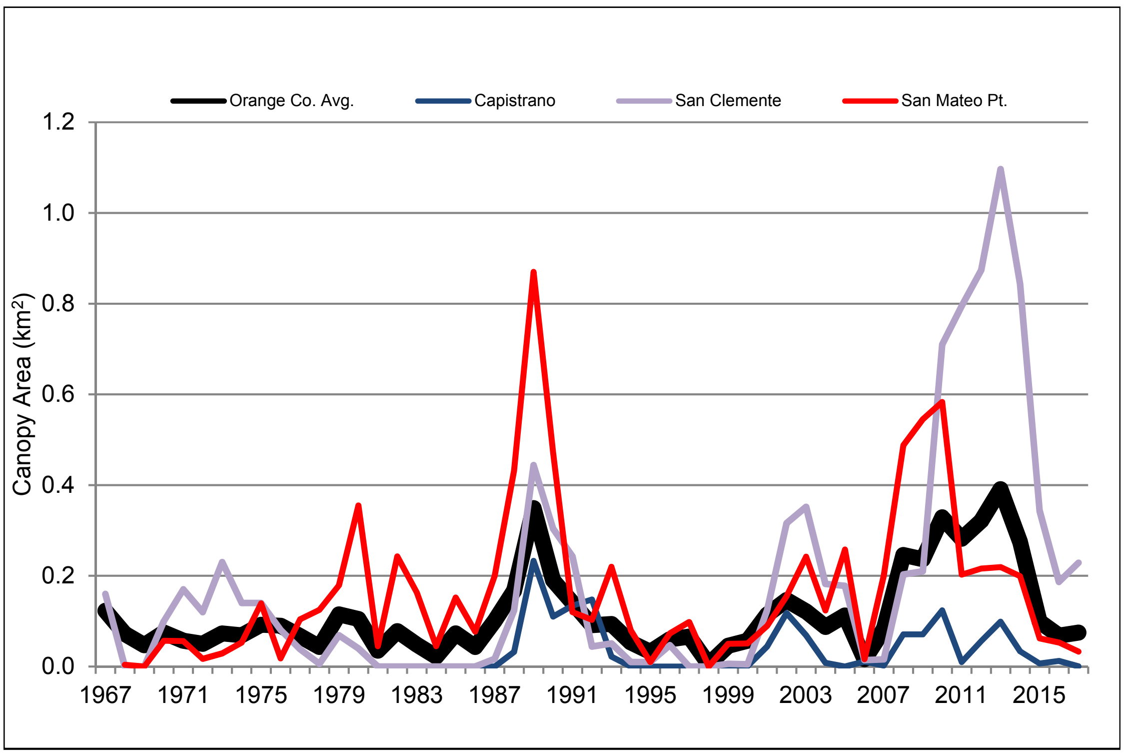


Figure 9. Comparisons between the average Orange County ABAPY and the canopy coverage from Capistrano Beach to San Mateo Point from 1967 through 2017.

San Mateo Point. This kelp bed decreased in size from 0.053 km^2 in 2016 to 0.033 km^2 in 2017 (a decrease of 37.7%) (Table 5). The canopy area in 2017 was only 3.8% of the maximum recorded in 1989 (Figure 3, Appendix B.4).

The San Mateo Point kelp bed (Appendix A.50) has declined in size since 2010 to a fairly small area in 2017. This is the smallest kelp canopy area recorded since 2006 (red line on Figure 9). Despite the slight increase in the Orange County ABAPY between 2016 and 2017, the San Mateo Point kelp bed decreased in size in 2017.

During the 2017 vessel survey (Table 6), the San Mateo Point surface canopy was medium in area (approximately 50% coverage) and measured approximately 200 meters by 1 kilometer. Tissue color was medium yellow, with 15% apical blades, and the fronds had light encrustation (approximately 10%). The kelp bed was composed of approximately 5% senile, 85% mature, and 10% young fronds. Most apical blades were located in subsurface areas.

San Onofre. This kelp bed decreased in size from 0.120 km^2 in 2016 to 0.087 km^2 in 2017 (a decrease of 27.5%) (Table 5). The canopy area in 2017 was only 11.3% of the maximum recorded in 1989 (Figure 3, Appendix B.4).

The San Onofre Nuclear Generating Station (SONGS) reactors were shut down in January 2012, and the decision was made in June 2013 to permanently retire the facility. Discharge flows from the ocean outfall have decreased substantially, since limited water flow is required to gradually cool down spent nuclear fuel (current flows are less than 4% of the previous volumes discharged during normal plant operations).

After reaching a peak size in 2013, the San Onofre kelp bed (Appendices A.50 and A.51) has decreased considerably in size (red line on Figure 10, Appendix B.4). The San Diego County average ABAPY (excluding the La Jolla and Point Loma beds, which would skew the average) decreased between 2016 and 2017, as did the San Onofre canopy area.

During the 2017 vessel survey (Table 6), the San Onofre surface canopy was medium in area (approximately 65% coverage) and measured approximately 150 by 150 meters. Tissue color was medium yellow, with 15% apical blades, and the fronds had medium encrustation (approximately 40%). The kelp bed was composed of approximately 10% senile, 70% mature, and 20% young fronds. Most apical blades were located in subsurface areas.

III.3.C - HORNO CANYON TO SANTA MARGARITA RIVER

Three kelp beds are located between Horno Canyon and the Santa Margarita River. In 2017, one bed increased in size, one decreased, and one was not visible (Table 5).

Horno Canyon. This kelp bed increased in size from 0.010 km^2 in 2016 to 0.011 km^2 in 2017 (an increase of 10.0%) (Table 5). The canopy area in 2017 was 8.8% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

Since 2013, the Horno Canyon kelp beds (Appendix A.52) have decreased to a fairly small size (green line on Figure 10, Appendix B.4). Although the San Diego County ABAPY decreased in 2017, the Horno Canyon canopy area slight increased slightly.

During the 2017 vessel survey (Table 6), the no surface canopy or subsurface kelp was observed at Horno Canyon.

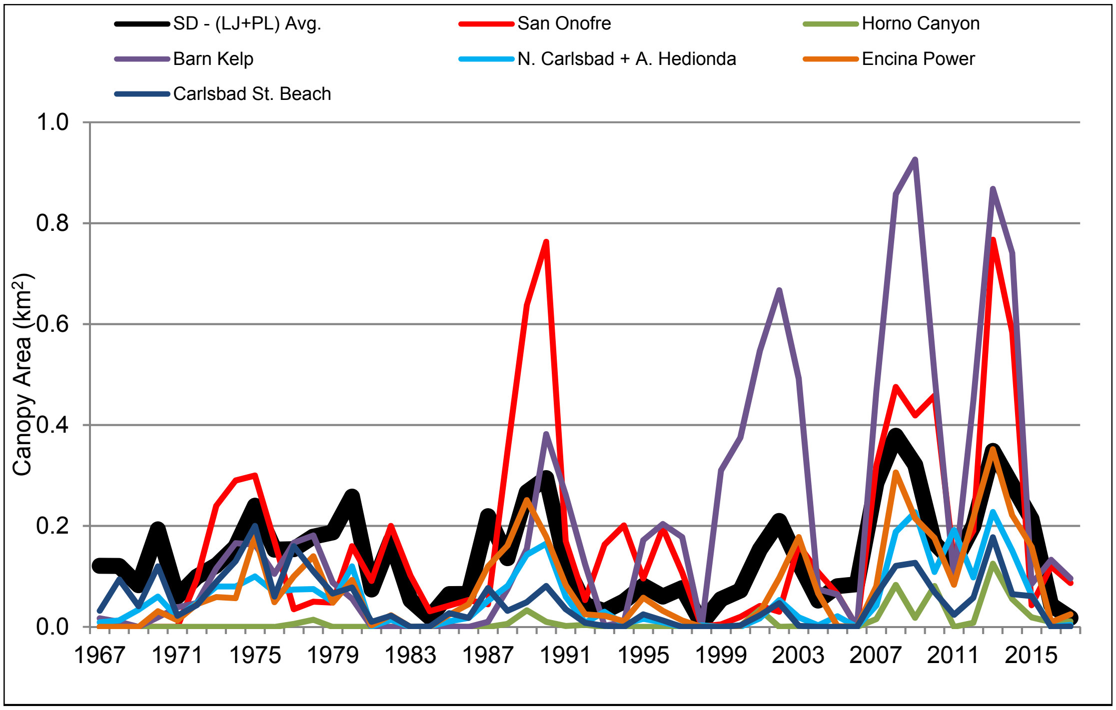


Figure 10. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverage from San Onofre to Carlsbad State Beach from 1967 to 2017.

Pendleton Artificial Reef (PAR) is just upcoast from Horno Canyon. No surface canopy was observed at this location. This is not a designated kelp bed due to its small size and lack of persistence.

Barn Kelp. This kelp bed decreased in size from 0.133 km^2 in 2016 to 0.096 km^2 in 2017 (a decrease of 27.8%) (Table 5). The canopy area in 2017 was 10.4% of the maximum recorded in 2009 (Figure 3, Appendix B.4).

In 2013, Barn Kelp (Appendices A.53 and A.54) was more than three times larger than average, and it was the fifth largest kelp bed in Region Nine (Appendix B.4). In 2017, this kelp bed was relatively small in size (purple line on Figure 10). The San Diego County ABAPY decreased in 2017, as did the size of the Barn kelp bed.

During the 2017 vessel survey (Table 6), the Barn Kelp surface canopy was scattered (approximately 50% coverage) and measured approximately 200 by 100 meters. Tissue color was medium yellow, with 10% apical blades, and the fronds had slight to medium encrustation (approximately 40%). The kelp bed was composed of approximately 10% senile, 70% mature, and 20% young fronds. Younger apical blades were located in subsurface areas.

No kelp was visible downcoast from Barn kelp offshore Camp Pendleton (Appendix A.55).

Santa Margarita. This kelp bed was not observed during 2017, nor was it visible in 2016 (Table 5).

The Santa Margarita kelp bed is a small bed that occasionally forms a canopy off the Santa Margarita River mouth (Appendix A.56). In 1911, Santa Margarita was the site of a substantial kelp bed that covered 0.858 km^2. Kelp disappeared here sometime before regular surveys began in 1967 by Dr. North. No kelp was seen during any of the vessel or aerial surveys until 1991, when a small bed covered an area of 0.049 km^2; it was much smaller in 1992, and disappeared in 1993. No canopy was observed at Santa Margarita for the next two decades, but a small kelp bed was visible during the December 2013 overflight. The size of the bed in 2013 (0.080 km^2) was 63% larger than in 1991. No canopy has been observed at this site since 2013 (Appendix B.4).

During the 2017 vessel surveys, no kelp was visible at Santa Margarita on or below the surface.

A small amount of kelp (0.003 km^2) was observed in Oceanside Harbor (Appendix A.57) in 2017. No kelp was visible in the harbor in 2016. This is not a designated kelp bed due to its small size.

III.3.D - NORTH CARLSBAD TO CARLSBAD STATE BEACH

There are four kelp beds located between North Carlsbad and Carlsbad State Beach. In 2017, three of the beds increased in size, while the other still was not visible (Table 5).

North Carlsbad. This kelp bed was not visible in 2016, but reappeared in 2017 at a size of 0.004 km^2 (Table 5). However, the canopy area in 2017 was only 2.2% of the maximum recorded in 1993 (Figure 3, Appendix B.4).

The North Carlsbad kelp bed is usually comprised of several small beds (Appendices A.58 and A.59). This kelp bed was fairly large in 2013, but subsequently disappeared in 2016 (turquoise line on Figure 10, Appendix B.4). This kelp bed reappeared in 2017, but was small in size. Despite the decrease in the San Diego County ABAPY in 2017, the North Carlsbad kelp bed increased in size.

During the 2017 vessel survey (Table 6), no surface canopy was observed at the North Carlsbad kelp bed. However, lots of subsurface kelp was visible on the fathometer, with approximately 40% new growth.

Agua Hedionda. This kelp bed was not observed in 2017, nor was it visible in 2016 (Table 5).

The Agua Hedionda kelp bed (Appendix A.59) had been visible since 2007 and peaked in size in 2013, but declined over the next few years before disappearing in 2016 (turquoise line on Figure 10, Appendix B.4).

No surface canopy was observed at the Agua Hedionda kelp bed in 2017 (Table 6). However, this was one of the two RNKSC kelp beds where divers conducted an in-water survey. Within a 50 x 3 meter transect, 42 adult kelp plants and 15 juvenile plants were observed, as well as 27 recruits (<40 centimeters). Visibility was very good in this area (30-40 feet), and minimal amounts of urchins or other algae were present.

Encina Power Plant. This kelp bed increased in size from 0.009 km^2 in 2016 to 0.025 km^2 in 2017 (an increase of 177.8%) (Table 5). This was the largest increase in canopy size for any of the Region Nine kelp beds in 2017. However, the canopy area in 2017 still was only 7.1% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

The Encina Power Plant kelp bed (Appendix A.60) reached its maximum size in 2013 (0.352 km^2) (Appendix B.4). The canopy decreased in size during each of the next three years through 2016. Although the San Diego County ABAPY decreased in 2017, the Encina Power Plant kelp bed increasing substantially in size in 2017 (orange line on Figure 10).

No surface canopy was observed at the Encina Power Plant kelp bed during the 2017 vessel survey (Table 6). However, lots of subsurface kelp was visible on the fathometer. Kelp fronds visible from the vessel were 90% senile or mature, and 10% young.

Carlsbad State Beach. This kelp bed was not observed in 2016, but barely reappeared at a size of 0.001 km^2 in 2017 (Table 5). However, the canopy area in 2017 was only 0.6% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

The Carlsbad State Beach (Carlsbad State Park) kelp bed (Appendices A.60 and A.61) made considerable gains in 2013, and increased three-fold to 0.178 km^2 (Appendix B.4). However, it decreased in size thereafter, and was not visible in 2016. Although the San Diego County ABAPY decreased in 2017, the Carlsbad State Beach kelp bed increased in size (blue line on Figure 10).

No surface canopy was observed at the Carlsbad State Beach kelp bed during the 2017 vessel survey (Table 6). However, lots of subsurface kelp was visible on the fathometer. Kelp fronds visible from the vessel were 90% senile or mature, and 10% young.

III.3.E - LEUCADIA TO TORREY PINES

Leucadia. This kelp bed decreased in size from 0.032 km^2 in 2016 to 0.010 km^2 in 2017 (a decrease of 69.7%) (Table 5). However, the canopy area in 2017 was only 1.8% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

The Leucadia kelp bed is comprised of the North, Central, and South Leucadia kelp beds (surveyed as three separate beds because of distinct breaks in the beds (Appendices A.62 and A.63).

In 2013, Leucadia kelp bed increased in size to its highest canopy coverage in the last 30 years (0.541 km^2), but by 2016 had declined to only 6% of the 2013 maximum (red line on Figure 11, Appendix B.4). In 2017, the North bed (off Batiquitos Lagoon) accounted for approximately one-third of the canopy area and the Central bed accounted for approximately two-thirds; no kelp canopy was visible in the South bed. The decrease in size in 2017 corresponded to a decline in the San Diego County ABAPY in 2017.

No surface canopy was observed at any of the Leucadia kelp beds during the 2017 vessel survey (Table 6). No subsurface kelp was visible at the North or South Leucadia kelp beds. However, sparse patches (10 x 100 meters) of subsurface kelp was visible on the fathometer. Most kelp fronds appeared to be senile.

Encinitas. This kelp bed decreased in size from 0.009 km^2 in 2016 to 0.003 km^2 in 2017 (a decrease of 66.7%) (Table 5). However, the canopy area in 2017 was only 0.9% of the maximum recorded in 2008 (Figure 3, Appendix B.4).

The Encinitas kelp bed (Appendix A.63) decreased in size considerably between 2013 and 2017 (green line on Figure 11, Appendix B.4). The 2017 canopy area was the smallest recorded since 2006. The decrease in size in 2017 corresponded to the decrease in the ABAPY.

During the 2017 vessel survey, the surface canopy was sparse and scattered at the Encinitas kelp bed (Table 6). Tissue color was medium yellow, with only 1% apical blades, and the fronds had heavy encrustation. The kelp bed was composed of approximately 5% senile, 92% mature, and 3% young fronds. A medium amount of subsurface kelp was visible on the fathometer.

Cardiff. This kelp bed decreased in size from 0.024 km^2 in 2016 to 0.003 km^2 in 2017 (a decrease of 87.5%) (Table 5). This was the greatest percentage decline for any of the Region Nine kelp beds in 2017. The canopy area in 2017 was only 0.5% of the maximum recorded in 2013 (Figure 3, Appendix B.4).

The Cardiff kelp bed (Appendix A.64) reached a peak of 0.590 km^2 in 2013, but has declined in size over the past few years (Appendix B.4). The large decrease in size observed in 2017 was even greater than the decrease in the San Diego County ABAPY (purple line on Figure 11).

During the 2017 vessel survey, the surface canopy was medium in area, and measured 100 x 100 meters (Table 6). Tissue color was 50% dark yellow and 50% light yellow, with 5% apical blades, and the fronds had light encrustation. The kelp bed was composed of approximately 5% senile, 45% mature, and 50% young fronds. Lots of subsurface kelp was visible on the fathometer.

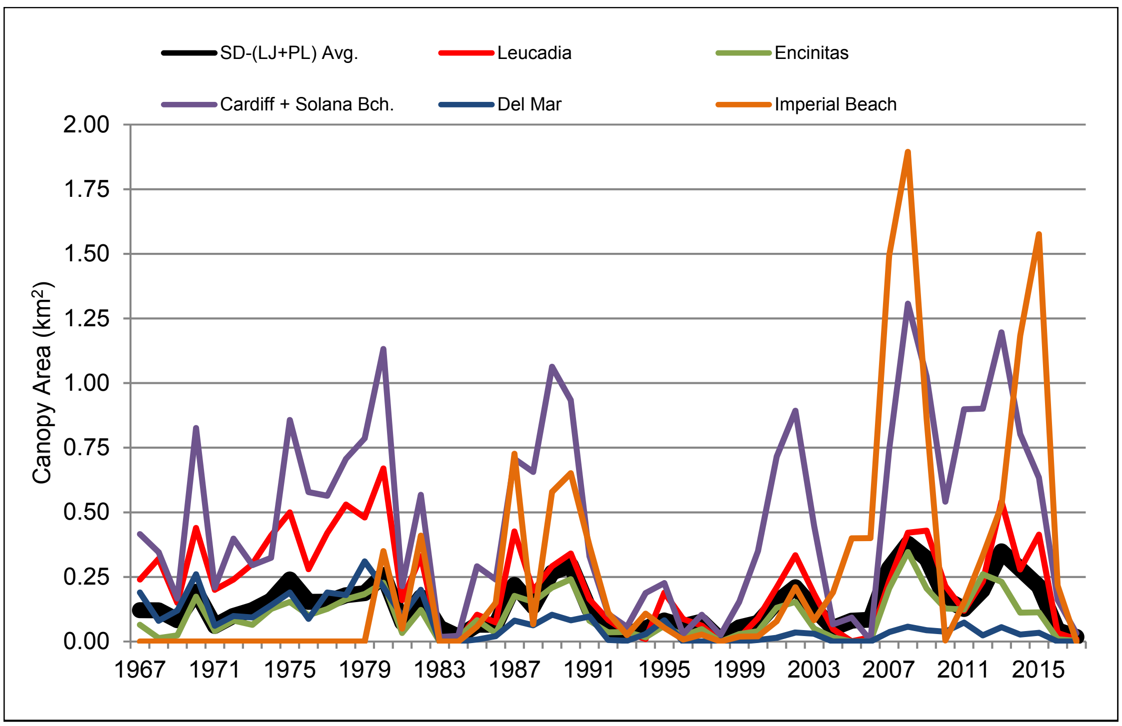


Figure 11. Comparisons between the average SD-(LJ+PL) ABAPY and canopy coverage from Leucadia to Del Mar (and Imperial Beach) from 1967 to 2017.

Solana Beach. This kelp bed decreased in size from 0.138 km^2 in 2016 to 0.029 km^2 in 2017 (a decrease of 79.0%) (Table 5). The canopy area in 2017 was only 3.5% of the maximum recorded in 1989 (Figure 3, Appendix B.4).

The Solana Beach kelp bed (Appendices A.64 and A.65) also reached a peak in 2013, but has declined in size over the past few years (Appendix B.4). The decrease in size observed in 2017 was greater than the overall decrease in the San Diego County ABAPY (purple line on Figure 11).

During the 2017 vessel survey, several medium patches of surface canopy were observed at the Solana Beach kelp bed, two areas measuring 100 x 100 meters, and a third area measuring approximately half that size (Table 6). Tissue color was 90% medium yellow and 10% dark yellow, with 2% apical blades, and the fronds had medium to heavy encrustation. The kelp bed was composed of approximately 95% mature and 5% young fronds. Lots of subsurface kelp was visible on the fathometer.

Del Mar. This kelp bed was not observed in 2017, nor was it visible in 2016 (Table 5).

The Del Mar kelp bed (Appendices A.66 and A.67) typically is one of the smallest beds in Region Nine, and in 2015 its canopy area (0.034 km^2) was the fourth smallest among beds displaying canopy (blue line on Figure 11, Appendix B.4). Although this bed was visible between 2007 and 2015, it disappeared in 2016 and was not visible in 2017.

No surface canopy was observed at the Del Mar kelp bed during the 2017 vessel survey (Table 6). This was the second kelp bed where divers conducted an in-water survey. Only several individual adult and several juvenile plants (<40 cm) were observed. Visibility was very good in this area (30 to 40 feet), and minimal amounts of urchins or other algae were present.

Torrey Pines. This kelp bed was not observed in 2017, nor was it visible in 2016 (Table 5).

Torrey Pines kelp bed (Appendices A.67 and A.68) appeared as a small trace of kelp during La Niña conditions in 1988 and 1989. It reappeared in 2006 as a measurable canopy (0.010 km^2) with scattered giant kelp about 1.5 km north of Scripps Pier, another concentration about 3.5 km north, and a third concentration of scattered giant kelp was found about 1.5 km north of that position (5 km north of the pier). The canopy disappeared in 2007, but from 2008 through 2013 small canopies were observed in various locations in the area. In 2013, Torrey Pines kelp bed was measured at its largest extent (0.081 km^2), but no canopy was visible from 2014 through 2017 (Appendix B.4).

During the 2017 vessel survey, no kelp was visible on or below the sea surface at the Torrey Pines kelp bed (Table 6).

III.3.F - LA JOLLA

La Jolla. This kelp bed decreased in size from 0.927 km^2 in 2016 to 0.694 km^2 in 2017 (a decrease of 25.1%) (Table 5). The canopy area in 2017 was 14.6% of the maximum recorded in 1989 (Figure 3, Appendix B.4).

La Jolla kelp bed is composed of two canopies: northern La Jolla and southern La Jolla (Appendices A.68 through A.70). Between southern La Jolla and Upper Point Loma (offshore Mission Bay), nearshore habitat is mostly sandy and kelp does not grow in this area (Appendices A.70 and A.71). The La Jolla kelp bed has decreased in size considerably since 2013 (Appendix B.4). The canopy area in 2017 was the lowest recorded since 2006 (red line on Figure 12). However, it still is the second largest kelp bed within Region Nine. The decrease in size in 2017 was similar to the decrease in the Point Loma/La Jolla ABAPY (Figure 12).

During the 2017 vessel survey, the La Jolla North kelp beds were sparse, covering an area approximately 180 meters wide (Table 6). Tissue color was medium yellow, with no apical blades, and the fronds had light encrustation. The kelp bed was composed of approximately 5% senile, 85% mature, and 10% young fronds. Subsurface kelp was visible on the fathometer. The La Jolla South kelp beds were extensive near shore. Tissue color was 70% pale yellow and 30% dark yellow, with some apical blades, and the fronds had heavy encrustation in old growth areas. The kelp bed was composed of approximately10% senile, 50% mature, and 40% young fronds. Some subsurface kelp was visible on the fathometer.

III.3.G - POINT LOMA TO CORONADO BEACH

Point Loma. This kelp bed decreased in size from 3.037 km^2 in 2016 to 1.787 km^2 in 2017 (a decrease of 41.2%) (Table 5). The canopy area in 2017 was 27.0% of the maximum recorded in 2008 (Figure 3, Appendix B.4).

The Point Loma kelp bed (Appendices A.71 through A.74) is composed of many, usually contiguous, kelp canopies ranging from depths of 5 to greater than 30 meters during years with sufficient nutrients. *Pelagophycus porra* is prevalent beyond about 30 meters depth at Point Loma (Turner et al. 1968). It is the largest bed in Region Nine. The canopy at Point Loma maintained a relatively large size (>5 km^2) from 2013 through 2015 (green line on Figure 12). However, in 2016, the canopy cover decreased 48% to a canopy area of 3.037 km^2, which was the lowest measured since 2006, and declined by an additional 41% in 2017 (Appendix B.4).

During the 2017 vessel survey, a solid canopy approximately 100 meters wide was observed at the Point Loma North kelp beds (Table 6). Tissue color 20% light yellow and 80% dark yellow, with only 2% apical blades, and the fronds had medium encrustation (50%). The kelp bed was composed of approximately 2% senile, 8% mature, and 90% young fronds. Subsurface kelp was visible on the fathometer at a depth of 65 feet, but none deeper. A solid canopy approximately 150 meters x 0.5 kilometers was observed along the nearshore area of the Point Loma South kelp beds (contiguous with the Point Loma North kelp beds). Tissue color was golden dark yellow, with 5% apical blades, and the fronds had some encrustation. The kelp bed was composed of approximately 5% mature and 95% young fronds. Subsurface kelp was visible on the fathometer at a depth of 55 feet, but none deeper.

No kelp observed at Coronado Beach (Appendix A.76) or Silver Strand (Appendix A.77).

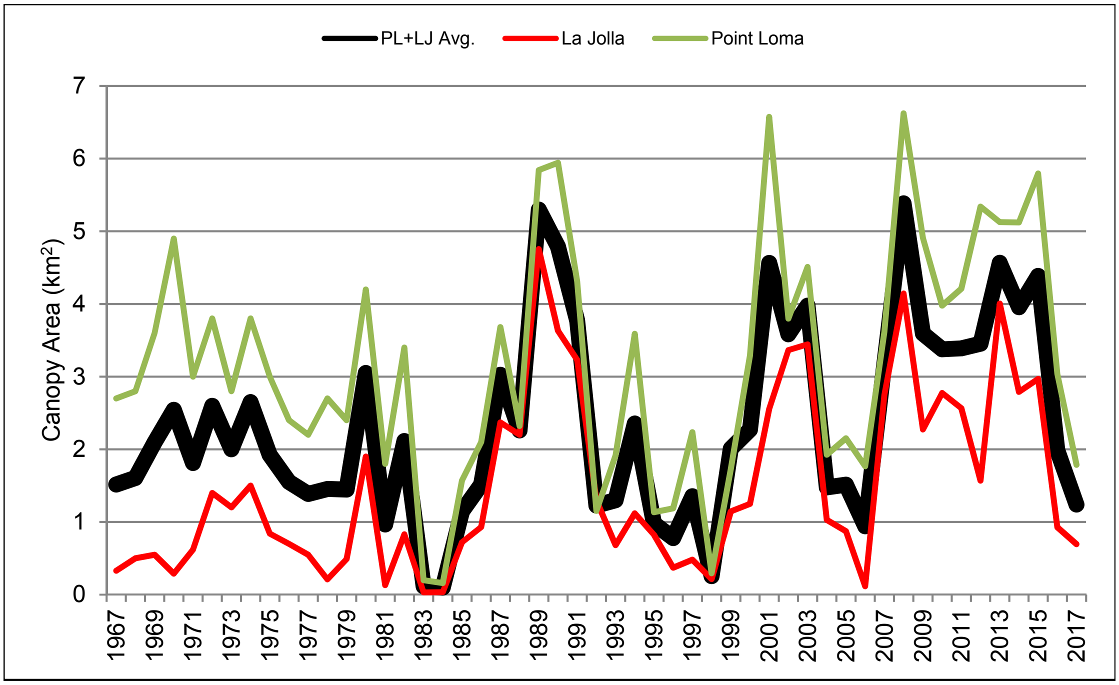


Figure 12. Comparisons between the (LJ+PL)/2 ABAPY and canopy coverage of the La Jolla and Point Loma kelp beds from 1967 to 2017.

III.3.H - CORONADO BEACH TO U.S./MEXICO BORDER

Imperial Beach. This kelp bed disappeared in in 2017, declining from a size of 0.217 km^2 in 2016 (Table 5).

The Imperial Beach kelp bed (Appendices A.79 and A.80) has varied considerably in size from year to year (orange line on Figure 11, Appendix B.4). The Imperial Beach kelp bed canopies have been observed in different locations during years when they were apparent. Svejkovsky (2015) noted "*major bed locations shifts and coverage area variability give the appearance in the persistence analysis that this kelp bed rarely persists longer than one year. In actuality the same bed appears to change in location slightly from year to year with some years (1999 and 2003) showing very sparse coverage and others (2008 and 2009) exhibiting much larger canopy area*."

The canopy area in 2008 was the largest ever recorded, but the kelp bed nearly disappeared in 2009. It rebounded to a very large size in 2015, only to disappear once again by June 2016. This kelp bed was not visible in 2017 (orange line on Figure 11, Appendix B.4).

No surface or subsurface kelp was visible at the Imperial Beach kelp bed during the 2017 vessel survey (Table 6).

IV – DISCUSSION

IV.1 - CENTRAL REGION KELP BEDS

The combined canopy coverage within the 26 kelp beds of the Central Region remained approximately the same in 2017 as it was in 2016 (slight increase in size of 1.9% in 2017) (Figure 13). As usual, the four Palos Verdes kelp beds plus the Cabrillo kelp bed accounted for most of the total canopy area (73.7% of the total) in the Central Region (Table 7). More individual kelp beds decreased in size (12) than increased in size (9) in 2017. In 2017, the canopy area of 10 kelp beds was 40% or more of the historical maximum size, with five kelp beds exceeding 75% of their historical maximum (three of which reached their maximum size ever recorded in 2017). The canopy area of six kelp beds was less than 10% of their historical maximum (Figure 3).

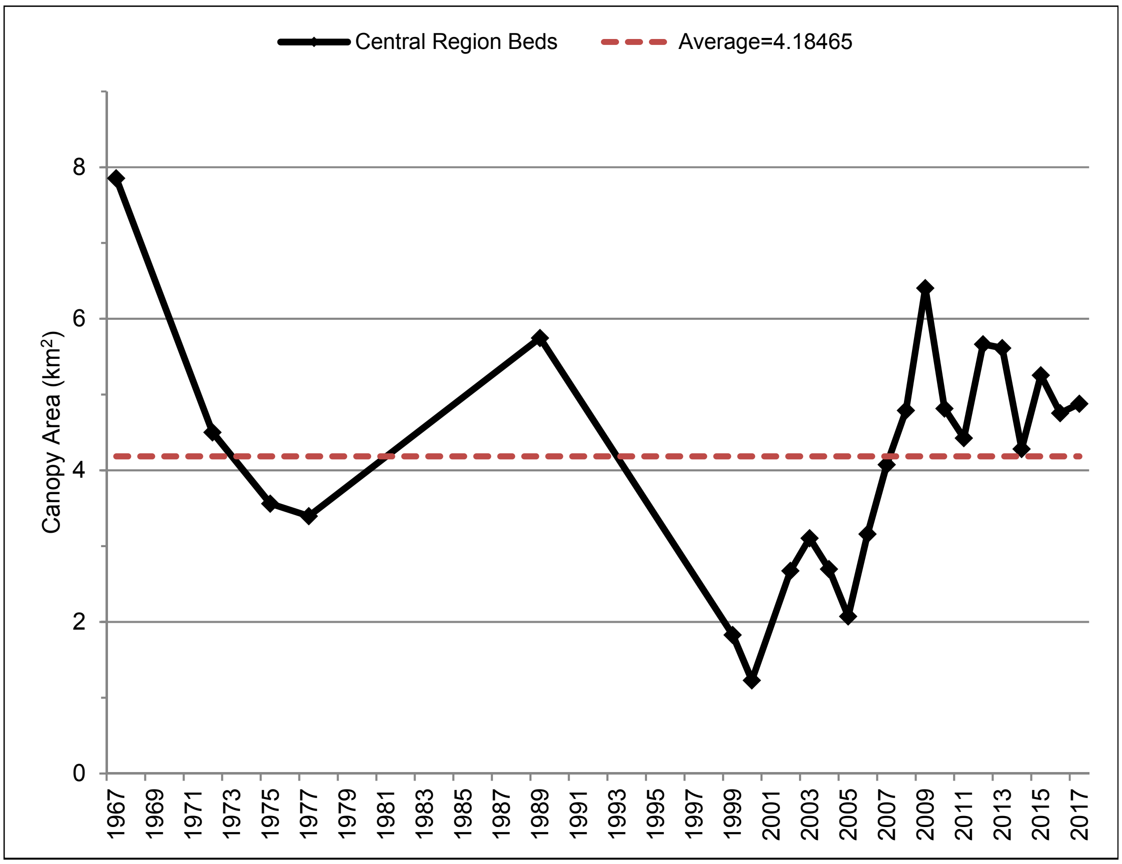


Figure 13. Combined canopy coverage of all kelp beds in the Central Region from Ventura to Newport Harbor/Irvine Coast from 1967 to 2017.

Table 7. Canopy coverage of the kelp beds (km^2) from Deer Creek to Newport/Irvine Coast from 2008 through 2017.

Kelp Bed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Deer Creek	0.074	0.105	0.062	0.055	0.041	0.104	0.103	0.124	0.087	0.105
Leo Carrillo	0.207	0.255	0.232	0.226	0.337	0.366	0.261	0.408	0.326	0.426
Nicolas Canyon	0.268	0.433	0.291	0.130	0.240	0.369	0.288	0.347	0.279	0.179
El Pescador/La Piedra	0.173	0.238	0.164	0.136	0.173	0.236	0.244	0.246	0.160	0.157
Lechuza	0.075	0.105	0.096	0.096	0.066	0.154	0.137	0.119	0.063	0.086
Total F&W 17	0.797	1.136	0.844	0.642	0.857	1.229	1.034	1.244	0.914	0.953
Point Dume	0.070	0.104	0.094	0.078	0.154	0.113	0.092	0.169	0.042	0.050
Paradise Cove	0.223	0.244	0.259	0.109	0.346	0.244	0.223	0.086	0.127	0.024
Escondido Wash	0.278	0.321	0.267	0.104	0.248	0.243	0.281	0.095	0.084	0.059
Latigo Canyon	0.124	0.195	0.142	0.070	0.202	0.133	0.212	0.052	0.057	0.044
Puerco/Amarillo	0.064	0.115	0.126	0.069	0.153	0.105	0.130	0.034	0.027	0.002
Malibu Point	0.011	0.012	0.066	0.074	0.084	0.060	0.039	—	0.035	0.001
Total F&W 16	0.769	0.991	0.954	0.504	1.189	0.897	0.976	0.436	0.372	0.180
La Costa	—	0.001	0.001	—	0.003	0.003	0.001	—	—	—
Las Flores	0.001	0.005	0.005	0.008	0.025	0.022	0.016	—	—	—
Big Rock	0.002	0.005	0.006	0.007	0.018	0.017	0.011	0.004	0.001	0.0001
Las Tunas	0.005	0.019	0.015	0.007	0.030	0.029	0.012	0.004	—	0.001
Topanga	0.001	0.002	0.052	0.041	0.048	0.044	0.016	0.005	—	—
Sunset	—	0.004	0.008	0.007	0.008	0.010	0.010	0.010	0.015	0.003
Total F&W 15	0.009	0.035	0.087	0.069	0.131	0.123	0.064	0.022	0.017	0.004
Malaga Cove-PV Pt. (IV)	1.839	2.122	1.136	1.139	1.337	0.974	0.264	1.410	1.420	1.048
PV Pt-PT. Vic (III)	0.300	0.570	0.624	0.452	0.488	0.502	0.468	0.750	0.430	0.576
Total F&W 14	2.140	2.692	1.760	1.591	1.825	1.476	0.732	2.160	1.850	1.624
Pt Vic to Pt Insp (II)	0.108	0.163	0.222	0.238	0.295	0.279	0.224	0.379	0.366	0.294
Pt Insp to Cabrillo (I)	0.608	0.980	0.389	0.465	0.384	0.672	0.533	0.478	0.610	0.935
Cabrillo	0.060	0.163	0.124	0.103	0.095	0.174	0.158	0.133	0.235	0.329
Total F&W 13	0.776	1.306	0.734	0.805	0.774	1.124	0.915	0.990	1.210	1.557
Total PV	2.916	3.998	2.494	2.396	2.599	2.600	1.647	3.149	3.060	3.181
POLA-POLB Harbor	0.213	0.151	0.277	0.397	0.495	0.337	0.196	0.359	0.359	0.531
Horseshoe	—	—	—	—	—	—	—	—	—	—
Huntington Flats	—	—	—	—	—	—	—	—	—	—
Newport-Irvine Coast	0.089	0.095	0.161	0.419	0.395	0.428	0.366	0.045	0.036	0.033
Total F&W 10	0.302	0.246	0.438	0.816	0.890	0.765	0.561	0.404	0.395	0.563
TOTAL	4.793	6.406	4.817	4.427	5.665	5.614	4.283	5.255	4.757	4.881

Red denotes warm-water years, **blue** denotes cold-water years, and neutral years are in **black**

"—" = no canopy area

Of the five northernmost kelp beds located between Point Mugu and Point Dume, three increased in size in 2017 and two decreased (Figure 3). Of the six kelp beds located between Point Dume and Malibu Point, only one increased in size (Point Dume, the northernmost bed in this area), while five decreased. Of the six kelp beds located between Malibu Point to Santa Monica Pier, three were very small in size and three were not visible (La Costa and Las Flores have been absent since 2015, and Topanga since 2016) (Table 7). Of the four kelp beds located between Malaga Cove and Point Fermin (Palos Verdes I through Palos Verdes IV), two increased in size and two decreased. Of the four kelp beds located between Point Fermin and Newport Beach, one increased in size, one decreased, and two were not visible (Horseshoe and Huntington Flats have been absent since CRKSC surveys began in 2003).

In 2000, the total kelp canopy coverage in the Central Region was only 1.23 km^2, the lowest amount ever recorded (Figure 13). However, by 2009, the canopy coverage had increased to 6.406 km^2, the highest amount recorded since 1967 (7.855 km^2). The combined kelp bed coverage has been at or above the long-term average every year for the past 10 years, although the combined canopy coverage for the past three years has been 18-27% below the 2009 level (Table 7; Figure 13).

Wastewater outfalls did not appear to have any impact on kelp bed health in the Central Region. The Los Angeles County Sanitation Districts' ocean outfall discharges highly treated wastewater effluent approximately 1.5 miles offshore and 200 feet deep onto the Palos Verdes Shelf. However, the Palos Verdes I, II, III, and IV kelp beds, as well as the Cabrillo kelp bed, which could potentially be influenced by the wastewater plume, appear to have been quite healthy for most of the past ten years. The City of Los Angeles' ocean outfall discharges highly treated wastewater effluent into Santa Monica Bay. However, there are no designated kelp beds in proximity to the discharge point five miles offshore, and although the wastewater plume circulates throughout a large part of Santa Monica Bay, it appears highly unlikely that distant kelp beds would be affected due to dilution of the plume. The City of Oxnard's ocean outfall discharges highly treated wastewater effluent approximately 1 mile offshore. However, there are no designated kelp beds in proximity to the discharge point. The Orange County Sanitation District's ocean outfall discharges highly treated wastewater effluent approximately five miles offshore, and there are no designated kelp beds in proximity to the discharge point.

IV.2 - REGION NINE KELP BEDS

The combined canopy coverage within the 24 kelp beds of Region Nine continued the decline that began in 2014, decreasing by 36.2% in 2017 (Figure 14). From a total size of 17.064 km^2 in 2013, the Region Nine kelp beds have decreased by 80.8% over the past four years (Table 8). The total canopy coverage of 3.273 km^2 in 2017 was the lowest recorded since 2006. This cycle has occurred in the past, with substantial drops from a high in 1980 to a low in 1984, from a high in 1980 to a low in 1998, and from a high in 2001 to a low in 2006, as well as the most recent decline from a peak in 2008 (the highest value recorded since 1967) to the current low in 2017 (Figure 14).

In 2017, the La Jolla and Point Loma kelp beds accounted for most of the total canopy coverage (75.8%) as usual (Table 8). But these two large kelp beds decreased in size by 37.4% in 2017, similar to the level of decline for the entire region.

Twice as many individual kelp beds decreased in size (14) than increased (7) in 2017 (Figure 3). In 2017, the canopy area of only one kelp bed (North Laguna Beach) was 40% or more of the historical maximum size, while the canopy area of 11 kelp beds was less than 10% of the historical maximum and another five kelp beds were less than 15% of their historical maximum (Figure 3).

Of the five kelp beds located between Abalone Point and Capistrano Beach, two increased in size in 2017, while three decreased (including the Capistrano Beach kelp bed, which nearly disappeared). Of the three kelp beds located between San Clemente and San Onofre, one increased in size in 2017 and two decreased (Figure 3). Of the three kelp beds located between Horno Canyon and the Santa Margarita River, one increased in size in 2017, one decreased, and one was not visible (the Santa Margarita kelp bed disappeared in 2014). Of the four kelp beds located between North Carlsbad and Carlsbad State Beach, three increased in size in 2017 (including North Carlsbad and Carlsbad State Beach, which reappeared) and one was not visible ((Agua Hedionda, which disappeared in 2016). Of the six kelp beds located between Leucadia and Torrey Pines, four decreased substantially (by two-thirds or more) in 2017 and two were not visible (Del Mar disappeared in 2016 and Torrey Pines in 2014). The Imperial Beach kelp bed reached a very large size in 2015 (1.576 km^2),but was last observed in March 2016 (0.217 km^2) and was not visible in 2017.

Vessel survey observations found that the kelp beds at Cardiff, North Laguna Beach, South Laguna Beach, and Point Loma had a high proportion of dark yellow kelp blades, indicating good nutrient uptake (Table 6). The other kelp beds generally had pale to medium yellow kelp blades, indicating poor nutrient uptake. The kelp beds at North Laguna Beach, South Laguna Beach, Dana Creek/Salt Point, and Point Loma had a high proportion of young individuals, suggesting that these kelp beds are experiencing good recruitment and could be increasing in size in the future. The remaining kelp beds were composed primarily of older plants, suggesting that these kelp beds are maturing and may decline unless recruitment occurs soon.

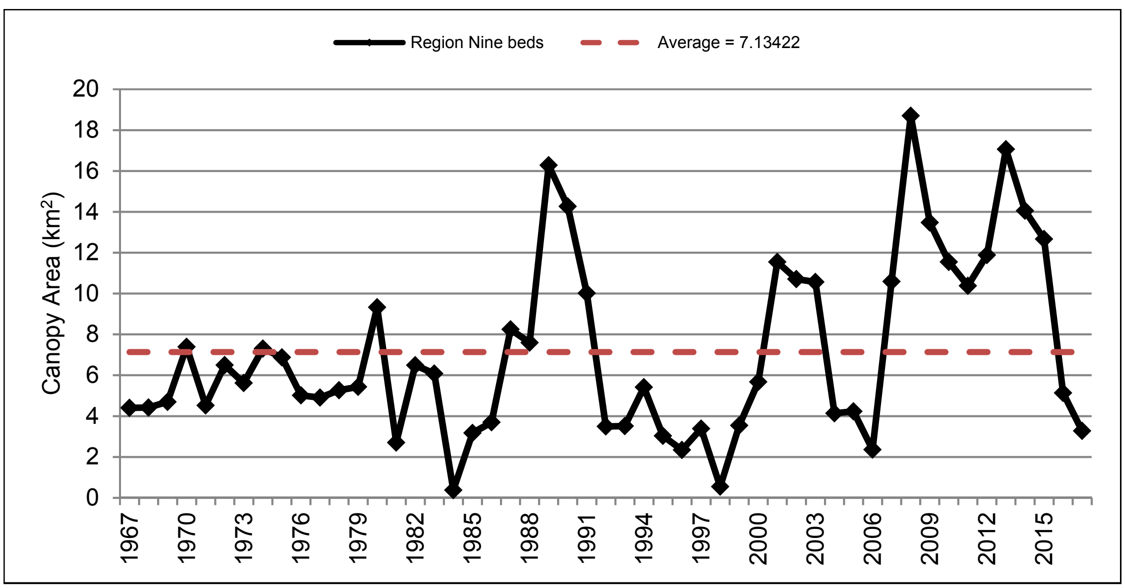


Figure 14. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2017.

Table 8. Canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 2008 through 2017.

Kelp Bed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
N Laguna Beach	0.002	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096
S Laguna Beach	0.025	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032
South Laguna	0.023	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003
Dana Pt/Salt Creek	1.068	0.892	0.839	0.442	0.607	0.835	0.528	0.137	0.110	0.133
Capistrano Beach	0.071	0.071	0.124	0.010	0.056	0.099	0.034	0.007	0.012	0.0004
Total F&W 9	1.189	1.043	1.178	0.838	1.086	1.385	0.879	0.287	0.237	0.264
San Clemente	0.203	0.210	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229
San Mateo Point	0.487	0.545	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033
San Onofre	0.476	0.419	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087
Total F&W 8	1.166	1.174	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349
Horno Canyon	0.083	0.018	0.081	—	0.008	0.125	0.055	0.019	0.010	0.011
Barn Kelp	0.858	0.926	0.500	0.095	0.442	0.868	0.741	0.085	0.133	0.096
Santa Margarita	—	—	—	—	—	0.080	—	—	—	—
Total F&W 7	0.941	0.944	0.581	0.095	0.450	1.073	0.795	0.104	0.143	0.107
North Carlsbad	0.108	0.135	0.078	0.017	0.052	0.125	0.086	0.047	—	0.004
Agua Hedionda	0.080	0.092	0.031	0.022	0.046	0.102	0.065	0.016	—	—
Encina Power Plant	0.306	0.215	0.176	0.084	0.216	0.352	0.221	0.159	0.009	0.025
Carlsbad St. Beach	0.121	0.127	0.069	0.024	0.058	0.178	0.065	0.061	—	0.001
Total F&W 6	0.615	0.569	0.354	0.147	0.372	0.757	0.437	0.282	0.009	0.031
Leucadia	0.421	0.429	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010
Encinitas	0.346	0.205	0.128	0.124	0.260	0.231	0.112	0.113	0.009	0.003
Cardiff	0.484	0.520	0.213	0.395	0.459	0.590	0.299	0.318	0.024	0.003
Solana Beach	0.823	0.505	0.328	0.504	0.442	0.606	0.504	0.316	0.138	0.029
Del Mar	0.057	0.044	0.038	0.074	0.024	0.056	0.027	0.034	—	—
Torrey Pines	0.001	0.0004	0.003	0.031	0.034	0.081	—	—	—	—
Total F&W 5	2.133	1.703	0.925	1.247	1.452	2.106	1.221	1.195	0.204	0.045
La Jolla F&W 4	4.145	2.274	2.776	2.565	1.569	4.006	2.790	2.968	0.927	0.694
Point Loma F&W 3&2	6.623	4.909	3.977	4.212	5.340	5.127	5.121	5.806	3.037	1.787
Imperial Beach F&W 1	1.895	0.861	0.004	0.152	0.333	0.526	1.183	1.576	0.217	—
TOTAL	18.706	13.476	11.545	10.379	11.882	17.064	14.053	12.667	5.134	3.277

Red denotes warm-water years, **blue** denotes cold-water years, and neutral years are in **black**

"-" = no canopy area

IV.3 - ENVIRONMENTAL VARIABLES

The general correspondence between seawater temperature and kelp distribution geographically has long been known. Critical temperatures limit essential events in kelp life history stages. In addition, there is an inverse relationship between temperature and nutrient availability which affects kelp productivity. Strong seasonal upwelling can bring nutrients to kelp beds. However, low water temperatures and high nutrient levels can lead to phytoplankton blooms in surface waters, thereby attenuating light to benthic areas. On large spatial and temporal scales, ENSO events are associated with correlative changes in temperature, nutrients, severe water motion through storm activity, and alterations of the light environment due to the loss of canopy species, which combined can cause large changes in giant kelp forests over the years (Schiel and Foster, 2015).

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

- Water temperature data from automated shore stations at Newport Pier and Scripps Pier. At these locations, automated samplers measure conductivity, temperature, and fluorometry every one to four minutes. Samplers are mounted at a depth of 2 m Mean Lower Low Water (MLLW) at Newport Piers, and at 5 m MLLW at Scripps Pier. These data are made available in real time via the Southern California Coastal Ocean Observation System (SCCOOS) website (**www.sccoos.org**).
- Water temperature data from the National Data Buoy Center (NDBC) for Point Dume (nearby in Santa Monica Bay), Santa Monica Pier, Oceanside, and Point Loma South are available in real time via the NDBC website (**www.ndbc.noaa.gov**). These data buoys record water temperature, and wave height, period, and direction at least every 30 minutes (frequency varies for each buoy) from approximately one meter below the waterline.
- Water temperature data were provided by Los Angeles County Sanitation Districts from offshore monitoring stations on the Palos Verdes Peninsula (Stations PVS and PVN). Both stations are located at a depth of 23 m, with sensors at the surface and depths of 2 m and 11 m MLLW.
- Water temperature data also were provided by City of San Diego, Public Utility, Marine Biology and Operations, Point Loma, CA, from a thermistor string approximately 3.8 km west-northwest of Point Loma in 60 m of water (City of San Diego 2017). Sensors were placed at four-meter intervals from near the sea surface to a depth of 54 m MLLW.
- Water temperature data also were provided by Orange County Sanitation District from a thermistor mooring located approximately eight kilometers offshore (-118.02220, 33.57620), upcoast of their outfall in 60 meters of water (Orange County Sanitation District, 2007).

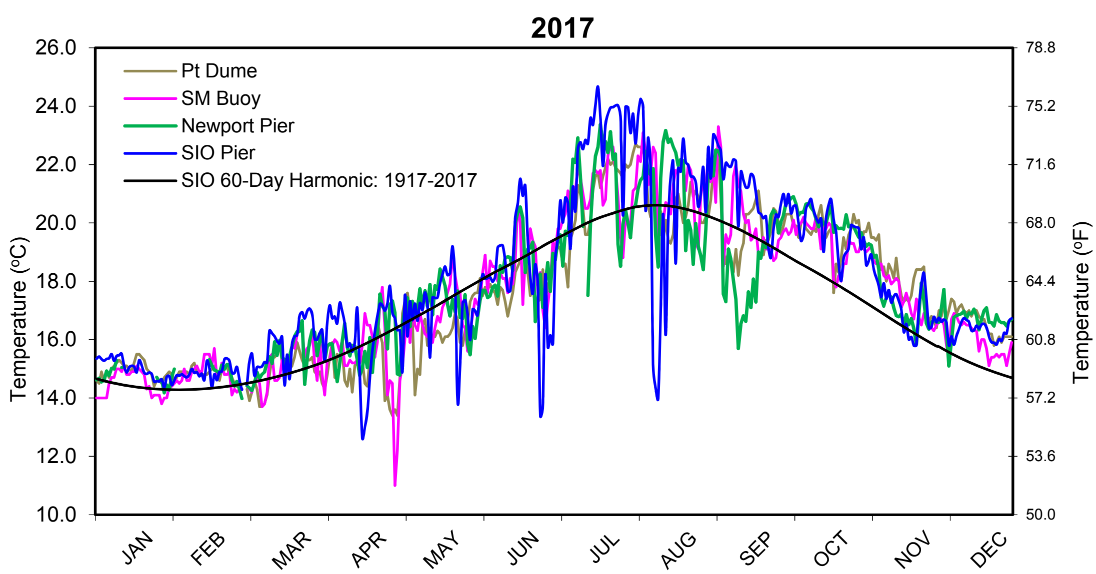
IV.3.A - WATER TEMPERATURE

Sea surface water temperature (SST) can be a useful surrogate for nutrient availability (water temperature is inversely related to nutrient availability). Although there appears to be good evidence that seawater density also can be used as a surrogate, and in some cases may predict nutrient availability better than temperature, long-term measurements of density are not available for broad areas of the Central Region or Region Nine. In contrast, nearshore temperature measurements have been ongoing for decades, resulting in readily accessible data sets.

Sea surface temperatures (SST) from Point Dume, Santa Monica, and Newport Pier, as well as the long-term harmonic mean (1917-2017) from Scripps Pier, are presented in Figure 15. SST values from Newport Pier, Oceanside, Scripps Pier, and Point Loma South, as well as the Scripps Pier long-term harmonic mean, are presented in Figure 16. Graphs of SST values at each of these individual locations are presented in Appendix C.

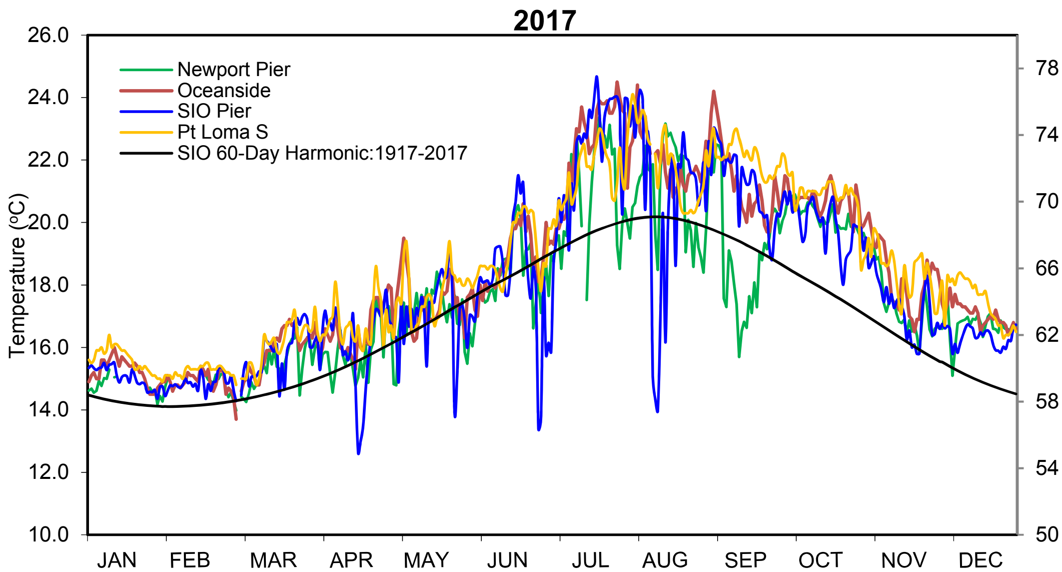
Water temperatures throughout the CRKSC and RNKSC areas (Figures 15 and 16) generally were warmer than average throughout all of 2017, particularly from January through March, and October through December. However, there were occasional periods of cooler than normal water temperatures in both regions, likely associated with upwelling events, from April through August. Daily SST values in both areas rarely fell below 14°C, a threshold below which nutrient availability is much greater than at higher water temperatures.

Two temperature monitoring instruments were moored off the Palos Verdes peninsula (Figure 17): Station PVN (TN) was in the northern section near Lunada Bay, and Station PVS (TM) was in the southern end at Royal Palms. Both stations are located at in water depths of 23 meters.



Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

Figure 15. Daily sea surface temperatures (SSTs) at Point Dume (Pt Dume), Santa Monica Pier (SM Buoy), Newport Pier, and Scripps Pier (SIO Pier) for 2017, and the long-term harmonic mean for Scripps Pier (SIO 60-Day Harmonic: calculated from 1917 through 2017).



Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

Figure 16. Daily sea surface temperatures (SSTs) at Newport Pier, Oceanside, Scripps Pier (SIO Pier), and Point Loma South (Pt Loma S) for 20167 and the long-term harmonic mean for Scripps Pier (SIO 60-Day Harmonic: calculated from 1917 through 2017).

At the Palos Verdes North and South stations, water temperatures were similar at the surface (blue lines on Figure 18 A and B) and at two meters below the surface (green line on Figure 18 A and B) throughout much of the year, although the surface temperatures often were warmer from June through September. Water temperatures at a depth of 11 meters below the surface (pink line on Figures 19 and 20) usually were cooler than at the surface or at two meters, except during January and December at Palos Verdes North, and during February and December at Palos Verdes South (no data recorded in January). From January through June 2017, water temperatures at 11 meters periodically were below 14°C, which rarely occurred at the surface or at two meters (Figure 19). These cooler temperatures lower in the water column suggest that nutrient availability would be expected to be greater than indicated by the SST values. Unfortunately, while surface water temperature data is available throughout most of the CRKSC and RNKSC area, sub-surface water temperature data is not as extensive or readily available.

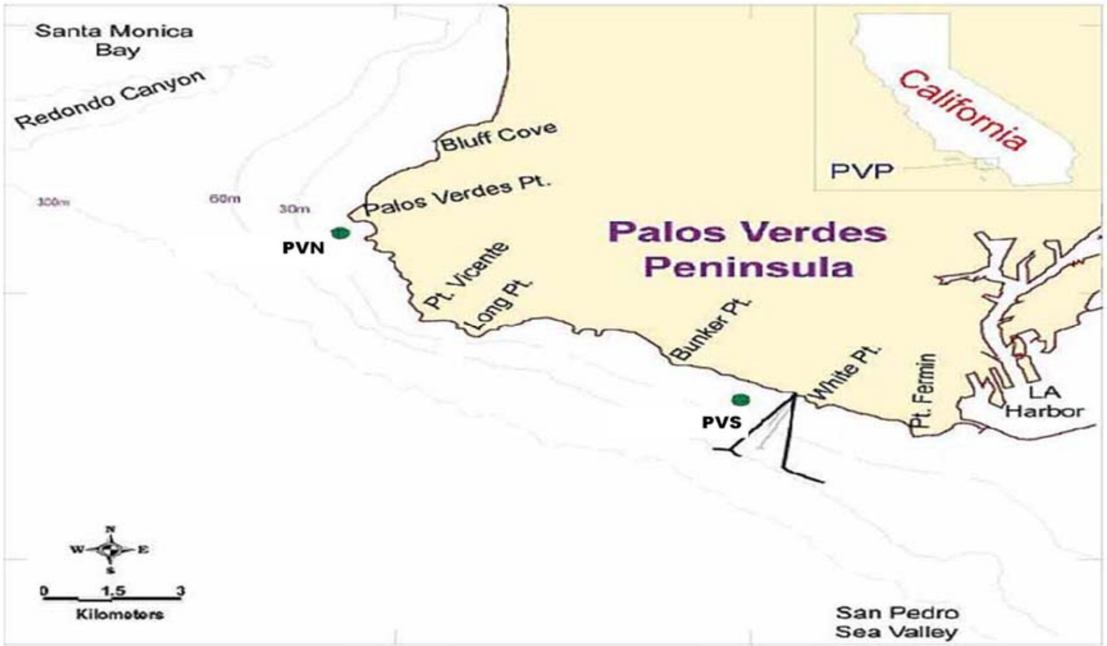
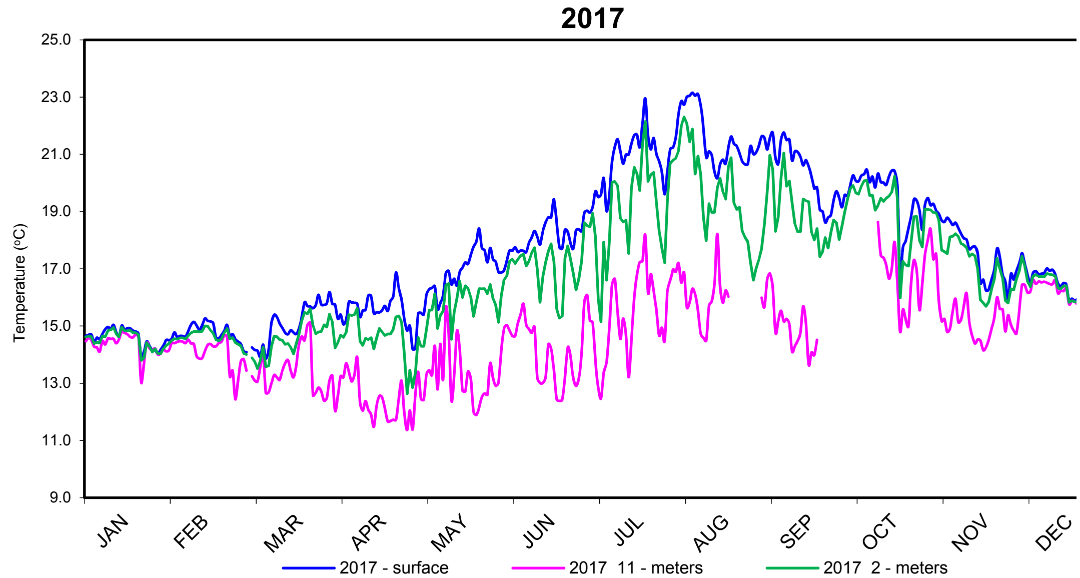


Figure 17. Location of Los Angeles County Sanitation Districts' Palos Verdes Shelf temperature monitoring deployments.

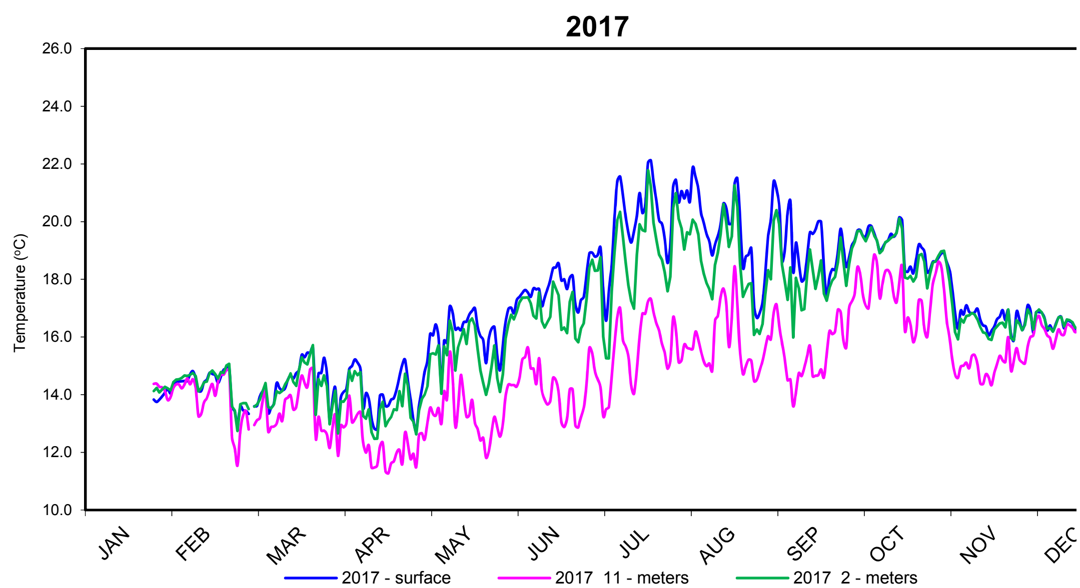
Temperature monitoring was accomplished via a thermistor string deployed off Point Loma by the City of San Diego's Ocean Monitoring Program (City of San Diego 2017) (Figure 19). Warmer temperatures, generally above 14ºC, were prevalent at shallower depths (10 to 15 meters) from the middle of August through November. Unfortunately, data is missing for these shallower depths from April through the middle of August. Such high temperatures could have an adverse impact on the kelp beds by limiting nutrient availability.

Temperature monitoring also was accomplished via a thermistor string (M18) deployed offshore by Orange County Sanitation District. It is located at -118.02220 N, 33.57620 W, where the water depth is approximately 60 meters. Temperatures near the surface were rarely below 14ºC, indicating potentially poor nutrient availability for kelp in surface waters (Figure 20). However, water temperatures below 14ºC occurred more frequently in deeper waters (depths of 35 to 60 meters).

A

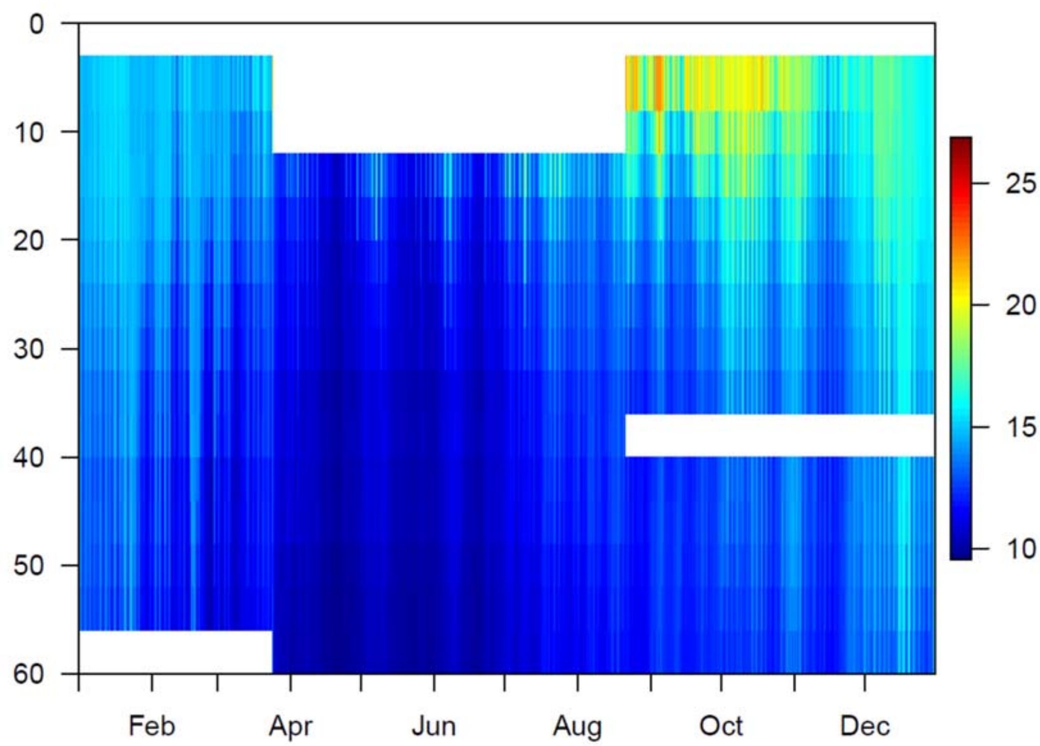


B



Source: LACSD (2017).

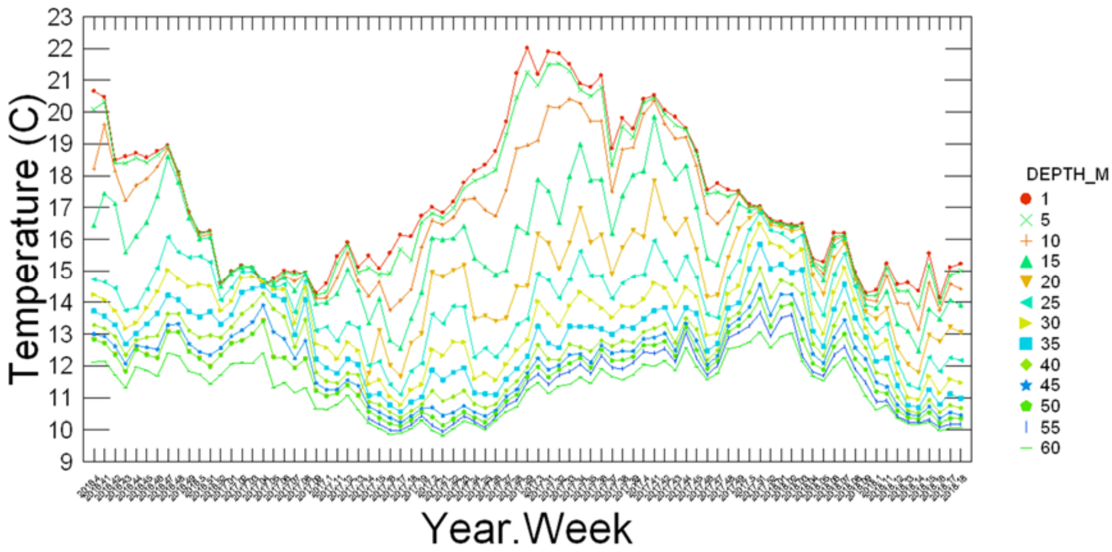
Figure 18. Daily sea surface temperatures (SSTs) off Palos Verdes at (A) Palos Verdes North Station (PVN) and (B) Palos Verdes South Station (PVS) in 2017.



Source: City of San Diego, 2017.

Figure 19. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2017.

Overall, the pattern of warm sea surface temperatures observed for the past three years continued in 2017. At Point Dume, the number of days with SSTs >16°C and >18°C was higher in 2017 than in 2016, and have been well above the long-term mean (1994-2016) every year since 2012 (Figure 21). The number of days with SSTs >20°C has decreased every year since 2014, but was still well above the long-term mean in 2017. At Newport Pier, the number of days with SSTs >16°C, >18°C, and >20°C was higher in 2017 than in 2016, and also have been well above the long-term mean for the past few years (since 2012 to 2014, depending on the temperature threshold). At Scripps Pier, the number of days with SSTs >16°C and >18°C was lower in 2017 than in 2016, while the number of days with SSTs>20°C was higher in 2017, but in each case it has been above the long-term mean since 2014.

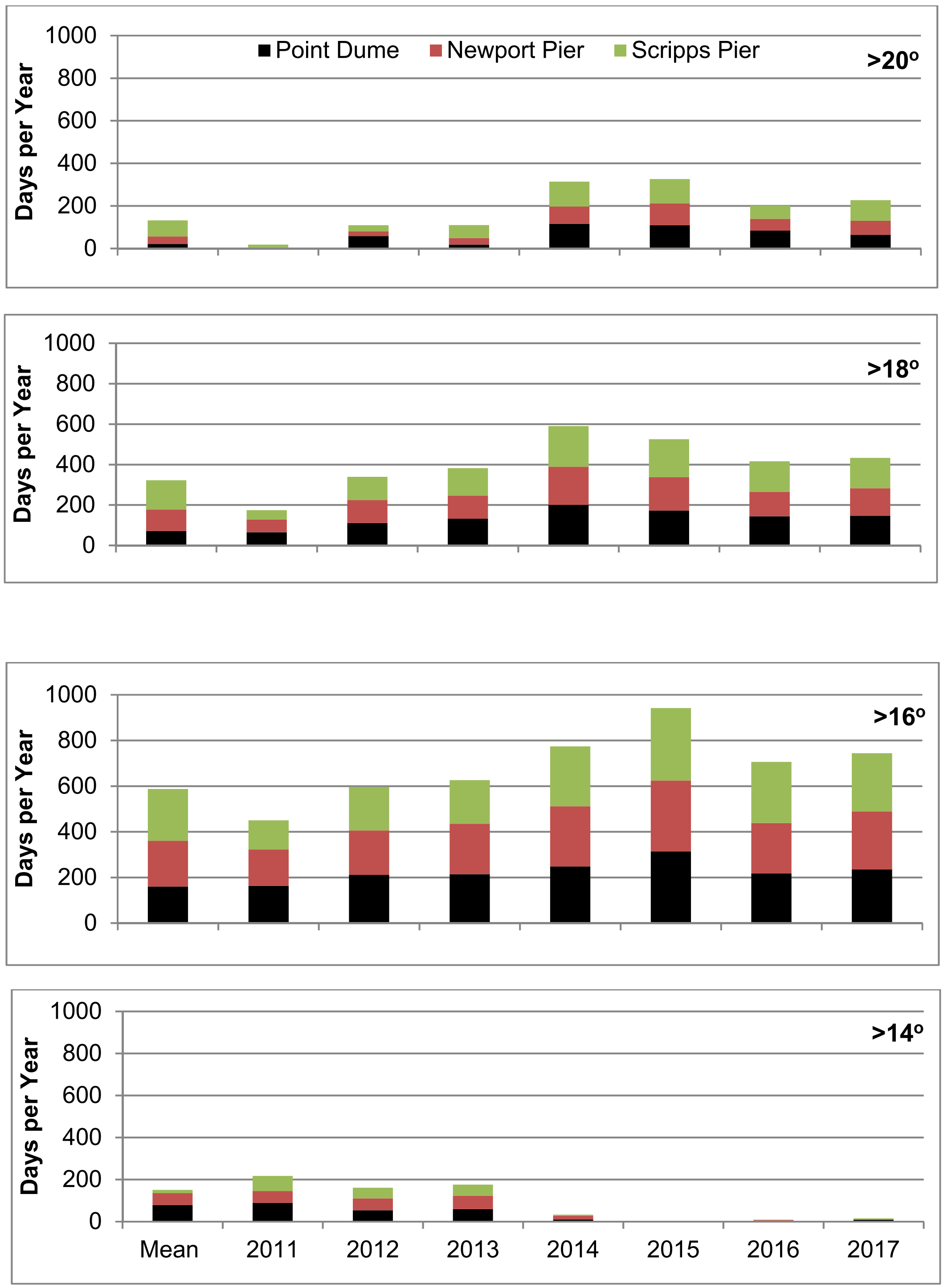


Source: Orange County Sanitation District, 2017.

Figure 20. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Orange County during 2017.

The number of days with cooler water temperatures (SSTs <14°C) in 2017 also was much lower than the long-term mean (Figure 21), as has been the case over the past three years. At Point Dume, only 9 days were recorded with water temperatures <14°C in 2017, compared to a long-term mean of 79 days per year. The number of days with cooler water temperatures at Point Dume has been well below the long-term mean every year since 2014. At Newport Pier, 0 days were observed with water temperatures <14°C in 2017, compared to the long-term mean of 56 days per year. The number of days with cooler water temperatures at Newport Pier also has been well below the long-term mean every year since 2014. At Scripps Pier, 6 days were observed with water temperatures <14°C in 2017, compared to the long-term mean of 16 days per year. The number of days with cooler water temperatures at Newport Pier has been below the long-term mean every year since 2014.

The annual mean SST values in 2017 were higher than the long-term averages for Point Dume, Newport Pier, and Scripps Pier, ranging from 17.5 to 17.9ºC (Table 9). At Point Dume and Newport Pier, the annual mean SSTs were substantially higher 1.5ºC and 1.2ºC, respectively) than the long-term means. At Scripps Pier, the annual mean was only 0.2ºC higher in 2017 than the long-term mean. Although still high, the annual mean SST values at all three locations were lower than the high annual means recorded in 2014 and 2015 (Table 9).



Note: Annual data presented from 2011 through 2017; mean calculated from 1994 through 2016

Figure 21. Number of days with SSTs >20°C, >18°C, >16°, and <14°C at Point Dume, Newport Pier, and Scripps Pier: 2011–2017, and the mean from 1994–2016.

Table 9. Comparison of mean temperature from 1994 through 2015 versus annual mean temperature from 2011 through 2016 at Point Dume, Newport Pier, and Scripps Pier.

		Annual Mean SST (°C)						
	Mean SST (°C) (1994–2016)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Point Dume	**16.0**	15.7	16.8	16.8	18.2	18.6	17.6	17.5
Newport Pier	**16.6**	15.9	16.6	16.7	18.0	18.4	17.8	17.8
Scripps Pier	**17.7**	15.7	16.6	17.0	18.8	18.9	17.7	17.9

Red cells indicate years above the long-term mean, white cells are equivalent to the mean, and blue cells below the long-term mean.

IV.3.B - NUTRIENTS

The Nutrient Quotient (NQ) Index described by North and MBC (2001) provides a useful indicator of the amount of nitrate that is theoretically available for uptake by kelp (in micrograms-per-gram per-hour) (Haines and Wheeler 1978; Gerard 1982). This method allows for an inter-annual comparison of the nutrients available to kelp, making it possible to pinpoint those years when nutrients were abundant or depleted, and to establish possible temporal trends.

This index is calculated for the 12-month period from July 1st through June 30th for a given time span (i.e., the 2017 NQ Indices shown on Figures 22 and 23 correspond to the period from July 1, 2017 to June 30, 2018). Consequently, the NQ Index is out of phase by six months with the kelp canopy areas reported, which are based on the highest abundance observed from four overflights conducted within a calendar year.

The NQ Index is calculated for each of six locations (Point Dume, Santa Monica Pier, Newport Pier, Oceanside, Scripps Pier, and Point Loma) by averaging the early-morning SST values at each station for each of the 12 months, assigning a point score to each monthly SST average (1 point if the average falls between 16.01 and 17.00ºC, 2 points if it is between 15.01 and 16.00ºC, 4 points if between 14.01 and 15.00ºC, 8 points if between 13.01 and 14.00ºC, and 14 points if between 12.01 and 13.00ºC. The NQ for the 12-month period is the sum of the monthly point scores. The NQ calculations for the six locations in 2017/2018 are shown in Table 10.

Table 10. Nutrient Quotient calculation for period from July 2017 to June 2018.

Sites	Monthly Average Temperature Ranges (°C) (Weighting Factor Per Month)					Total Nutrient Quotient (Calculation Formula)
	12.01 to 13.00 (14 pts)	13.01 to 14.00 (8 pts)	14.01 to 15.00 (4 pts)	15.01 to 16.00 (2 pts)	16.01 to 17.00 (1 pt)	
Point Dume			Mar 2018 Apr 2018	Feb 2018	Dec 2017 Jan 2018 May 2018	**13** (4 pts x 2) + (2 pts x 1) + (1 pt x 3)
Santa Monica Pier			Mar 2018	Jan 2018 Feb 2018 Apr 2018	Dec 2017 May 2018	**12** (4 pts x 1) + (2 pts x 3) + (1 pt x 2)
Newport Pier			Mar 2018	Jan 2018 Feb 2018 Apr 2018	Dec 2017 May 2018	**12** (4 pts x 1) + (2 pts x 3) + (1 pt x 2)
Oceanside			Feb 2018 Mar 2018	Jan 2018 Apr 2018	May 2018	**13** (4 pts x 2) + (2 pts x 2) + (1 pt x 1)
Scripps Pier			Mar 2018	Jan 2018 Feb 2018 Apr 2018	Dec 2017 May 2018	**12** (4 pts x 1) + (2 pts x 3) + (1 pt x 2)
Point Loma				Feb 2018 Mar 2018	Jan 2018 Apr 2018 May 2018	**7** (2 pts x 2) + (1 pt x 3)

The 2017/2018 NQ Index was calculated to be 13 for Point Dume and Oceanside, 12 for Santa Monica Pier, Newport Pier and Scripps Pier, and 7 for Point Loma (Table 10). In the Central Coast Region, the NQ Indices for Point Dume, Santa Monica Pier and Newport Pier continued to be lower in 2017 than the long-term average (2002 through 2016). This has been the case since 2013, and in 2015 the NQ Indices for all three locations were the lowest ever recorded (Figure 22). The NQ Indices for Point Dume and Newport Pier were higher in 2017 than during the previous three years, while the NQ Index for Santa Monica Pier was slightly lower in 2017 than in 2016 (Figure 22). The NQ Index for 2017 at Oceanside was approximately equal to the long-term mean (2009 through 2016), while the NQ Indices for Scripps Pier and Point Loma in 2017 were lower than the long-term mean (2008 through 2016 for Point Loma, and 1984 through 2016 for Scripps Pier). The NQ Indices for Oceanside and Point Loma were considerably higher in 2017 than the low values recorded in 2015 and 2016, while the NQ Index for Scripps Pier was slightly higher in 2017 than in 2016 (Figure 23).

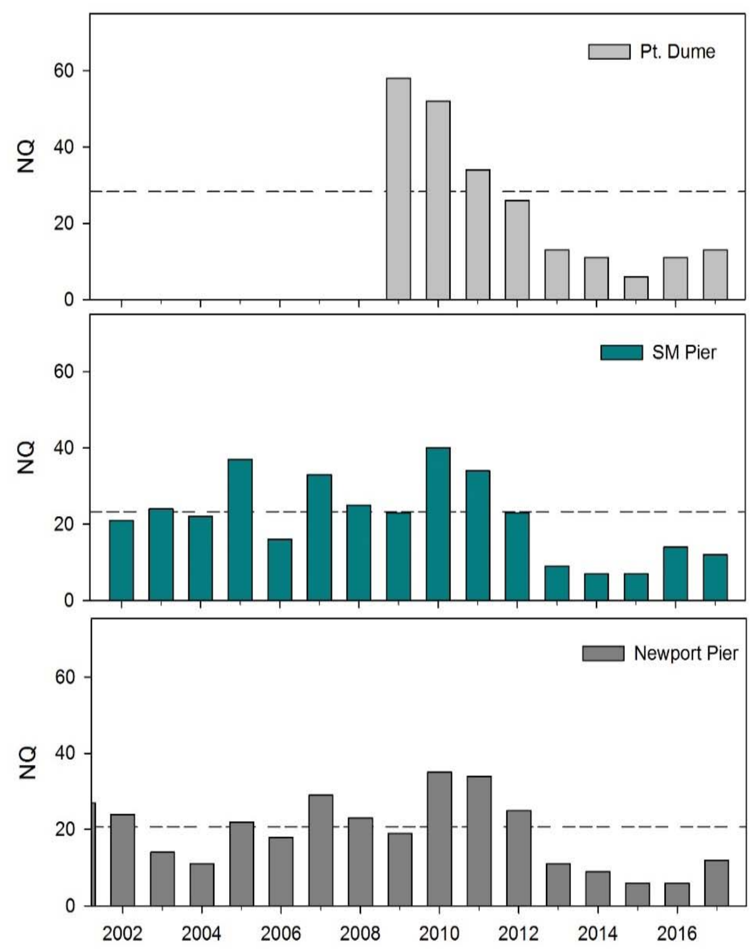


Figure 22. Nutrient Quotient (NQ) values in the Central Region, 2002–2017.

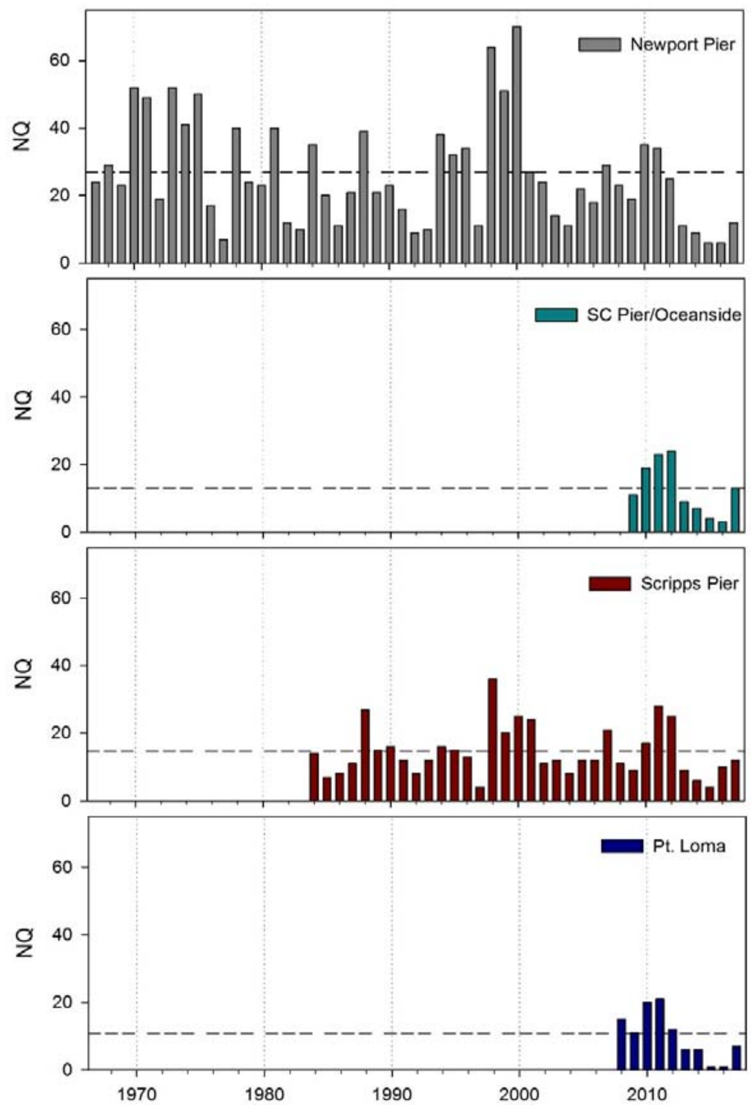


Figure 23. Nutrient Quotient (NQ) values in Region Nine, 1967–2017.

The extent of surface canopy in the kelp beds in 2017 would be related primarily to the NQ Index reported for 2016 (covering the period from July 2016 through June 2017), since December 2017 was the only month of the year when the average monthly water temperatures were low enough to contribute points to the 2017 NQ Index (covering the period from July 2017 through June 2018). The 2016 NQ Indices for Point Dume and Santa Monica Pier were below the long-term average (Figure 22), but higher than the Index values for 2015. The NQ Index for Newport Pier remained low in 2016. The lower nutrient availability could partially explain why the total kelp canopy area in the Central Region has been lower for the past few years, compared to the levels recorded in 2012 and 2013, when nutrient availability was higher.

The 2016 NQ Indices for San Clemente Pier/Oceanside and Point Loma were the lowest recorded since 2008, and well below the long-term averages (Figure 23). The NQ Index for Scripps Pier was higher in 2016 than in 2015, but still below the long-term average. The limited nutrient availability over the past four years could help explain the steep decline in the total kelp canopy area in Region Nine from the high level recorded in 2013.

The nutrient climate shifted from waters with sufficient nitrate prior to the 1976/1977 regime shift, to depleted conditions afterward (Parnell et al. 2010). The response of giant kelp beds to nutrient replete years before the regime shift was dampened compared to their response afterward. The sensitivity of kelp canopies to nutrient limitation appears to have increased after 1977, and this intensification of physical control (as opposed to biological control) after 1977 is evident in the strong correlation of seawater density (δ_t) and density of giant kelp (Parnell et al. 2010). The NQ index recorded during the 1997/1998 El Niño indicated a particularly bad year for kelp beds in the SCB. During that season, NQ values ranged from 3 to 11. In contrast, during 1988/1989 (a year in which kelp beds reached their maximum extents in several decades) NQ values ranged from 27 to 39 (Figures 22 and 23). The variability in SSTs and nutrients is driven by prevailing flow characteristics and bathymetric features that result in periodic upwelling along the rocky shores of the coastline, particularly from Deer Creek to Point Dume, along the Palos Verdes Peninsula, and at the Dana Point, La Jolla, and Point Loma kelp beds.

IV.3.C – UPWELLING

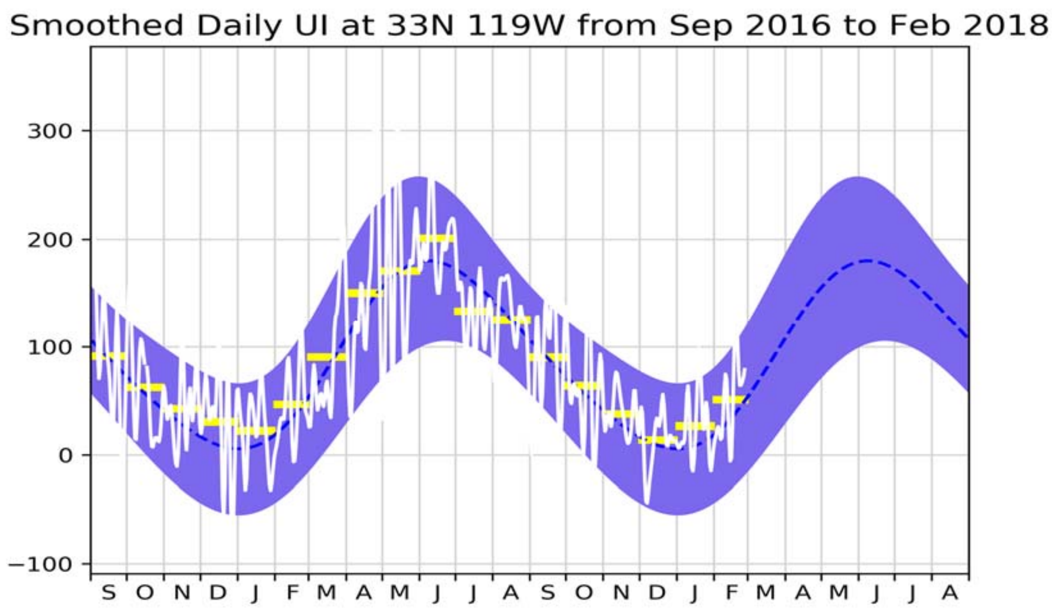
The frictional stress of equatorward wind on the ocean's surface, combined with the effect of the earth's rotation, causes water in the surface layer to move away from the western coast of continental land masses. This offshore moving water is replaced by water which upwells, or flow toward the surface, from depths of 50 to 100 meters or more. Upwelled water is cooler and saltier than the original surface water, and typically has much greater concentrations of nutrients, such as nitrates, phosphates and silicates, that are key to sustaining biological production.

Upwelling in 2017 (at a location approximately 161 km west of Solana Beach) increased each month from January through June, then decreased through December (Figure 24 A). The Upwelling Anomaly Index demonstrates that upwelling in 2017 was considerably higher than the long-term mean (1946-2016) during the months of April and June (Figure 24 B), while most other months of the year were similar to or a little higher than the long-term mean (Figure 24 B and Figure 25).

IV.3.D - ENVIRONMENTAL INDICES

The El Nino/Southern Oscillation (ENSO) is the most important coupled ocean-atmosphere phenomenon affecting climate variability on interannual time scales. ENSO can be monitored via the Multivariate ENSO Index (MEI), which is based on a suite of six variables observed over the tropical Pacific Ocean (sea-level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky) (**https://www.esri.noaa.gov/psd/enso/mei/**). Negative values of the MEI represent the cold ENSO phase (i.e., La Nina), while positive MEI values represent the warm ENSO phase (El Nino).

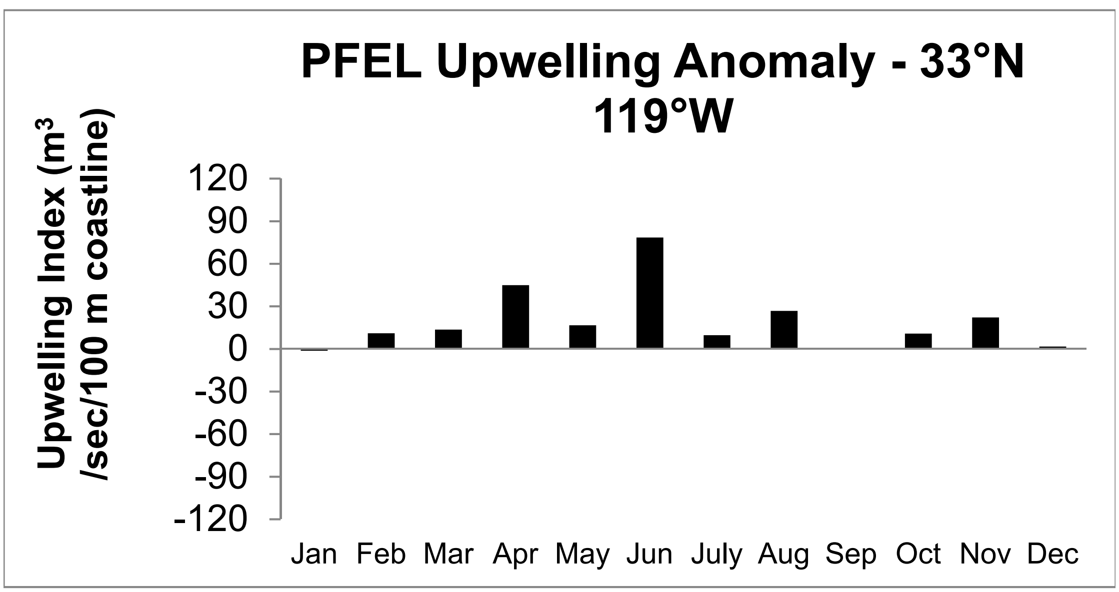
A



The dashed curve is a smoothed bi-harmonic fit to the daily UI from 1967–1991. The purple area represents one standard error, and the yellow bars are monthly means. Units are cubic meters per second per 100 meters of coastline.

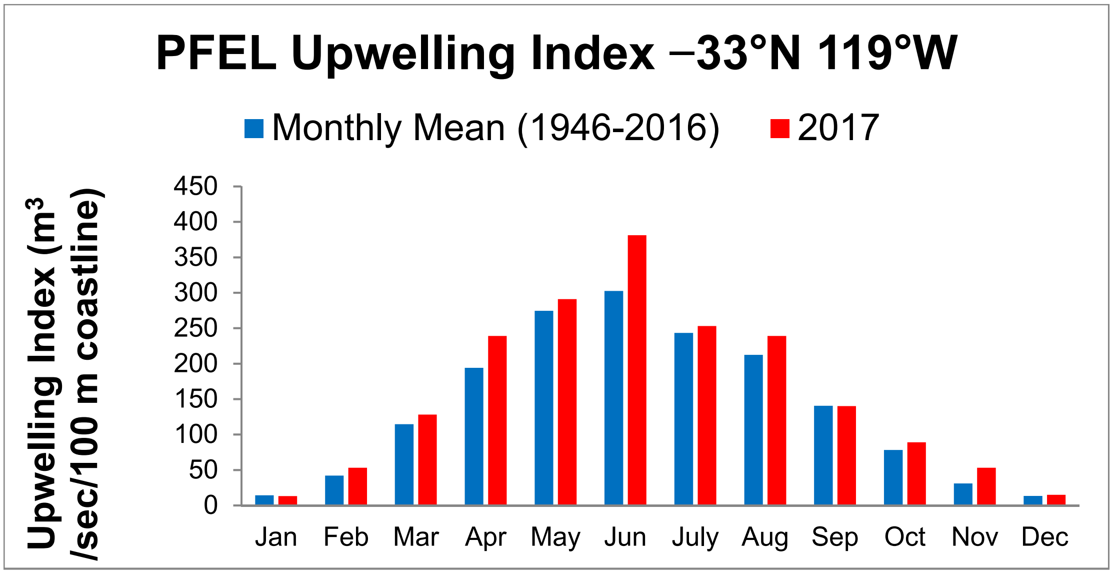
Source: (NOAA PFEG 2017)

B



Source: (NOAA PFEG 2017)

Figure 24. (A) Daily Upwelling Index (UI) at 33°N 119°W for 2017. (B) UI anomaly at 33°N 199°W (2017) compared to the 71-year monthly mean from 1946 through 2016).



Source: (NOAA PFEG 2017)

Figure 25. Monthly upwelling index for 2017 compared to the 71-year monthly mean from 1946 through 2016.

The North Pacific Gyre Oscillation (NPGO) is a climate pattern that is based on sea surface height variability in the Northeast Pacific Ocean. The NPGO is significantly correlated with fluctuations of salinity, nutrients, and chlorophyll-a measured in long-term observations in the California Current and Gulf of Alaska. Fluctuations in the NPGO are driven by regional and basin-scale variations in wind-driven upwelling and horizontal advection, which are the fundamental processes controlling salinity and nutrient concentrations. Nutrient fluctuations drive concomitant changes in phytoplankton concentrations, and may result in similar variability in higher trophic levels (**http://www.o3d.org/npgo/**).

The Pacific Decadal Oscillation (PDO) is a long-lived El Nino-like pattern of Pacific climate variability. The PDO and ENSO have similar spatial climate fingerprints, but exhibit very different behavior in time. While twentieth century PDO events typically persist for 20 to 30 years, typical ENSO events tend to persist for only 6 to 18 months. A “cool” PDO regime persisted from 1890 through 1924 and again from 1947 through 1976, while a “warm” PDO regime dominated from 1923 through 1946 and from 1977 through the mid-1990s. Warm eras correlate with enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the United States, while cold PDO eras produce the opposite (**http://research.jisao.washington.edu/pdo**). Causes for PDO fluctuations are not currently known.

The MEI and the Pacific Decadal Oscillation (PDO) changed phase about the same time in 2014; the MEI transitioned from negative to positive in April 2014, and the PDO became positive in January 2014 (Figure 26; Mantua 2017; and NOAA-ESRL 2017). The MEI transitioned back to negative in September 2016, but became positive from April through August 2017 before transforming to negative for the remainder of the year (Figure 26). The

PDO has remained positive since 2014, although the index values from July through December 2017 were the lowest recorded since February 2014. The NPGO changed from positive to negative in October 2013, and has stayed negative for most of the time since then, including all of 2017, although it was positive for five months in 2016 (Di Lorenzo 2017). The PDO transition to positive indicated warmer temperatures in the North Pacific, while the NPGO transition to negative was indicative of lower productivity along the coast (Di Lorenzo et al. 2008; Leising et al. 2015).

IV.3.E - WAVE HEIGHTS

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

Typical swell sizes and directions were observed through most of 2017. At the upcoast portion of the region near Port Hueneme (Anacapa Passage), waves approached from the west (270º) about 65% of the time, from the south (180º) about 12% of the time, and from the west-southwest (247.5º) about 10% of the time (Table 11, Figure 27). Off San Pedro, waves originated out of the west about 55% of the time, the south-southeast (157.5º) about 16% of the time, the south about 12% of the time, and the west-southwest about 9% of the time (Table 11, Figure 27). Off Oceanside, waves approached from the south-southwest (202.5º) about 38% of the time, from the south about 25% of the time, from the west about 14% of the time, from the southwest (225º) about 11% of the time, and from the west-southwest about 10% of the time (Table 11, Figure 27). Offshore of Point Loma, waves were from the west about 30% of the time, from the south about 22% of the time, from the south-southwest about 20% of the time, and from the west-northwest (292.5º) about 10% of the time (Table 11, Figure 27).

High-energy waves that negatively affect kelp beds usually are low-frequency, high-amplitude waves approaching from the west. Although waves at Anacapa Passage (CDIP Buoy 111 off Ventura) were predominately from the west (Table 11), wave heights were not especially large in 2017, exceeding three meters from January 21 through January 24, 2017 (maximum of 3.45 meters) and October 21, 2017 (maximum of 3.04 meters), and were nearly three meters on January 20, February 17 through 23, March 30 and 31, and May 7, 2017 (ranging from a maximum of 2.67 to 2.99 meters). Waves in 2017 (Table 12) were not as large as those recorded the previous year (when the maximum waves exceeded four meters on February 1 and March 8, 2016) (MBC 2017).

Wave heights at San Pedro (CDIP Buoy 092) exceeded three meters from January 21 through 24, 2017 (maximum of 3.87 meters), February 17 through 19, 2017 (maximum of 3.56 meters), on March 23 and 31, 2017 (maximum of 3.21 meters), February 23, March 23, March 31 and May 7, 2017. Wave heights were nearly three meters on January 20 and October 21, 2017 (Table 12). Waves at San Pedro originated from the west approximately half the time (Table 11), but wave heights in 2017 did not approach the maximum recorded in 2016 (more than five meters on February 1, 2016) (MBC 2017).

Wave heights at Oceanside (CDIP Buoy 045) exceeded three meters on January 20, 21, and 22 (maximum of 3.72 meter), and from February 17 through 19, 2017 (Table 12). Waves originated primarily from the south and south-southwest (Table 11) and were not as large in 2017 Table 12) as in 2016 (maximum exceeded five meters on February 1, 2016) (MBC 2017).

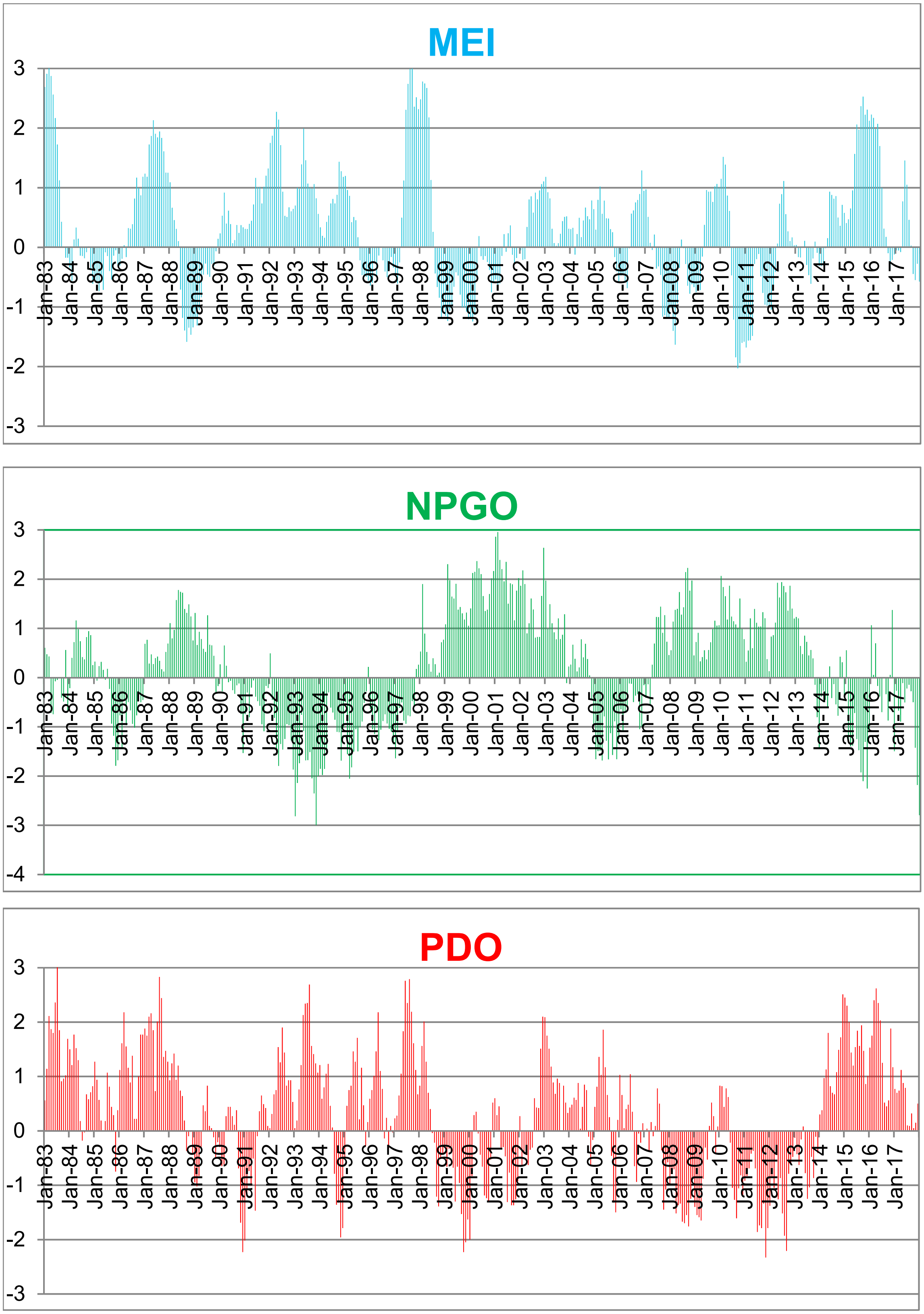


Figure 26. The Pacific Decadal Oscillation Index (PDO), the North Pacific Gyre Oscillation Index (NPGO), and the Multivariate Enso Index (MEI) from January 1983 through December 2017.

Table 11. Direction of swells in 2017.

Direction	Anacapa Passage	San Pedro	Oceanside	Pont Loma South
West (270°)	65%	55%	14%	30%
South (180°)	12%	12%	25%	22%
West-southwest (247.5°)	10%	9%		9%
South-southeast (157.5°)		16%		
South-southwest (202.5°)			38%	20%
Southwest (225°)			11%	8%
West-northwest (292.5°)				10%

Wave heights at Point Loma South (CDIP Buoy 191) exceeded four meters from January 21 through January 24 and three meters on January 20 and 25 (maximum of 4.94 meters on January 22, 2017). Wave heights exceeded five meters on February 19 (maximum of 5.54 meters) and four meters February 17 and 18, 2017. Wave heights also exceeded three meters on February 23, March 23, March 31, and May 7, and were nearly three meters on October 21, 2017 (Table 12). Waves originated from the west approximately one-third of the year (Table 11).

The January 21st-24th storm produced large wave heights (Table 12) and large nearshore swells were evident along almost the entire area of the Central Coast region and Region Nine on January 22, 2017 (Figure 28). The February 17th-19th storm also produced large wave heights with large nearshore swells along most of the Southern California coast (Figure 29), with larger swells in the San Diego area than were recorded during the January storm. Large swells become breaking waves as they approach shallow coastal waters and can rip loose kelp holdfasts and cause the loss of entire kelp beds (as recorded at La Jolla and Point Loma during several large storms) (Seymour et al. 1989).

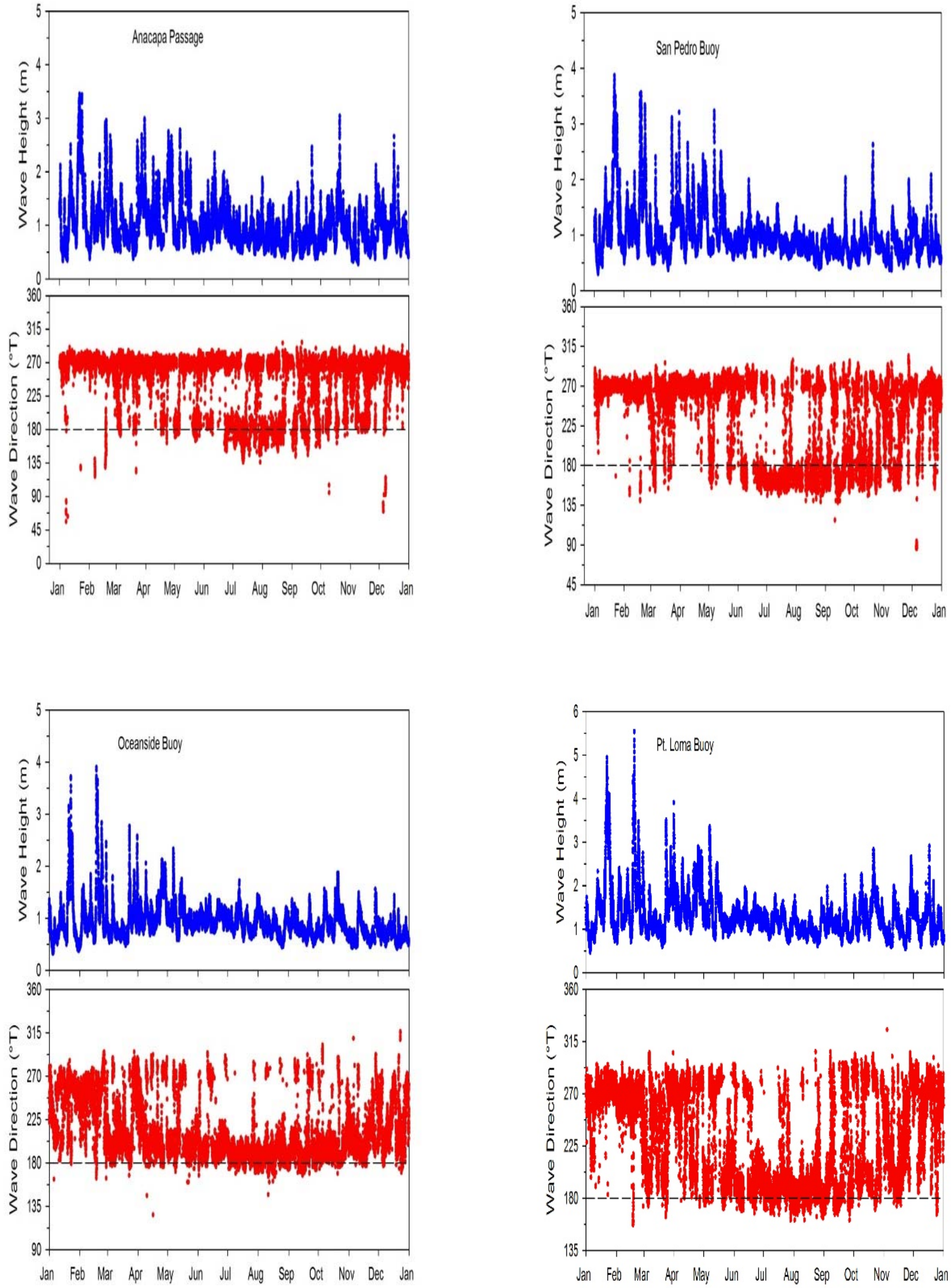


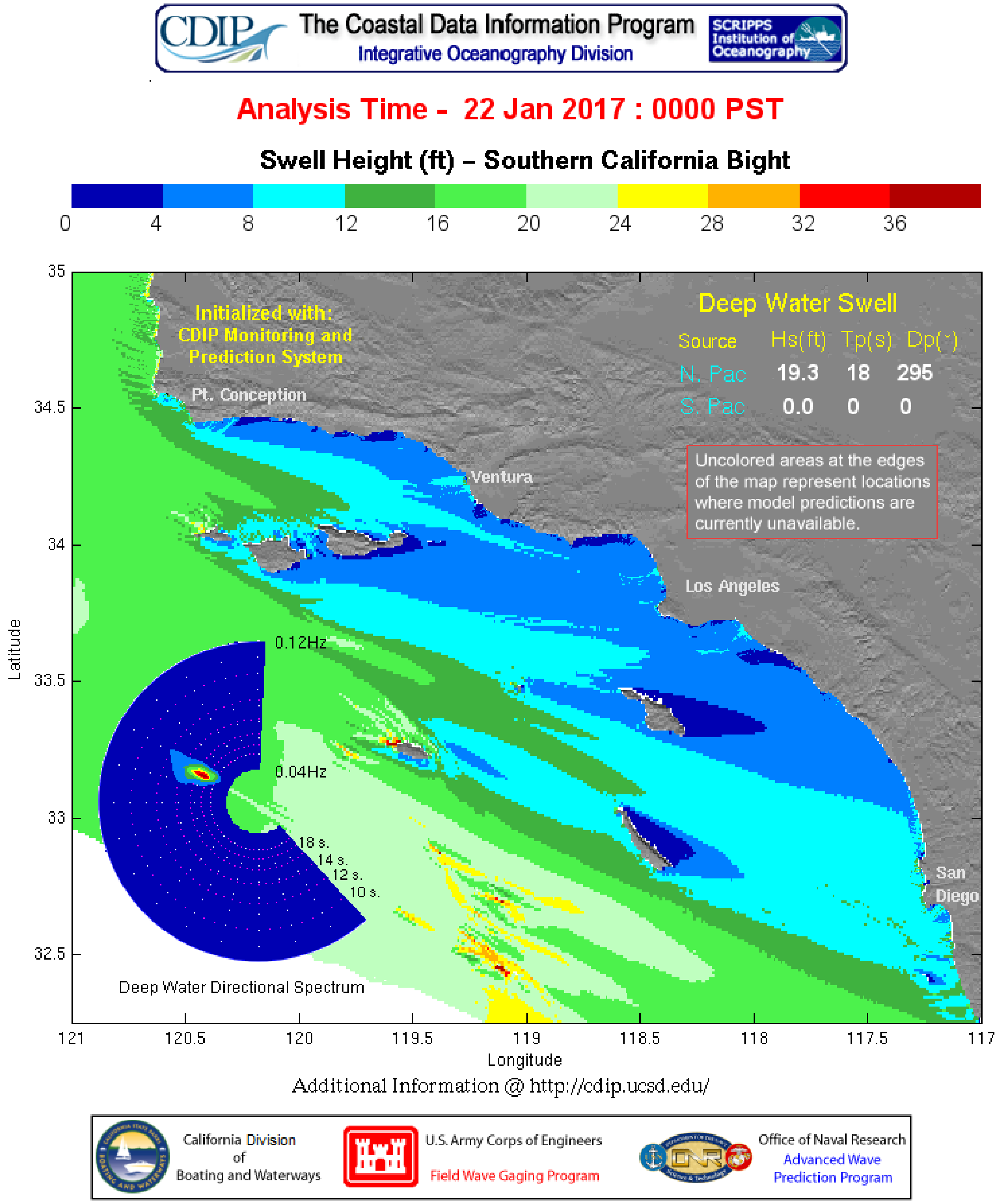
Figure 27. Wave height (blue) and direction (red) at Anacapa Passage Buoy, San Pedro Buoy, Oceanside Buoy, and Point Loma Buoy from January through December 2017.

Table 12. Large waves in 2017.

Date	Anacapa Passage (max in meters)	San Pedro (max in meters)	Oceanside (max in meters)	Pont Loma South (max in meters)
January 20	2.86	2.95	3.15	3.46
January 21	3.45	3.70	2.89	4.30
January 22	3.38	3.87	3.22	4.94
January 23	3.12	3.50	3.72	4.12
January 24	3.44	3.17	2.62	4.09
January 25				3.42
February 17	2.92	3.53	3.68	4.39
February 18	2.96	3.54	3.90	4.52
February 19	2.87	3.56	3.65	5.54
February 23	2.67	3.30	2.84	3.47
March 23		3.11	2.77	3.51
March 30	2.99			
March 31	2.91	3.21		3.91
May 7	2.78	3.23		3.36
October 21	3.04	2.63		2.83

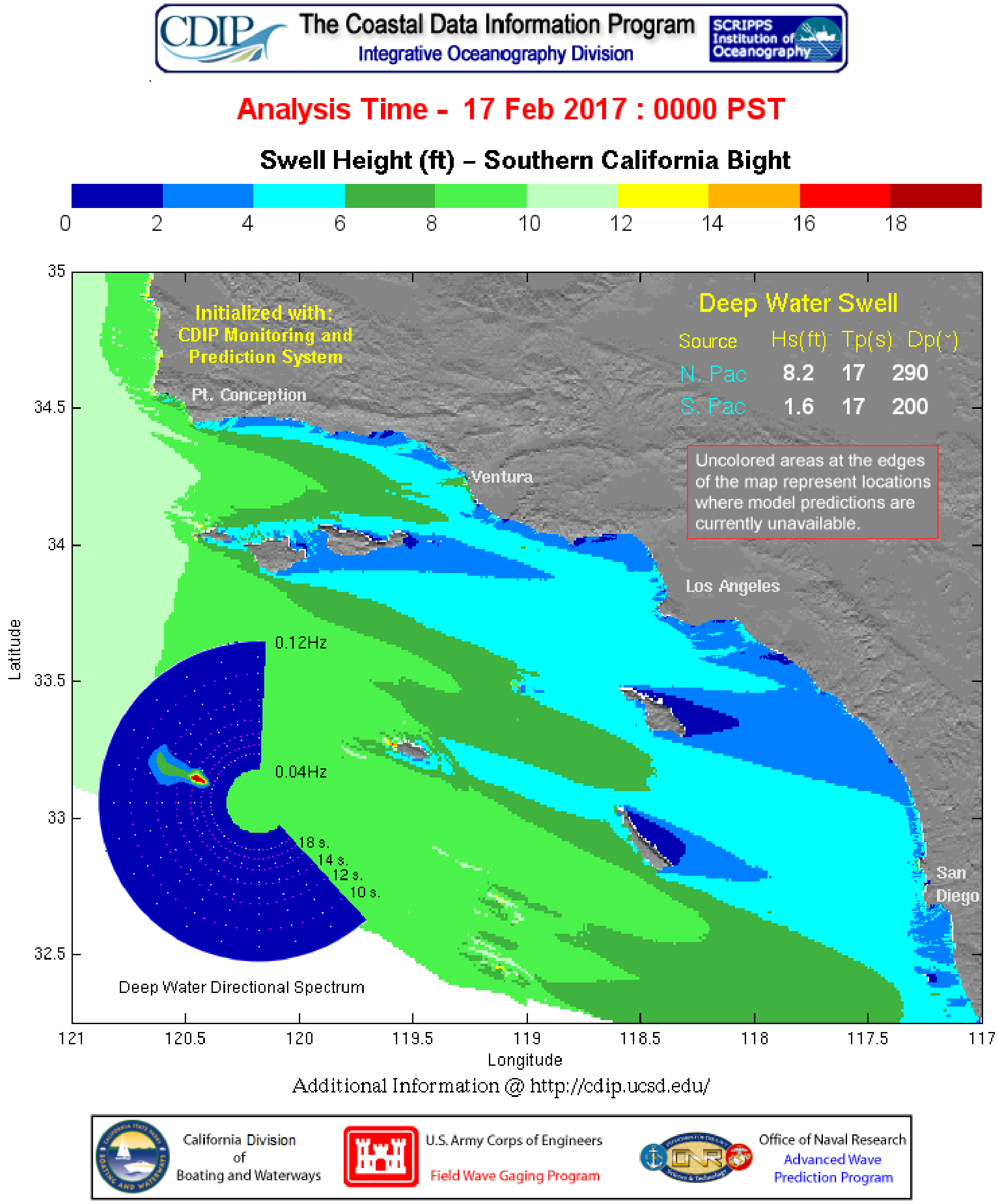
IV.3.F - RAINFALL

Periods of sustained high turbidity in southern California waters often result from high rainfall. Rainfall data for four areas (Oxnard, Los Angeles, Costa Mesa, and San Diego) within the Central Coast region and Region Nine is shown in Figure 30. The total amount of rainfall in 2017 declined from north to south, with most rain (85% or more, depending on the area) falling during the months of January and February in all four areas (Figure 31). Oxnard recorded the highest rainfall in 2017 at 18.1 inches, above the annual average of 15.6 inches. Los Angeles and Costa Mesa recorded similar amounts of rainfall in 2017 (approximately 12 and 11 inches respectively, both very close to their annual averages. San Diego recorded the least amount of rainfall in 2017 at 7.9 inches, below the annual average of 10.1 inches. Rainfall levels were not particularly high in 2017, and were unlikely to generate any extended periods of high turbidity.



Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/

Figure 28. Swell height and direction in the Southern California Bight on January 22, 2017.



Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/

Figure 29. Swell height and direction in the Southern California Bight on February 17, 2017.

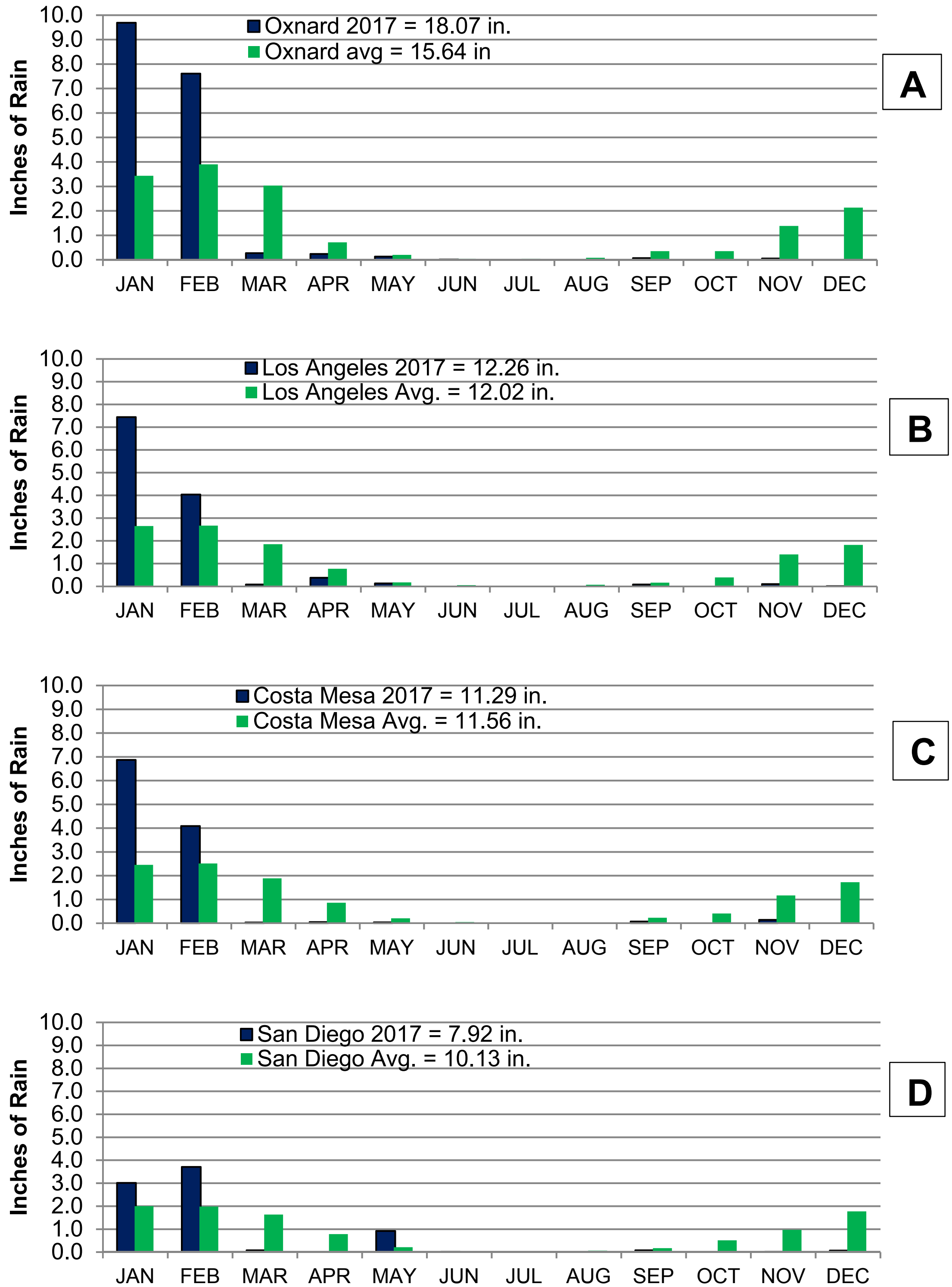


Figure 30. Monthly 2017 rainfall and average monthly rainfall recorded for (A) Oxnard, (B) Los Angeles International Airport (Los Angeles), (C) Costa Mesa, and (D) Lindbergh Field (San Diego).

IV.3.G - PHYTOPLANKTON

Harmful Algal Bloom (HAB) data are available in real time for several locations via the SCCOOS website (**www.sccoos.org**). High concentrations of the *Pseudo-nitzschia seriata* group (phytoplankton associated with harmful algal blooms) were often recorded at the Santa Monica Pier from March through July, and at Newport Pier from February through July (Figures 31 A and 32 A). Domoic acid concentrations, a toxin produced by these phytoplankton, were highest in late April to early May. High concentrations of the *Pseudo-nitzschia delicatissima* group were observed periodically throughout the year at both the Santa Monica and Newport Piers (Figures 31 B and 32 B).

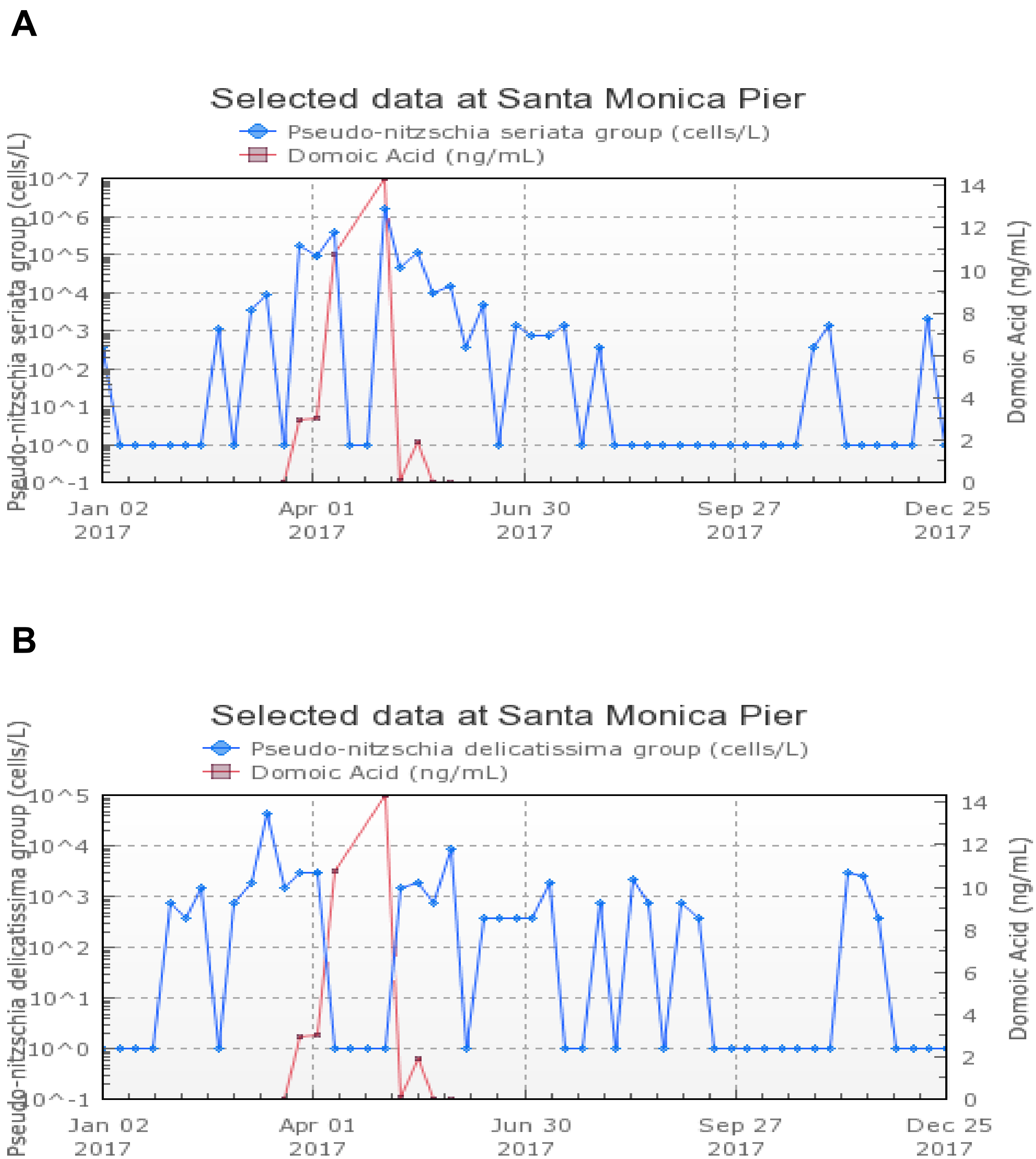
High concentrations of phytoplankton can effectively exclude light from all but the shallowest depths (R. Shipe, pers. comm.). This limits photosynthetic activity at depth and may have been responsible for a portion of the severe impacts on the kelp bed resources observed in 2005 and 2006 (Gallegos and Jordan 2002, Gallegos and Bergstrom 2005).

IV.4 - KELP RESTORATION

IV.4.A – CENTRAL REGION

To enable the recovery of historical kelp forests in Santa Monica Bay, the Bay Foundation's "Kelp Project" has engaged in sea urchin suppression to reduce the density of urchins on shallow rocky reefs since 1997 (House et al., 2018). Early efforts (1997-2009) were supported by the Santa Monica Baykeeper. The Kelp Project has demonstrated that reducing urchin density to less than two sea urchins per square meter enabled the natural development of giant kelp and other macroalgae at restoration areas in Malibu and Palos Verdes. Restoration areas off of Escondido Beach, Malibu, have proven resilient to disturbances for over 10 years. After reaching restoration targets of <2 sea urchins per square meter and >1 giant kelp holdfast per 10 square meters, the restoration measures were stopped in 2004. The kelp in this area has matured and recovered from many disturbances, including large-scale red tide events in 2005 and 2006 and a 20-year storm event in that same period. Surveys performed in the restoration area off Escondido Beach in 2008 quantified large kelp plants in high densities. Kelp restoration efforts now are focused on 61.5 hectares of existing urchin barrens along the Palos Verdes Peninsula (Figure 33).

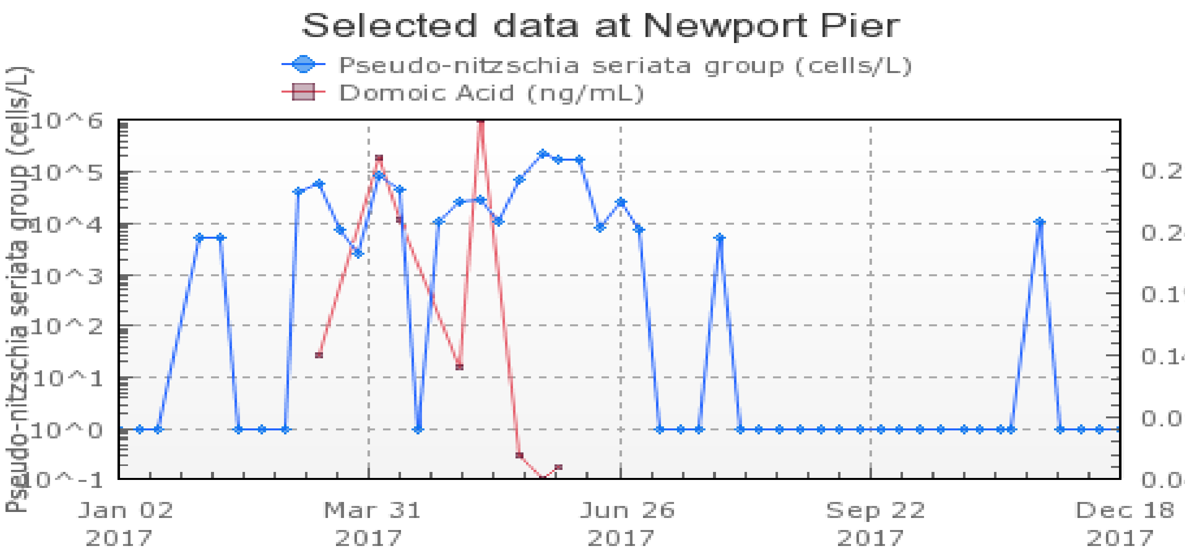
The Bay Foundation mapped and recorded 0.615 km^2 of urchin barrens around the PV III and PV II kelp beds in 2010 (Ford et al. 2015). Subsequent SCUBA-based community monitoring further qualified these barrens as areas featuring low diversity and productivity relative to areas of the Palos Verdes Peninsula supporting temporally and spatially stable giant kelp forests. Additional study has shown that the urchin individuals inhabiting these barrens are in poor physical condition, with low gonadosomatic indices relative to urchins in neighboring kelp forests (Claisse et al. 2013).



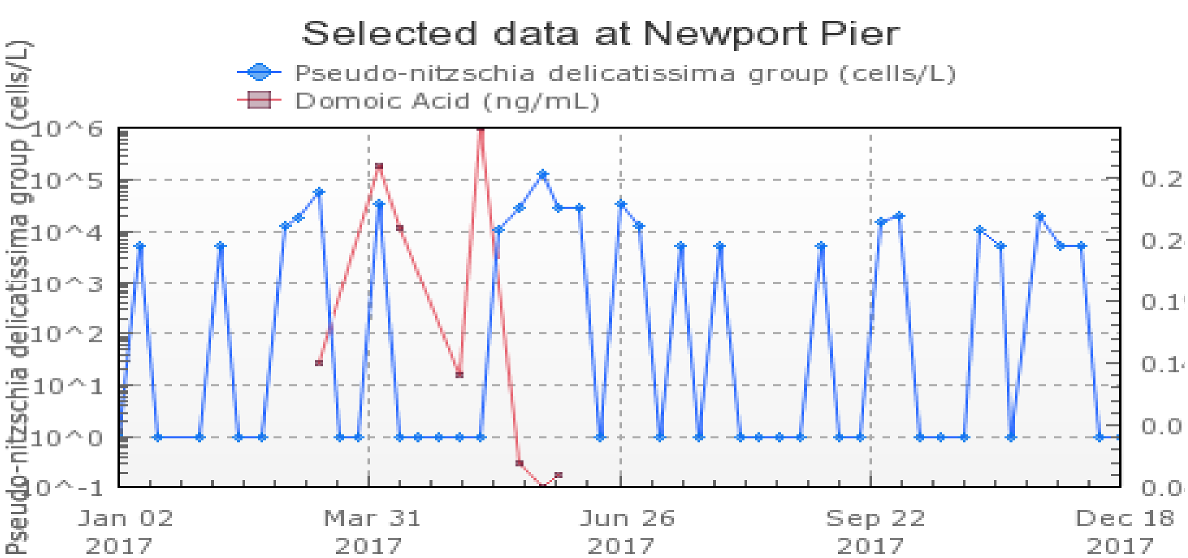
Source: SCCOOS (2017).

Figure 31. Concentrations of the Harmful Algal Bloom species and domoic acid concentrations at Santa Monica Pier. Data includes (A) *Pseudo-nitschia seriata* group and (B) *Pseudo-nitschia delicatissima* group)..

A

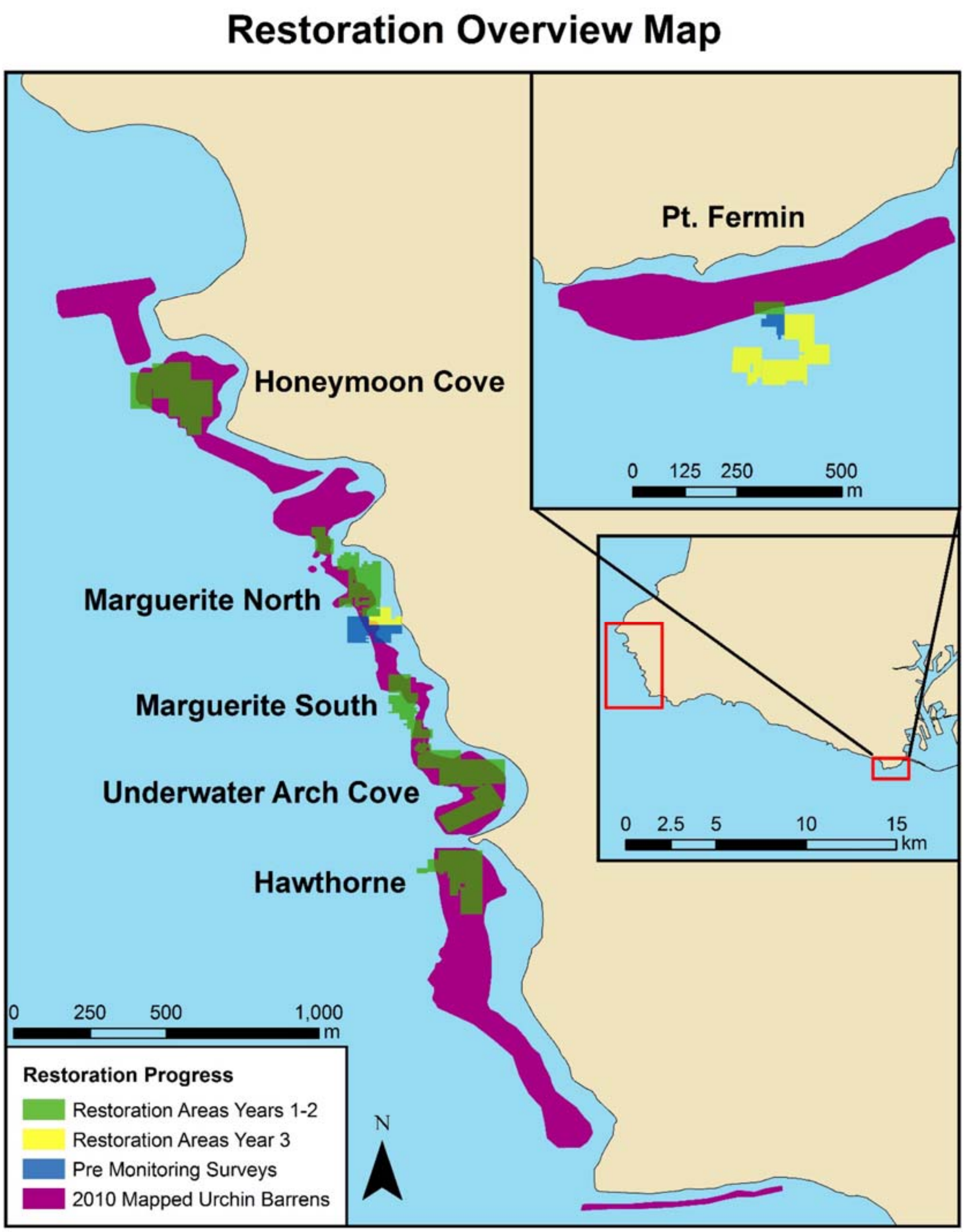


B



Source: SCCOOS (2017).

Figure 32. Concentrations of the Harmful Algal Bloom species and domoic acid concentrations at Newport Pier. Data includes (A) *Pseudo-nitschia seriata* group and (B)*Pseudo-nitschia delicatissima* group).



Source: Ford et al., 2017.

Figure 33. Urchin barrens as mapped in 2010 and kelp bed restoration areas of the Bay Foundation's Kelp Project.

To enable the recovery of historic kelp forests in Santa Monica Bay, the "Kelp Project" engaged in sea urchin suppression to reduce the density of urchins on shallow rocky reefs beginning in 1997; these early efforts (1997-2009) were supported by the Santa Monica Bay Baykeeper. The Kelp Project demonstrated that reducing urchin density from as high as 100 sea urchins per square meter to less than 2 sea urchins per square meter enabled the natural development of giant kelp and other macroalgae at restoration areas in Malibu and Palos Verdes. Restoration areas off of Escondido Beach, Malibu, have proven resilient to disturbances for over 10 years. After reaching restoration targets of <2 sea urchins per square meter and >1 giant kelp holdfast per 10 square meters, the restoration measures were stopped in 2004 (Ford and Meux 2010). The kelp in this area has matured and recovered from many disturbances, including large-scale red tide events in 2005 and 2006 and a 200-year storm event in the same period. Surveys performed in the restoration areas off Escondido Beach in 2008 quantified large kelp plants in high densities (Pondella et al. 2011).

Kelp restoration efforts now are focused on 54 hectares of existing urchin barrens which have been identified along the Palos Verdes Peninsula. The purpose of the Palos Verdes Kelp Forest Restoration Project, initiated in 2013, is to reduce the density of purple sea urchins to 2 per square meter within the boundaries of sea urchin barrens off the Palos Verdes Peninsula. This should allow for the recruitment and development of giant kelp and other species of macroalgae in these areas by reducing sea urchin grazing pressure to restore biogenic habitat to rock reefs that historically supported kelp forests (Ford et al. 2017).

Restoration sites have been established at 5 sites off Palos Verdes: Honeymoon Cove, Marguerite, Underwater Arch Cove, Hawthorne and Point Fermin. Pre-restoration monitoring is conducted on all sites (according to CDFW standards) to estimate the density of purple urchins, red urchins, and giant kelp, and to characterize the substrate. Post-restoration monitoring is conducted within 1 to 2 weeks after urchin suppression by the restoration teams to verify that urchin densities have been reduced to <2 per square meter and restoration sites are re-surveyed periodically (monthly to quarterly) to verify that purple sea urchin densities remain at <2 per square meter. Response monitoring is conducted at a later time to determine the responses of the natural community to restoration activities. The assessment technique used for response monitoring is adapted from the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) methodology and is performed by the Vantuna Research Group. In addition, an adaptation of the Core and Biodiversity protocols used on the west coast of North America as part of the MARINe network will be applied to the intertidal and shallow subtidal areas addressed by the project. Finally, a gonadosomatic index generated in 2011 for red and purple sea urchins, specific to the Palos Verdes Peninsula, will be applied to data gathered by the restoration project to evaluate the condition of urchins in restoration areas (Ford et al. 2017).

Restoration and monitoring activities have been conducted in restoration, control and reference sites since July 2013 and are ongoing. Restoration efforts are Honeymoon Cove and Underwater Arch Cove are considered complete: urchin suppression has resulted in urchin densities below the target of <2 per square meter in a total area of 8.33 acres for Honeymoon Cove and 8.37 acres for Underwater Arch Cove. Restoration efforts remain in progress at the other three restoration sites, but urchin suppression has resulted in urchin densities below the restoration target in a total area of 8.79 acres for Marguerite, 4.29 acres for Hawthorne and 3.93 acres for Point Fermin. An estimated 3,248,619 purple urchins have been suppressed over three years at these five restoration sites on the Palos Verdes Peninsula (Ford et al. 2017).

Analyses of gonadosomatic indices of urchins, species richness of fishes, and fish biomass, as well as increased density of giant kelp, indicate preliminary results from the restoration effort were positive (Ford et al. 2015). Kelp coverage within the restoration areas (identified in yellow in Appendix A.29) was sparse in 2016, but at Honeymoon Cove it appeared to be denser in 2016 than it was in 2009, previously the year with the highest canopy coverage in the last 25 years.

In 2017, Honeymoon Cove, Underwater Arch Cove, and Marguerite were considered to be completely restored (House et al, 2018). During 2016, exploration of the boulder fields that comprise the nonconsolidated portions of the reef complexes demonstrated that numerous purple and some red sea urchins were displaying cryptic behavior, perhaps in response to the warm water and wasting event during the El Nino period. During the summer of 2017, an area of Underwater Arch had to be revisited for further urchin suppression. It is possible that a large tidepool (the largest on the Palos Verdes Peninsula) served as a refuge for purple urchins during the warm water/wasting event. Periodic surveys will continue to determine whether urchin densities remain at target values in the upcoming years.

IV.4.B – REGION NINE

The Orange County Giant Kelp Restoration Project began in 2002 with an aim to restore historical giant kelp forests along the Orange County Coastline via outreach and education. Orange County Coastkeeper has worked with volunteers to grow, plant, and monitor giant kelp in northern Orange Country. Restoration sites, control sites, and a reference site were chosen in Crystal Cove State Park (Newport Beach), Heisler Park (Laguna Beach) and Salt Creek (Dana Point). Volunteers working with marine biologist Nancy Caruso also removed sea urchins that had overpopulated kelp reefs, relocating them to deeper water.

Beginning in 2002, the kelp beds at San Clemente were enhanced by the placement of approximately 50 small artificial reefs (each measuring 40 m x 40 m) on barren sand at depths of about 12 to 15 m. Kelp immediately recruited to these reefs, and canopies in the shape of small squares were visible during most of the aerial surveys of 2002 and 2003. In early 2008, Southern California Edison (SCE) added additional reef material (covering 0.712 km^2 in total) and kelp recruited to the new reefs in late 2008. SCE has determined that the 174-acre San Clemente reef is only sustaining approximately half the volume of fish required by its 1991 agreement with the California Coastal Commission, so SCE proposes to add an additional 200 acres of kelp reef to the project (possibly in 2018 or 2019).

IV.5 - KELP HARVESTING

There are 87 administrative kelp beds located offshore of California’s mainland coast and surrounding the Channel Islands. These kelp beds contain giant kelp (*Macrocystis*) or bull kelp (*Nereocystis*), or a combination of both. As of November 2016, each kelp bed falls within one of the following management categories:

Open	Available to harvest by all commercial kelp harvesters	33 kelp beds
Leasable	Available to harvest by commercial kelp harvesters until an exclusive lease is granted by the California Fish and Wildlife Commission, then only available to lessee	28 kelp beds (5 are currently leased)
Lease only	Commercial harvest of kelp is prohibited unless an exclusive lease is granted by the California Fish and Wildlife Commission	3 kelp beds
Closed	Commercial harvest of kelp is prohibited	18 kelp beds

Approximately 41% of the State's kelp beds have been designated as available for leasing, while approximately 38% have been designated as available for kelp harvest by any licensed kelp harvester (to insure that smaller kelp harvesters have access to kelp and are not shut out by lease agreements). Approximately 21% of kelp beds are closed to kelp harvesting, as harvest has been deemed too potentially disruptive to the environment to be allowed.

All commercial harvesters of marine algae must purchase an annual commercial kelp harvester license and abide by commercial algae harvest regulations (California Code of Regulations, Title 14, Sections 165 and 165.5). Eelgrass (*Zostera* species) and surfgrass (*Phyllospadix* species) are prohibited from commercial harvest. There currently are no provisions for the commercial harvest of other large kelps, such as elk kelp (*Pelagophycus*), feather boa kelp (*Egregia*), or members of the genus *Pterygophora*. Members of the genera *Porphyra*, *Laminaria*, *Monostrema*, and other aquatic plants utilized fresh or preserved as human food are classified as edible seaweeds. Agar-bearing marine algae are defined as members of the genera *Gelidium*, *Pterocladia*, *Gracilaria*, *Iridaea*, *Gloiopeltis*, and *Gigartina*. Edible and agar algae harvesting are governed by regulations.

Kelp harvesters may not cut attached giant and bull kelp at a depth greater than four feet below the sea surface at the time of cutting, allow no cut kelp to escape from harvest, weigh and report the amount harvested, and pay a royalty to the State for each wet ton of kelp harvested. A Commission-approved kelp harvest plan is required for kelp bed lease holders and for the mechanical harvest of kelp in all locations where harvest is allowed.

Recreational harvest of marine algae for personal use is permitted in California. Those harvesting for personal use must abide by the regulations governing the recreational harvest. The daily bag limit for recreational harvesters of marine algae is 10 pounds wet weight in the aggregate. Recreational harvesters are prohibited from harvesting or disturbing eelgrass (*Zostera* species), surfgrass (*Phyllospadix* species), and sea palm (*Postelsia palmaeformis*). Marine aquatic plants may not be cut or harvested in state marine reserves. Regulations may prohibit cutting or harvesting of marine aquatic plants within state marine conservation areas and state marine parks (California Code of Regulations, Title 14, Section 632b).

The administrative kelp bed status in the Central Coast region is shown in Figure 34. Kelp areas 13 and 14 are open (except for portions that are closed within marine protected areas), kelp area 15 is closed, and kelp areas 16 and 17 are leasable (except for portions that are closed within marine protected areas).

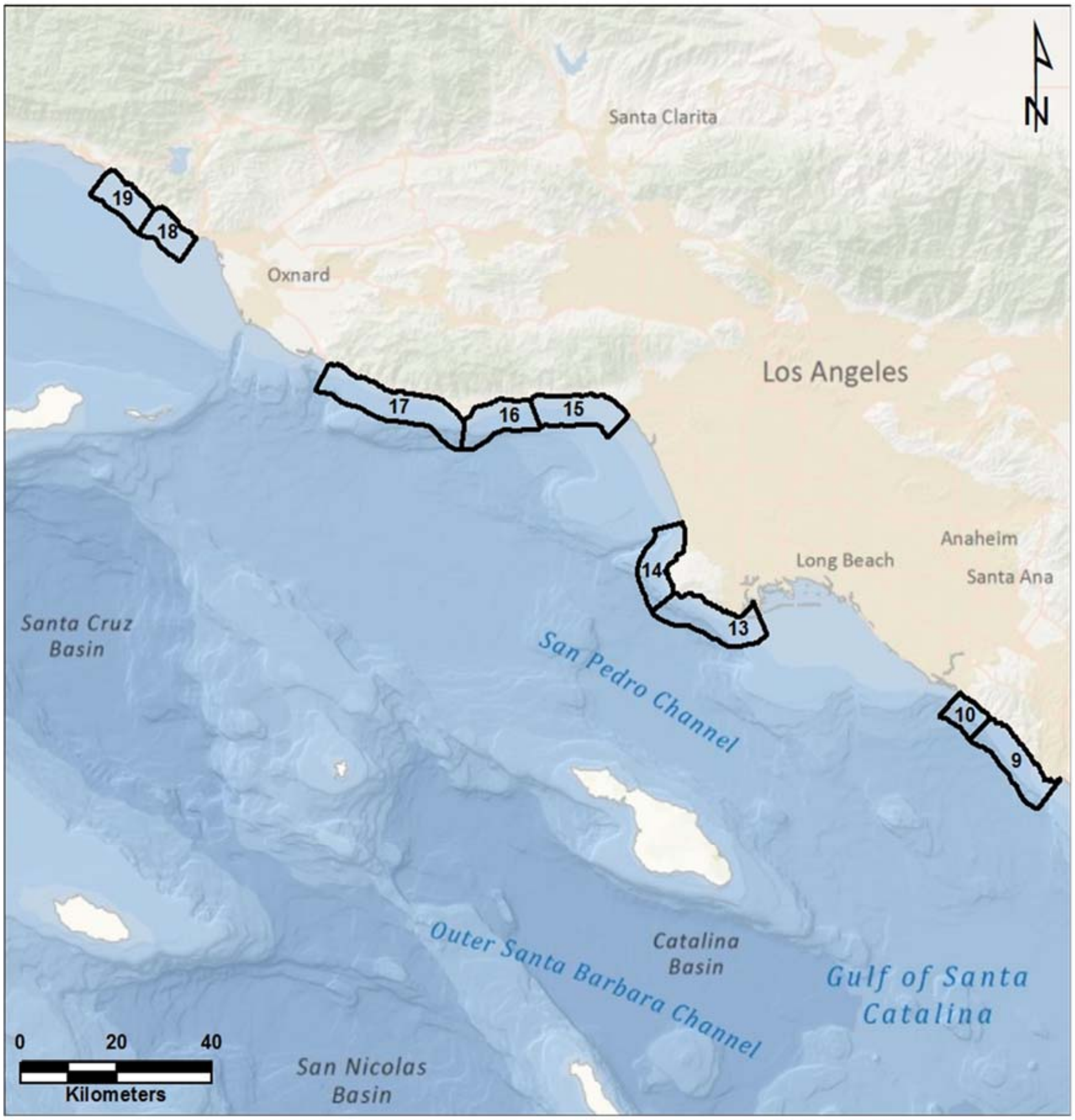
The administrative kelp bed status in the Region Nine study area is shown in Figure 35. Kelp areas 1 and 2 are open, kelp area 3 is leased, kelp areas 4, 5, and 6 are leasable (except for portions that are closed within marine protected areas), kelp areas 7, 8, and 9 are open (except for portions of 9 that are closed within marine protected areas), and kelp area 10 is closed.

Commercial marine algae harvest data are shown in Figure 36 for the period from 1931 to 2015 (**https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest**). The annual harvest exceeded 100,000 metric tons in the 1950s, 1960s and 1970s, but declined considerably in the early 1980s. The annual harvest again exceeded 100,000 metric tons in the early 1990s, but subsequently declined. Since 2006, the annual harvest has been relatively low (less than 5,000 metric tons per year).

Table 13 shows how the CRKSC kelp bed designations correspond to the California Department of Fish and Wildlife (F & W) administrative lease kelp area designations. Multiple CRKSC kelp beds fall within each of the F & W lease areas 13 through 16. Table 13 also shows how the RNKSC kelp bed designations correspond to the F & W administrative lease kelp bed designations. Multiple RNKSC kelp beds fall within each of F & W lease areas 5 through 9. Lease area 4 contains the La Jolla kelp bed, lease areas 2 and 3 contain the Point Loma kelp bed, and lease area 1 contains the Imperial Beach kelp bed.

In March 2018, Knocean Sciences (Dallas, Texas) applied to F & W to renew its existing Kelp Bed 3 lease (Bed 3 extends from the southern tip of Point Loma to the south jetty of Mission Bay, and covers an area of 2.58 square miles). Knocean Sciences proposed to harvest a maximum of 200 tons per year of giant kelp during the first two years of the five-year lease renewal, and 2,000 tons per year during years three through five. As part of the renewal process, Knocean Sciences proposed a royalty bid to the F & G Commission of $3.00 per wet ton of kelp harvested. Knocean Sciences plans to harvest giant kelp from May through November via mechanical harvesting from vessels specially modified for this purpose.

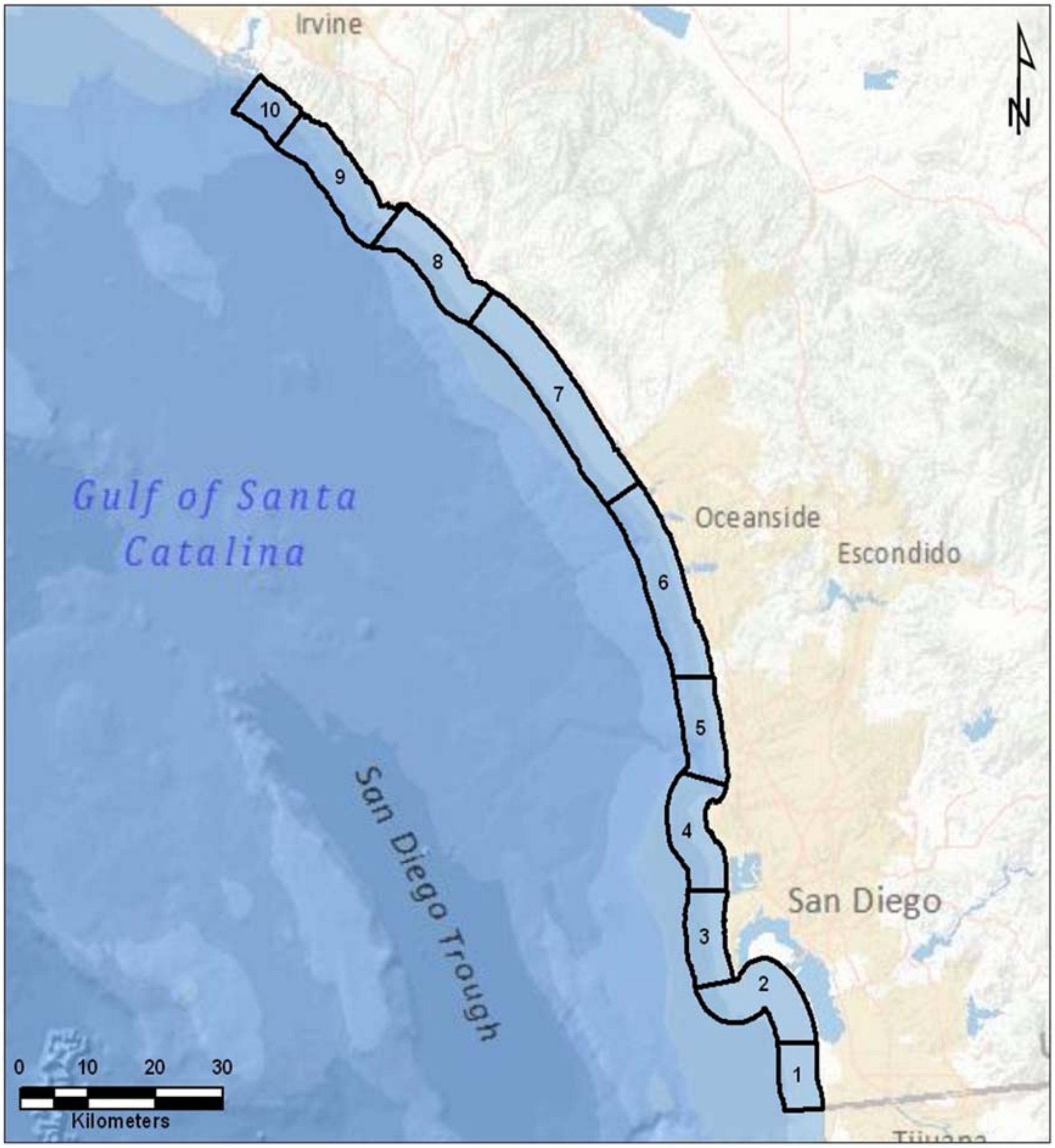
Kelp harvesting peaked in the 1970s, exceeding 150,000 metric tons per year in some years (Figure 36). However, kelp harvesting has been relatively low (less than 10,000 metric tons per year) since 2006. It is unlikely that this low amount of kelp harvesting would have any impact on the health of the kelp beds.



Source: California Department of Fish and Wildlife

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134676&inline

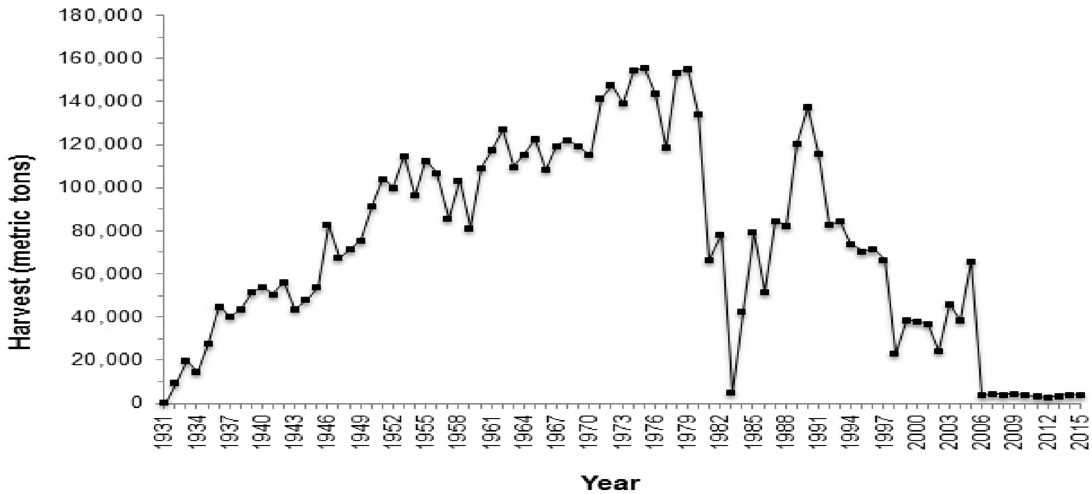
Figure 34. Administrative kelp bed leases in the Central Region study area.



Source: California Department of Fish and Wildlife

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134676&inline

Figure 35. Administrative kelp bed lease areas in the Region Nine study area.



Source: California Department of Fish and Wildlife
https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest

Figure 36. Commercial kelp harvest landings for giant and bull kelp from 1931 through 2015.

Table 13. Region Nine and Central Region kelp bed designations compared to California Department of Fish and Wildlife kelp bed designations.

F & W Lease Area	Region Nine Kelp Bed Designations		F & W Lease Area	Central Region Kelp Bed Designations
Bed 1	Imperial Beach		Bed 10	POLA-POLB Harbor, Horseshoe, Huntington Flats, Newport-Irvine Coast
Beds 2 and 3	Point Loma		Bed 13	Point Vicente to Point Inspiration (PV-II), Point Inspiration to Cabrillo (PV-I), Cabrillo
Bed 4	La Jolla		Bed 14	Malaga Cove to Palos Verdes Point (PV-IV), Palos Verdes Point to Point Vicente (PV-III)
Bed 5	Leucadia, Encinitas, Cardiff, Solana Beach, Del Mar, Torrey Pines		Bed 15	La Costa, Las Flores, Big Rock, Las Tunas, Topanga, Sunset
Bed 6	North Carlsbad, Agua Hedionda, Encina Power Plant, Carlsbad State Beach		Bed 16	Point Dume, Paradise Cove, Escondido Wash, Latigo Canyon, Puerco/Amarillo, Malibu Point
Bed 7	Horno Canyon, Barn Kelp, Santa Margarita		Bed 17	Deer Creek, Leo Carrillo, Nicholas Canyon, El Pescador/La Piedra, Lechuza
Bed 8	San Clemente, San Mateo Point, San Onofre			
Bed 9	North Laguna Beach, South Laguna Beach, South Laguna, Dana Point/Salt Creek, Capistrano Beach			

V - UPDATE TO PRESENT

The first aerial survey for 2018 was conducted on March 18, 2018. Based on a preliminary review of the data, most of the kelp beds in the Central Region had increased in size from the maximum canopy areas recorded in 2017. Several kelp beds were considerably larger in early 2018 than the 2017 levels. In Region Nine, many of the kelp beds from Solana Beach and northward were larger in early 2018 than their 2017 levels. The La Jolla kelp bed also was larger in March 2018 than its maximum in December 2017, but the Point Loma kelp bed remained roughly the same size in early 2018 as it was in December 2017. Sea surface temperatures in the Central Region and Region Nine were a little cooler from January–June 2018 than during 2017 (with the exception of Point Loma), which could result in a higher nutrient quotient and better nutrient availability in most areas.

The second aerial survey for 2018 was conducted on July 2, 2018. The pilot reported that kelp was quite abundant in most areas.

VI - CONCLUSIONS

In the Central Region, the total combined kelp surface canopy increased slightly (by 1.9%) in 2017. However, more individual beds decreased in size in 2017 than increased in size. Ten kelp beds exceeded 40% of their historical maximum size, including three beds that reached the highest level recorded since surveys began in 2003, while only six kelp beds declined to less than 10% of their maximum size. The total kelp coverage in the Central Region has been at or above the long-term average every year for the past 10 years, although for the past three years it has been 18 to 27% below the high level recorded in 2009 (6.406 km^2).

In Region Nine, the total kelp coverage decreased by 36.2% in 2017, continuing the decline that began in 2014. After peaking at a size of 17.064 km^2 in 2013, the kelp bed area has decreased by 80.8% over the past four years. Twice as many individual kelp beds decreased in size than increased in 2017. Only one kelp bed exceeded 40% of the historical maximum, while 11 kelp beds declined to less than 10% of their maximum size.

Water temperatures throughout the CRKSC and RNKSC areas generally were warmer than average throughout all of 2017, particularly from January through March, and October through December. However, there were occasional periods of cooler than normal water temperatures in both regions, likely associated with upwelling events, from April through August. Daily SST values in both areas rarely fell below 14^{o}C, a threshold below which nutrient availability is much greater than at higher water temperatures. Based on relatively low NQ Index scores, nutrient availability remained below average in most CRKSC and RNKSC areas in 2017, as has been the case since 2013. Upwelling was strong during 2017, particularly in April and June, which may have produced higher nutrient availability in certain areas.

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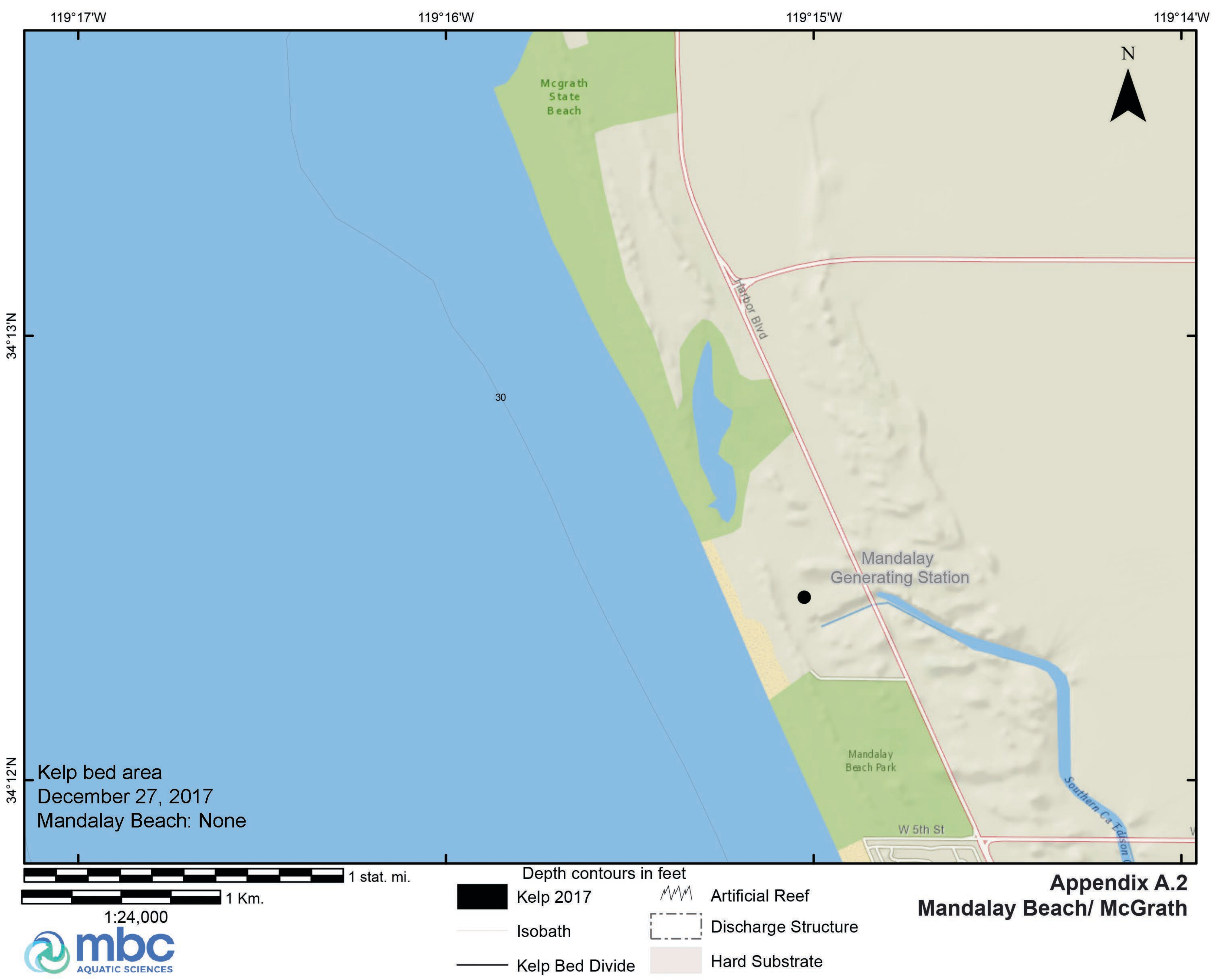
APPENDIX A

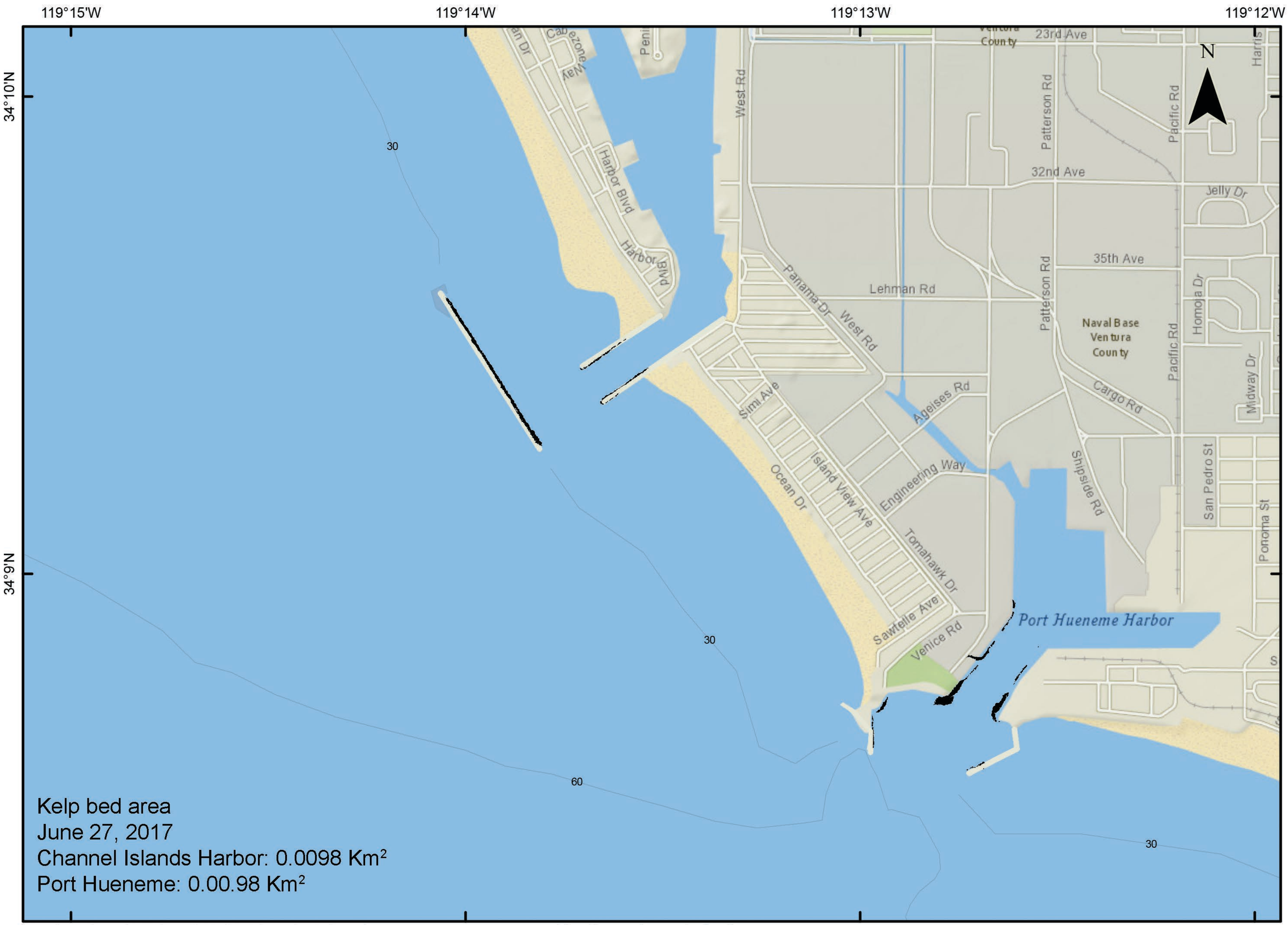
Kelp Canopy Maps

Appendix A.1
Ventura Marina



Appendix A.2
Mandalay Beach/ McGrath

Appendix A.3
Oxnard (Silver Strand)



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

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

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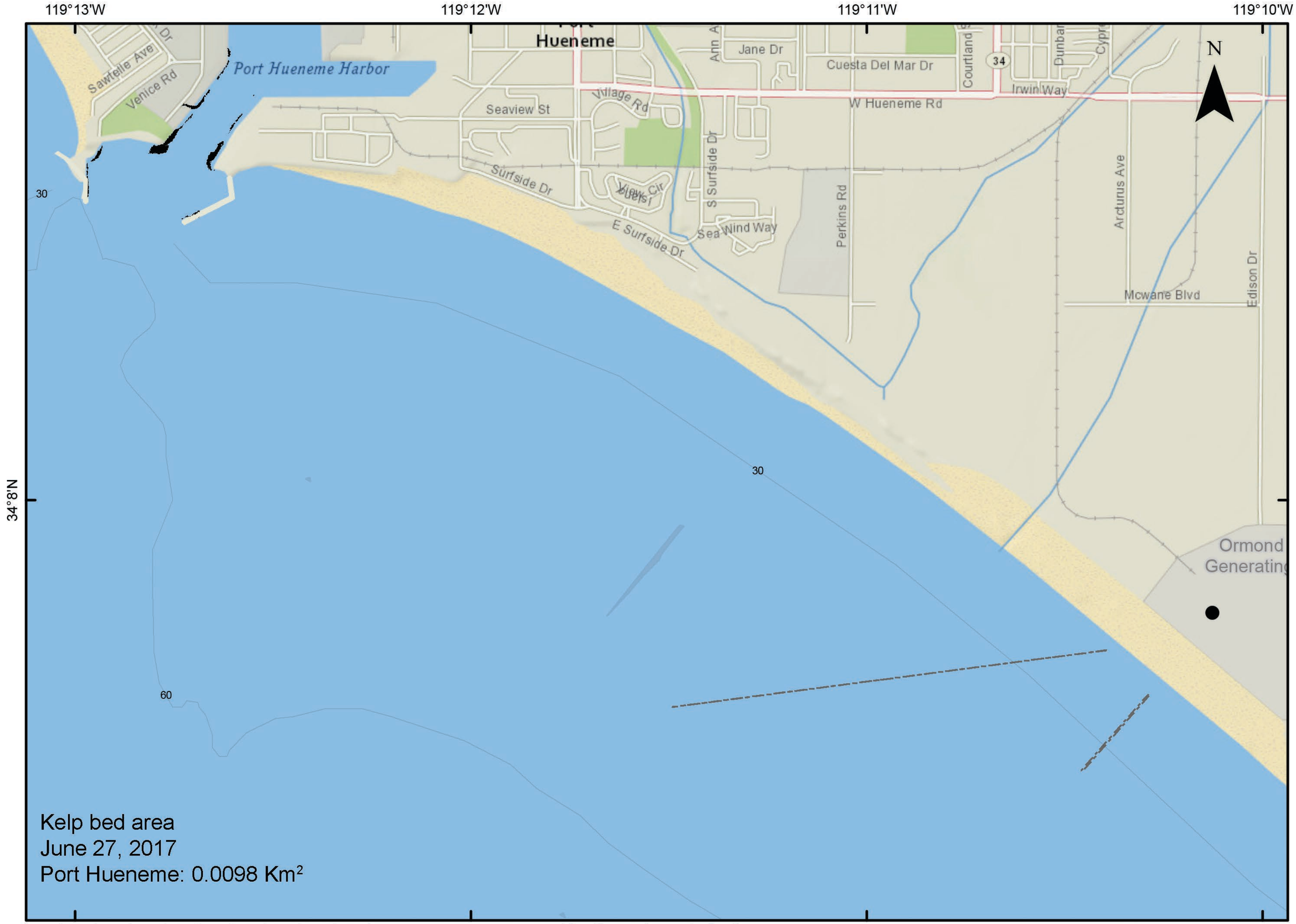
Appendix A.4
Channel Island Harbor/ Port Hueneme Harbor



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.5
Port Hueneme Beach

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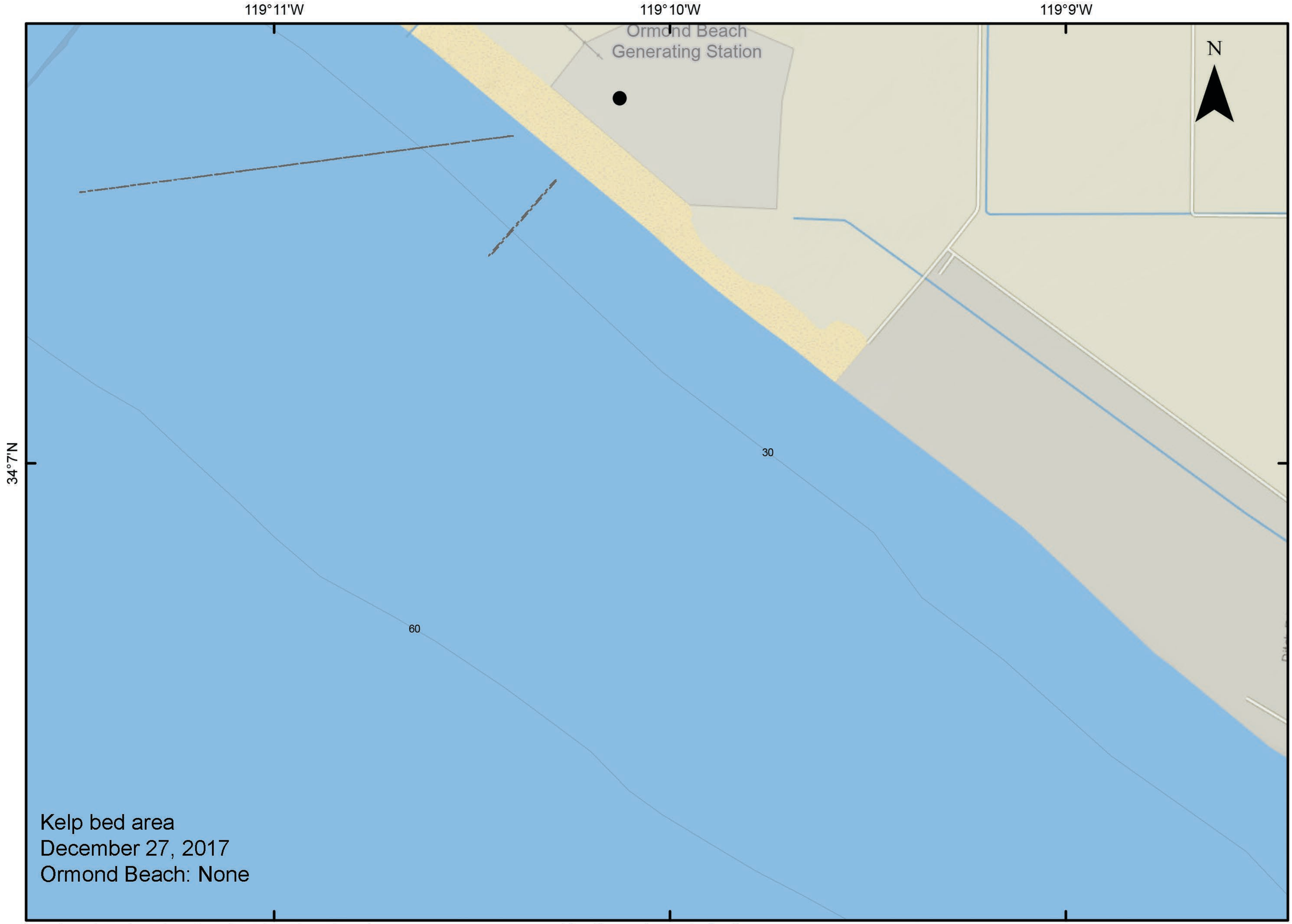


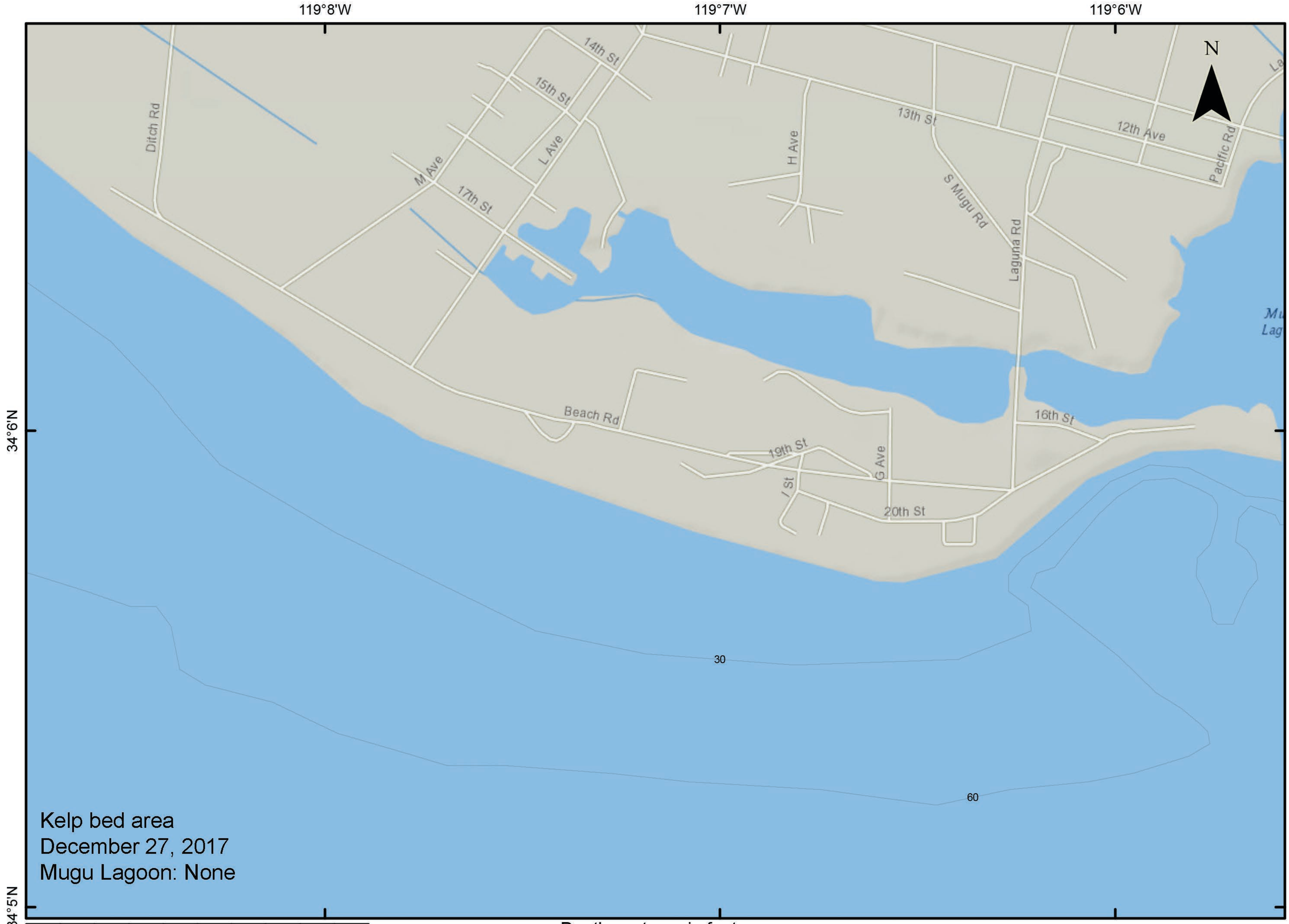
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.6
Ormond Beach



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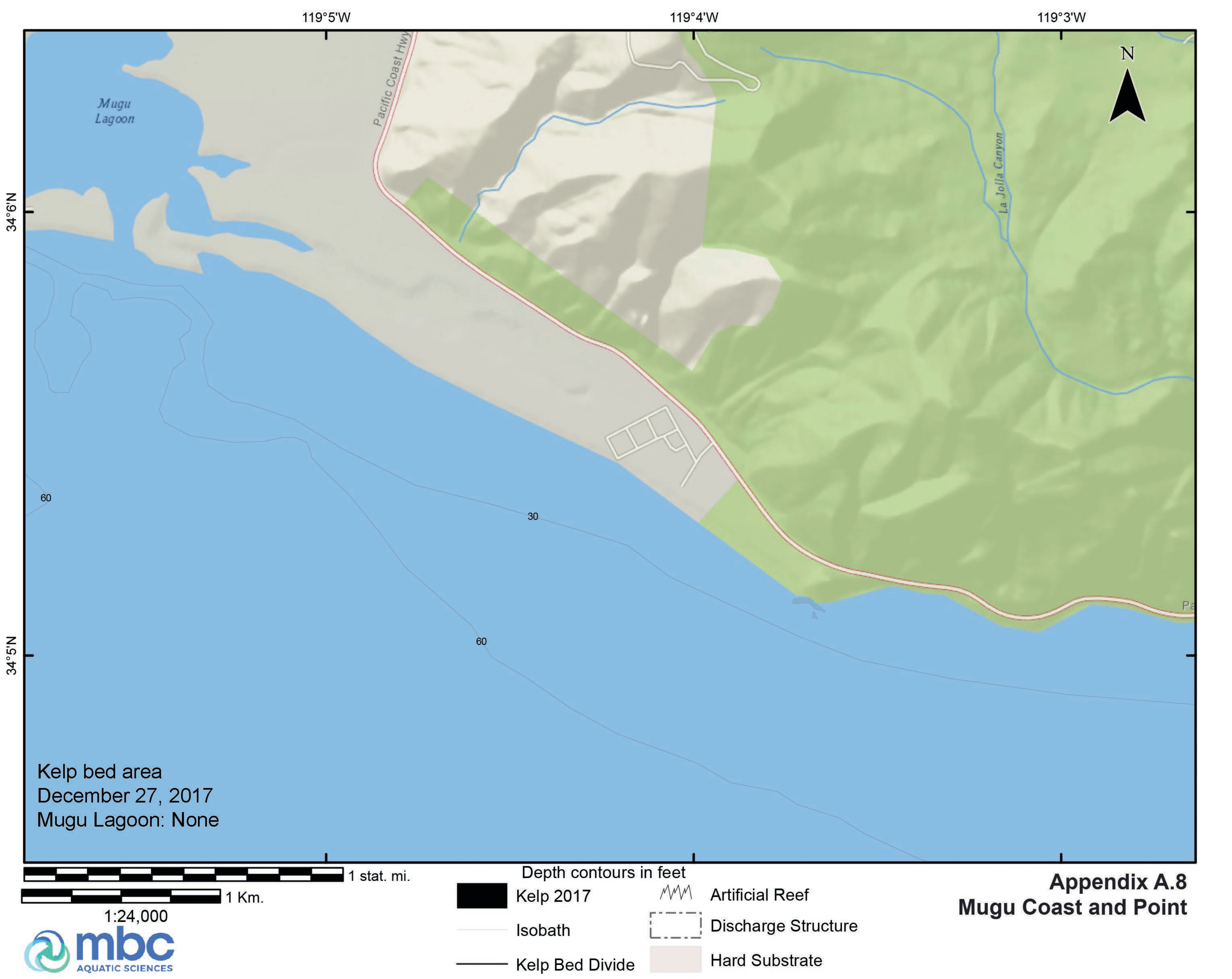
1 Km.
1:24,000

Depth contours in feet

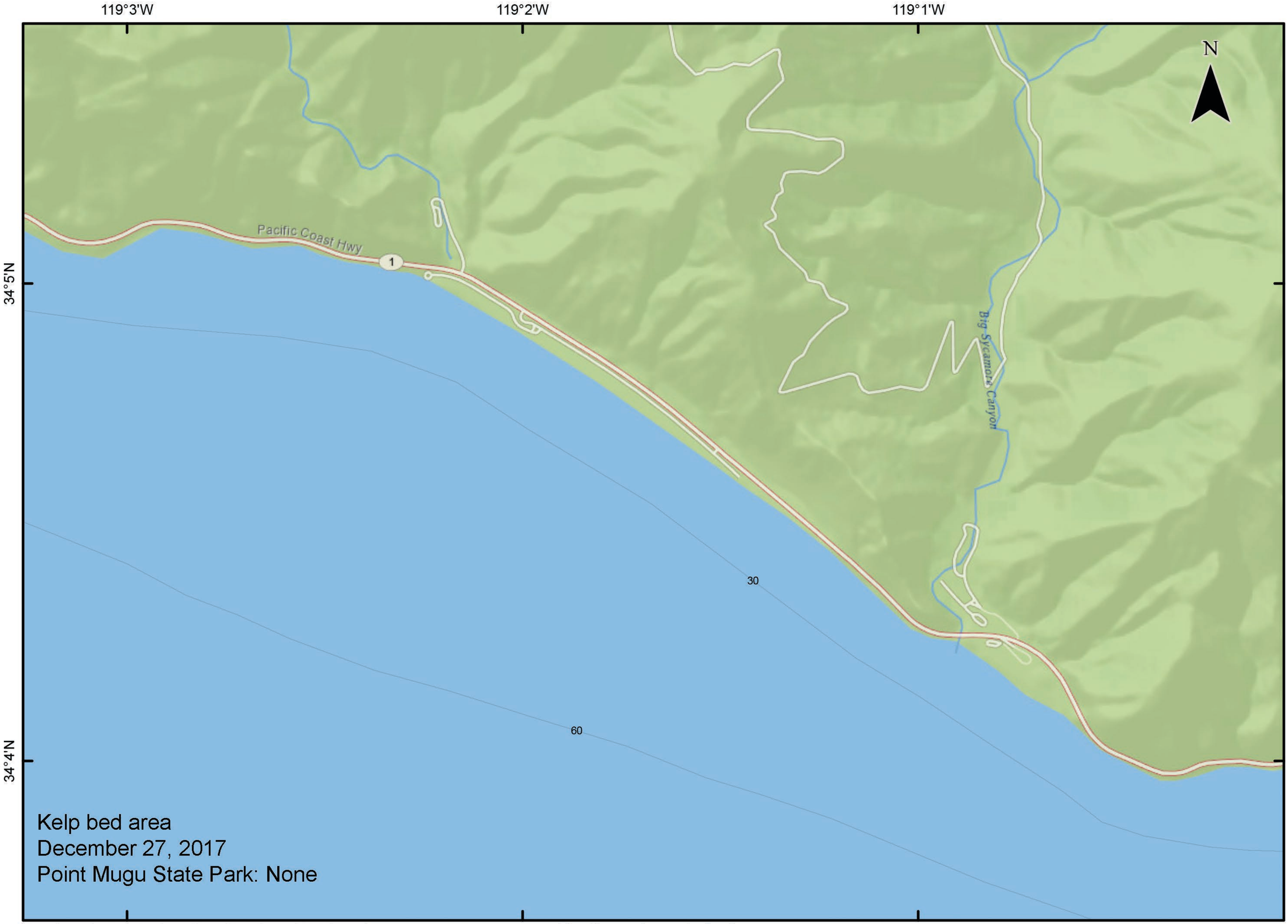
Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.7
Mugu Lagoon/ Base



Appendix A.8
Mugu Coast and Point



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2017

Isobath

Kelp Bed Divide

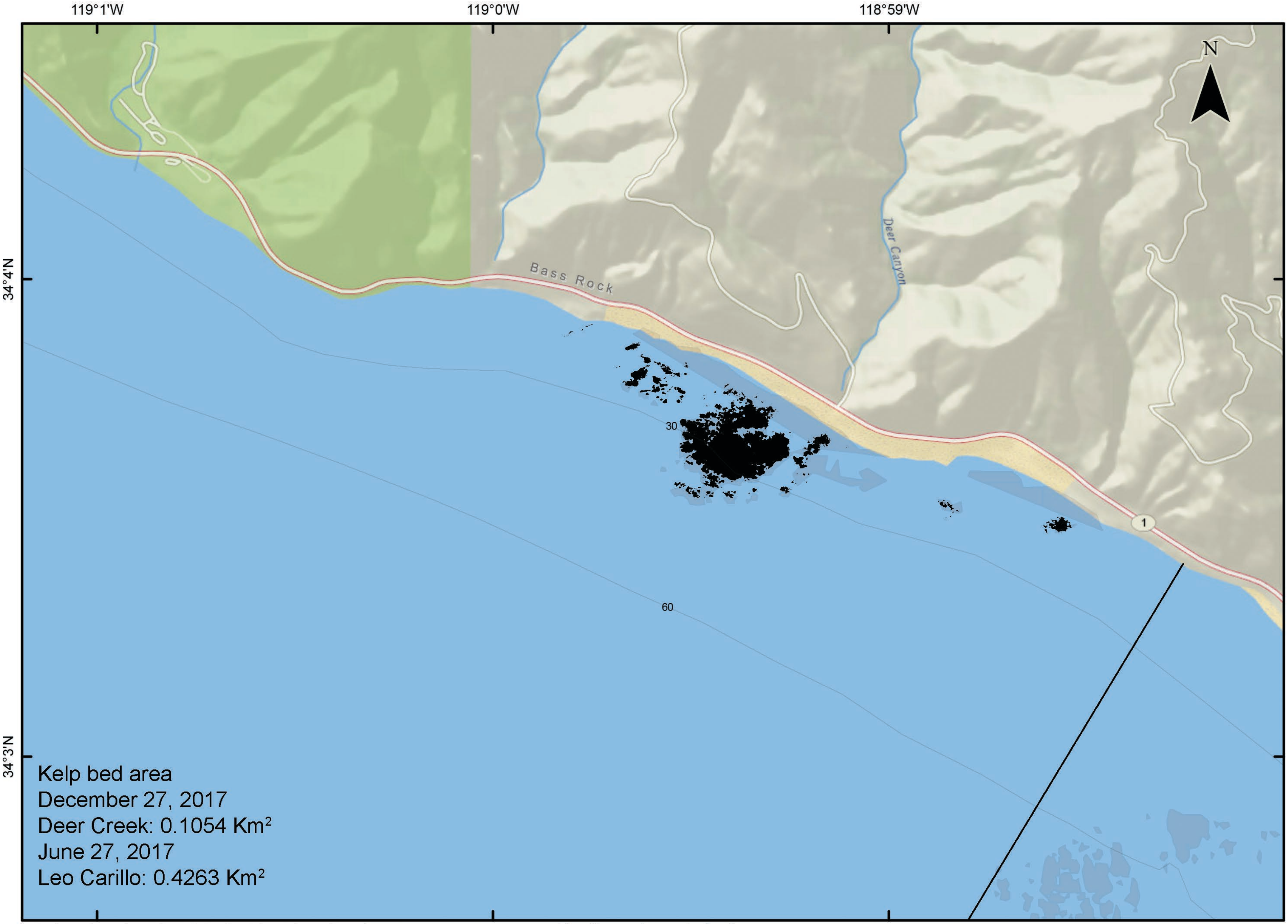
Artificial Reef

Discharge Structure

Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.9
Mugu State Park



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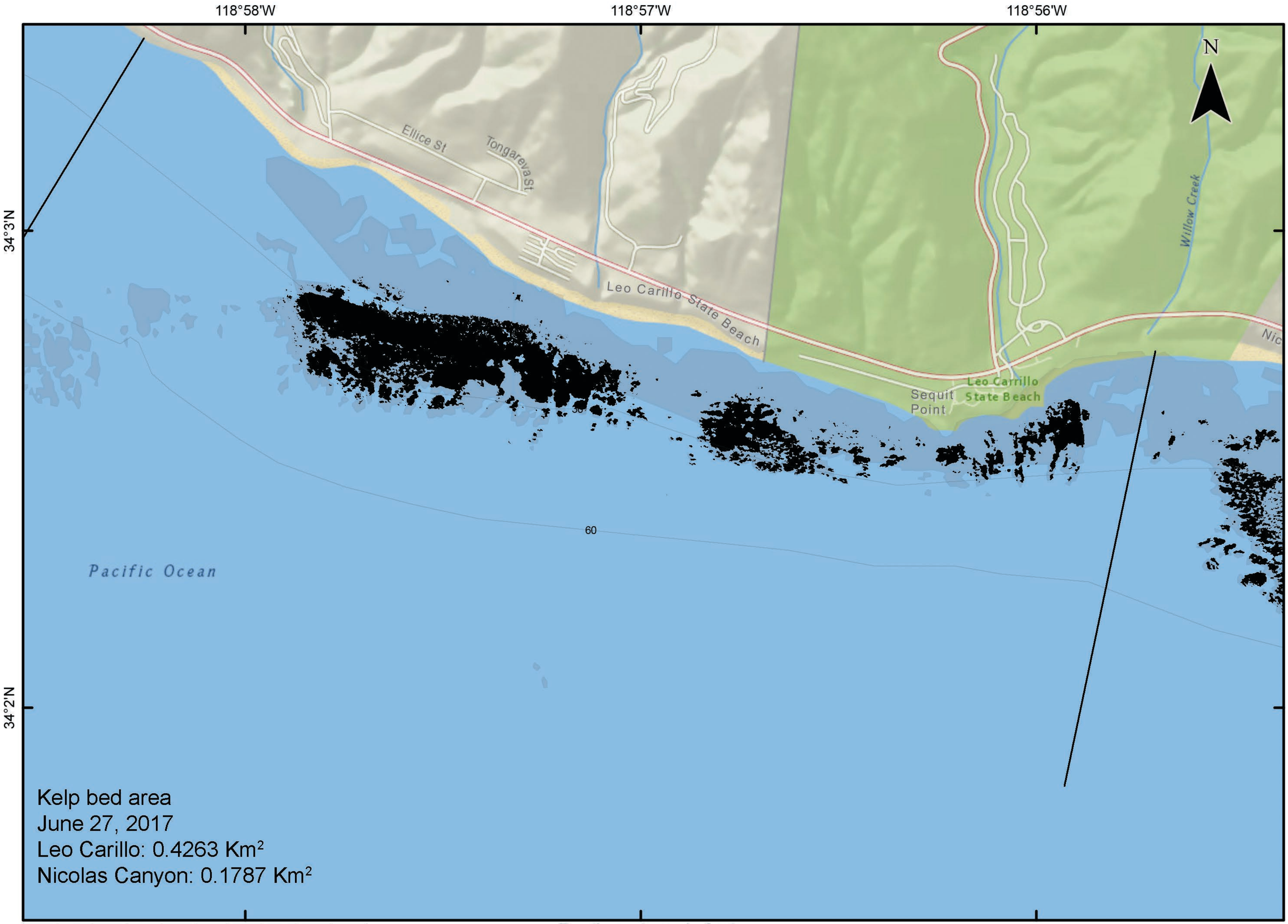
1 Km.
1:24,000

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.10
Deer Creek



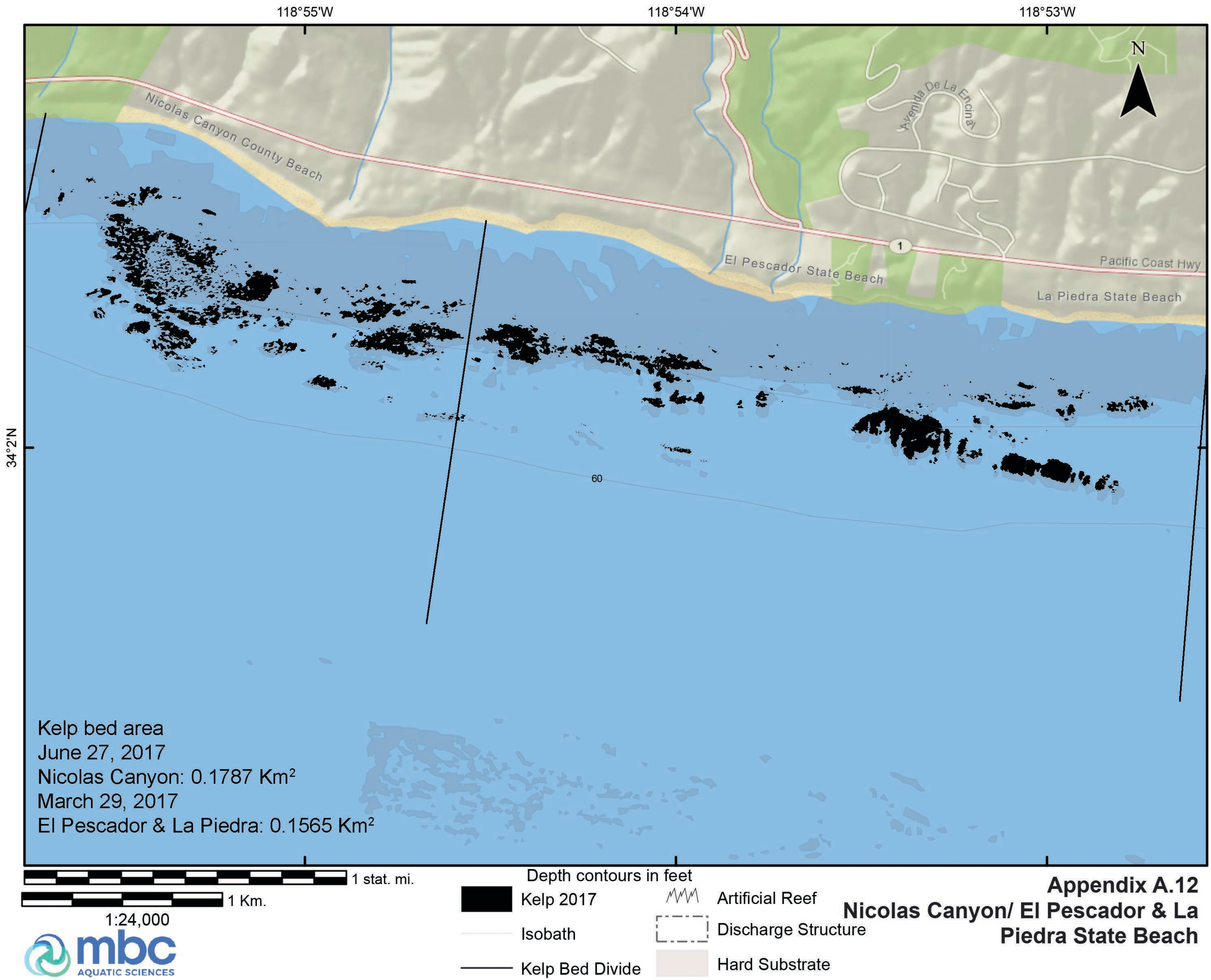
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

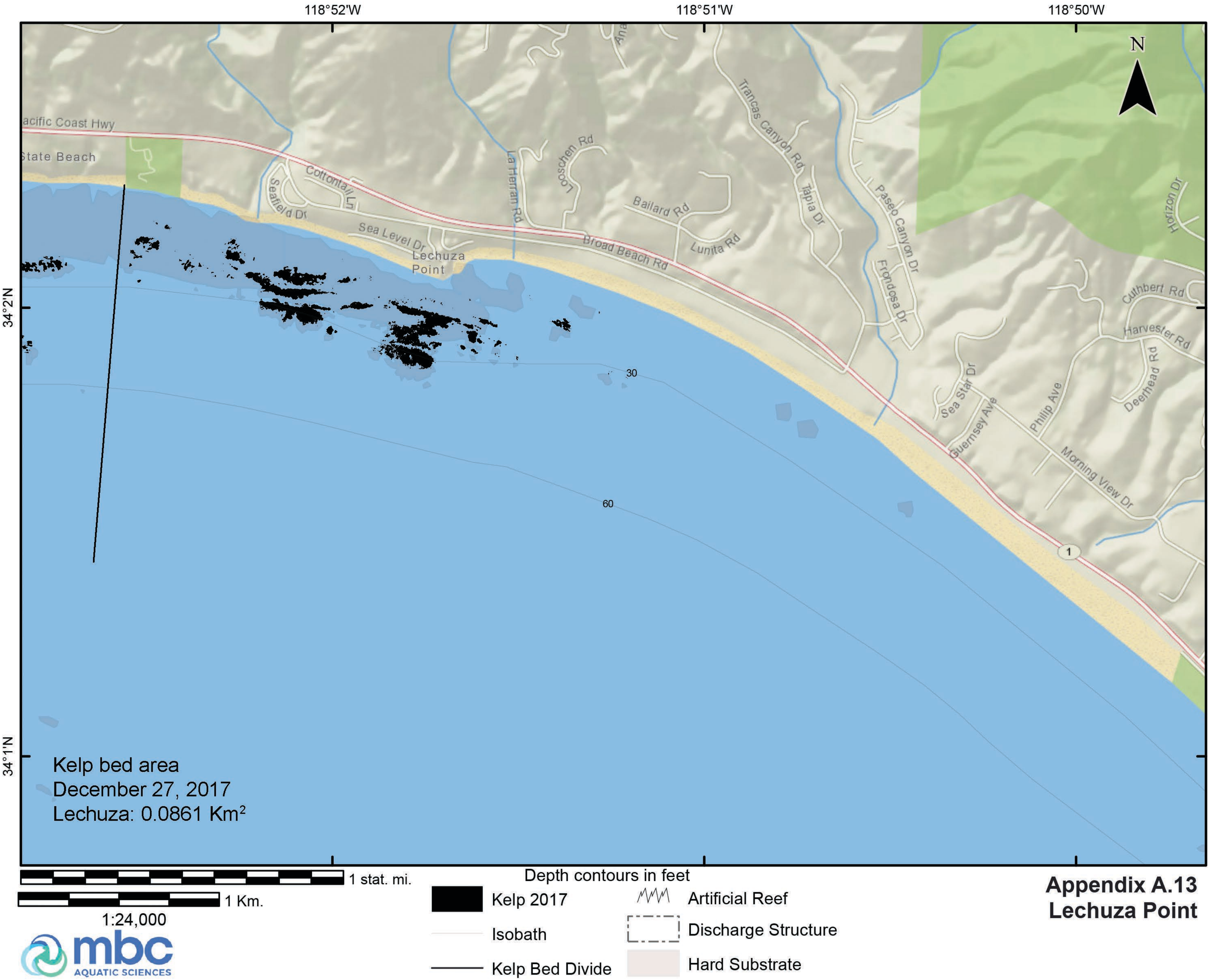
- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

mbc AQUATIC SCIENCES

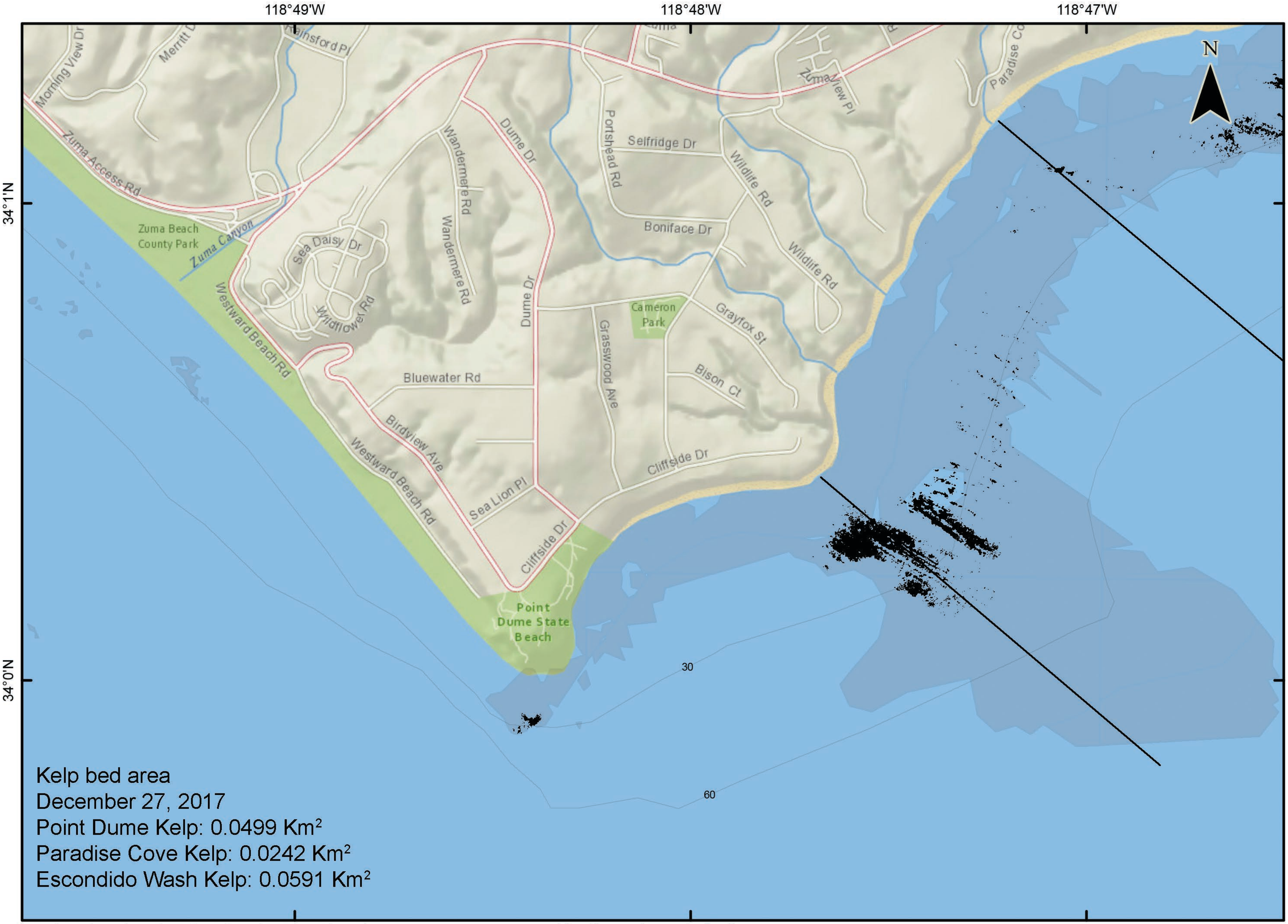
Appendix A.11
Leo Carillo State Beach/ Sequit Point



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



Appendix A.13
Lechuza Point



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1 Km.
1:24,000

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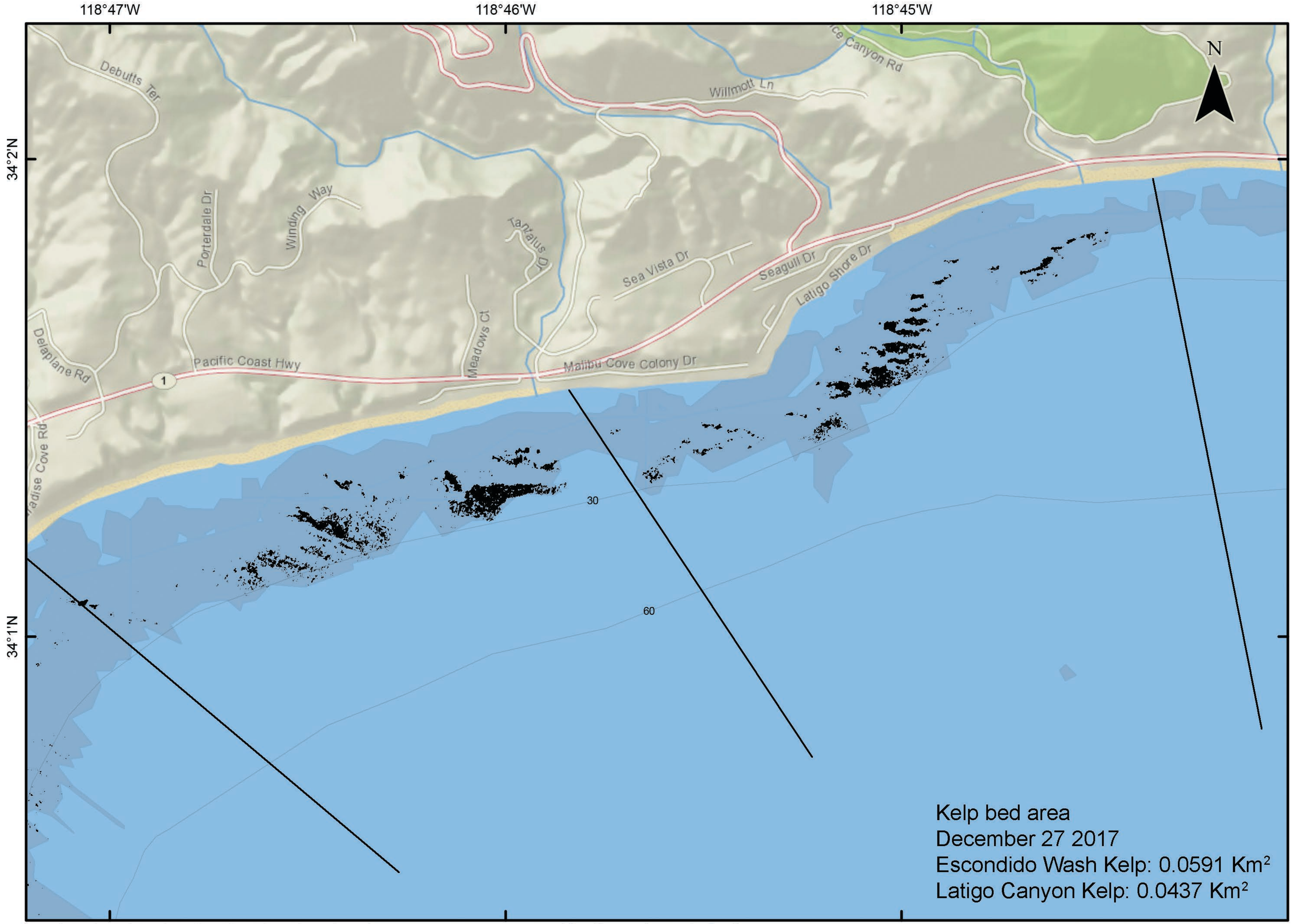
Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

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



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

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.15
Escondido Wash/ Latigo Canyon

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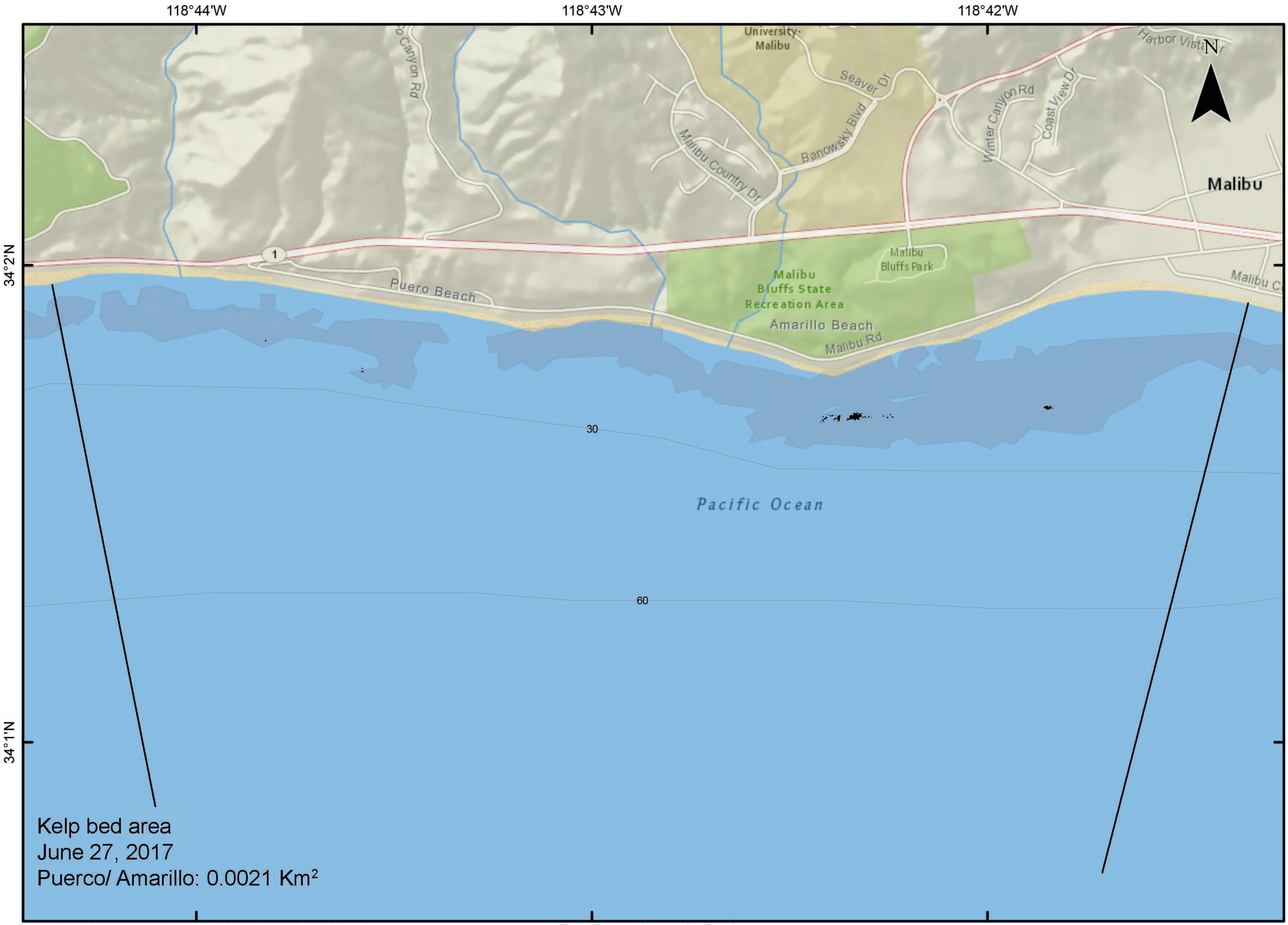


1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp 2017

Isobath

Kelp Bed Divide

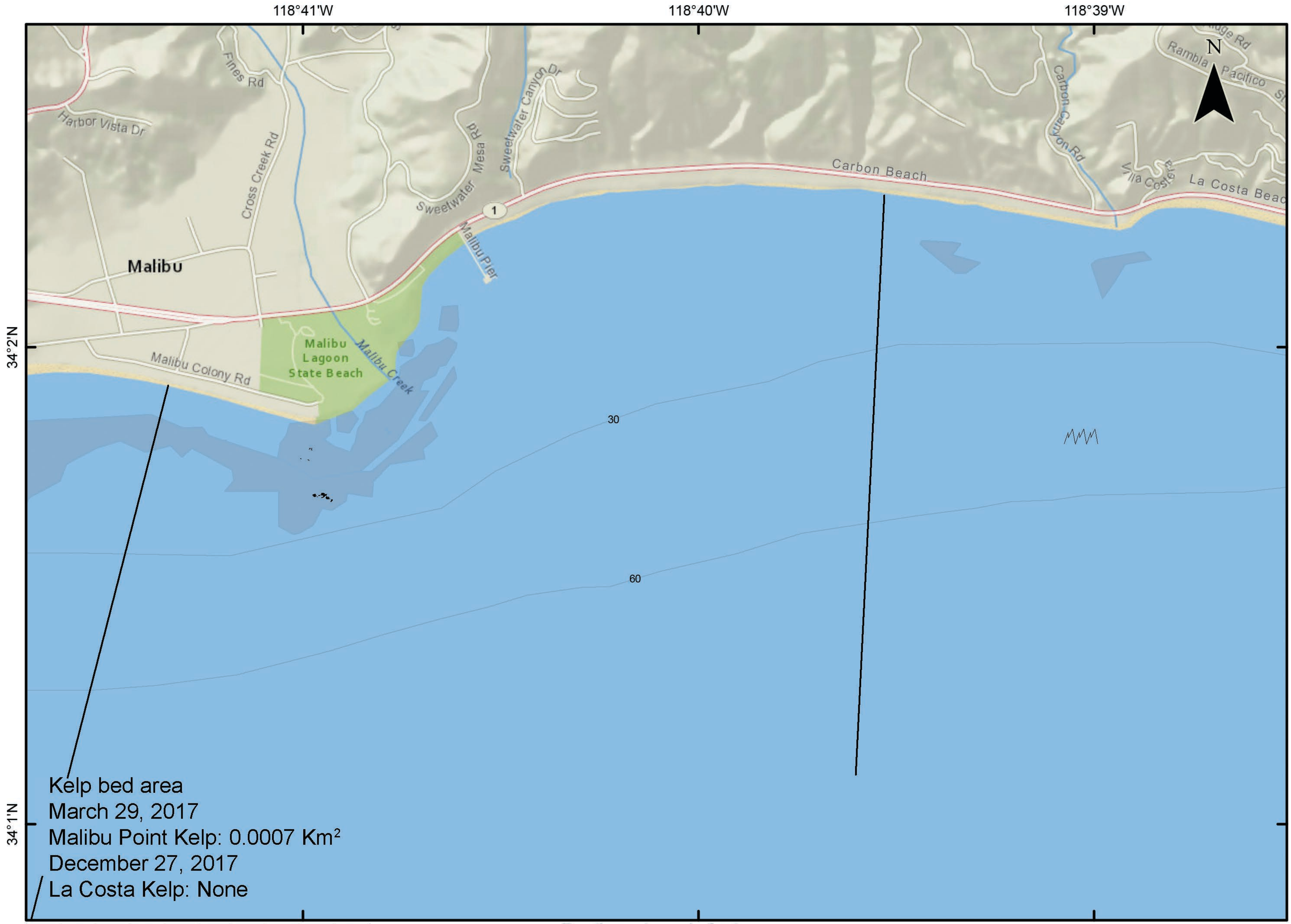
Artificial Reef

Discharge Structure

Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.16
Puerco/ Amarilo Beach



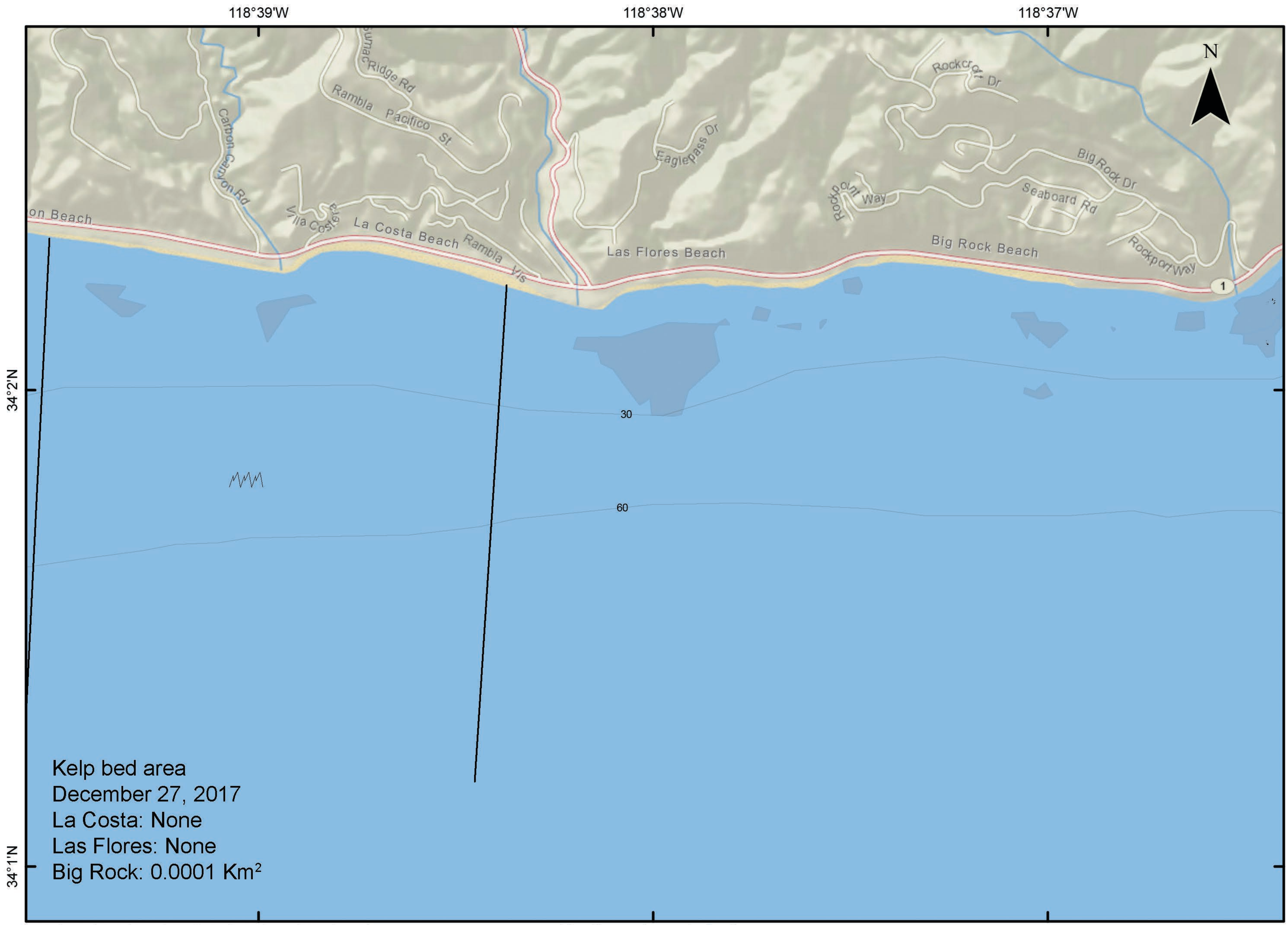
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.17
Malibu Point/ La Costa Beach



1 stat. mi.

1 Km.

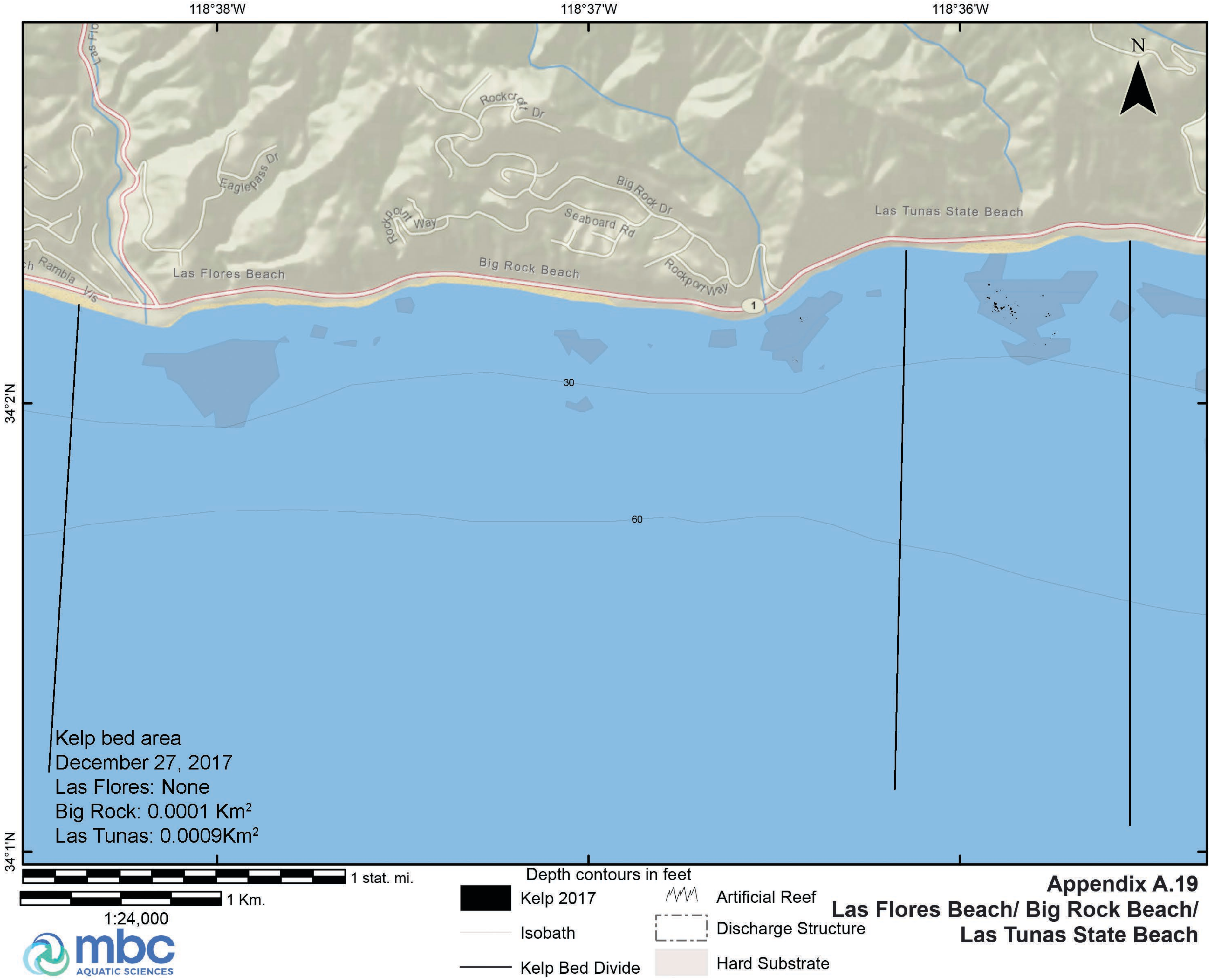
1:24,000

Depth contours in feet

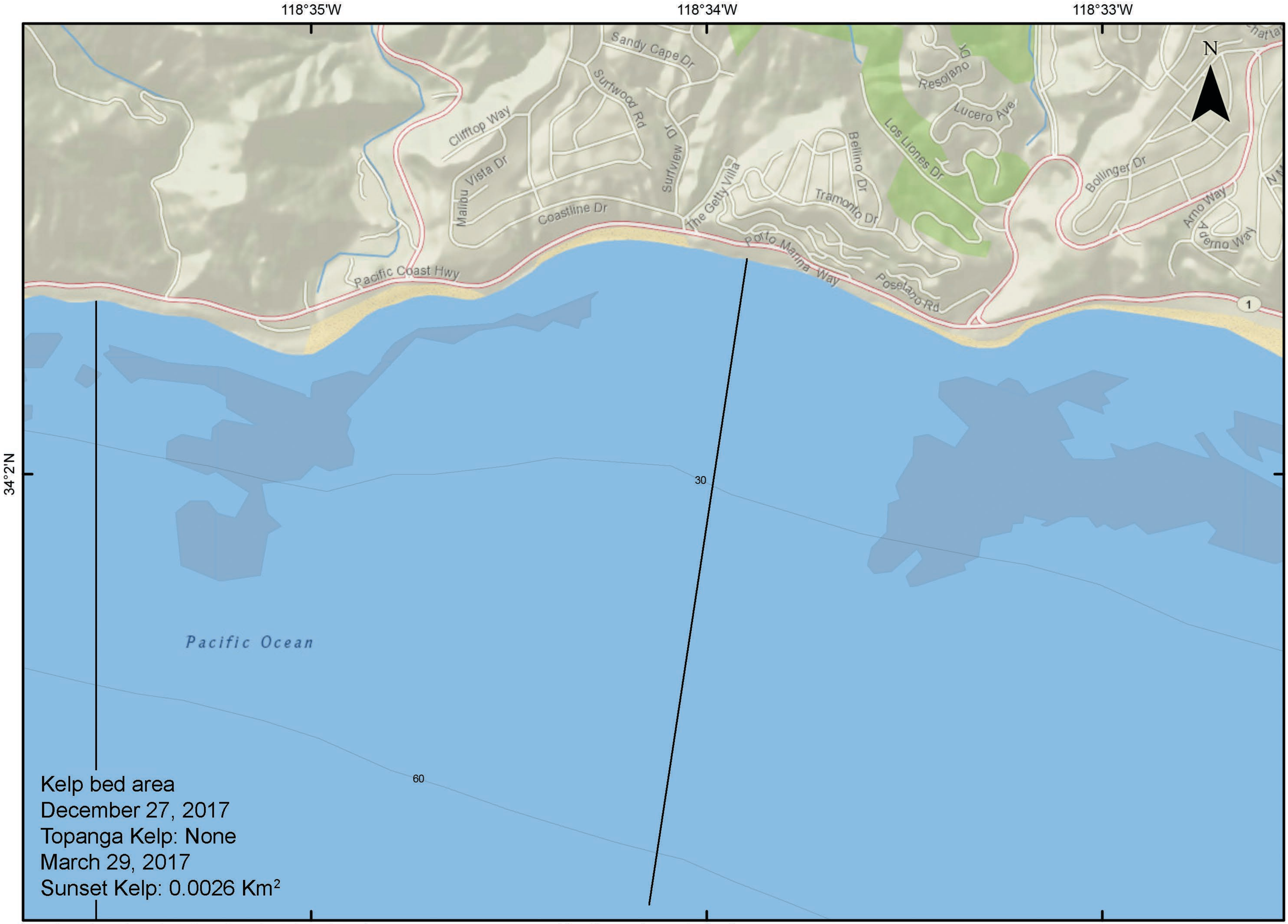
- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

mbc AQUATIC SCIENCES

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



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



1 stat. mi.

1 Km.

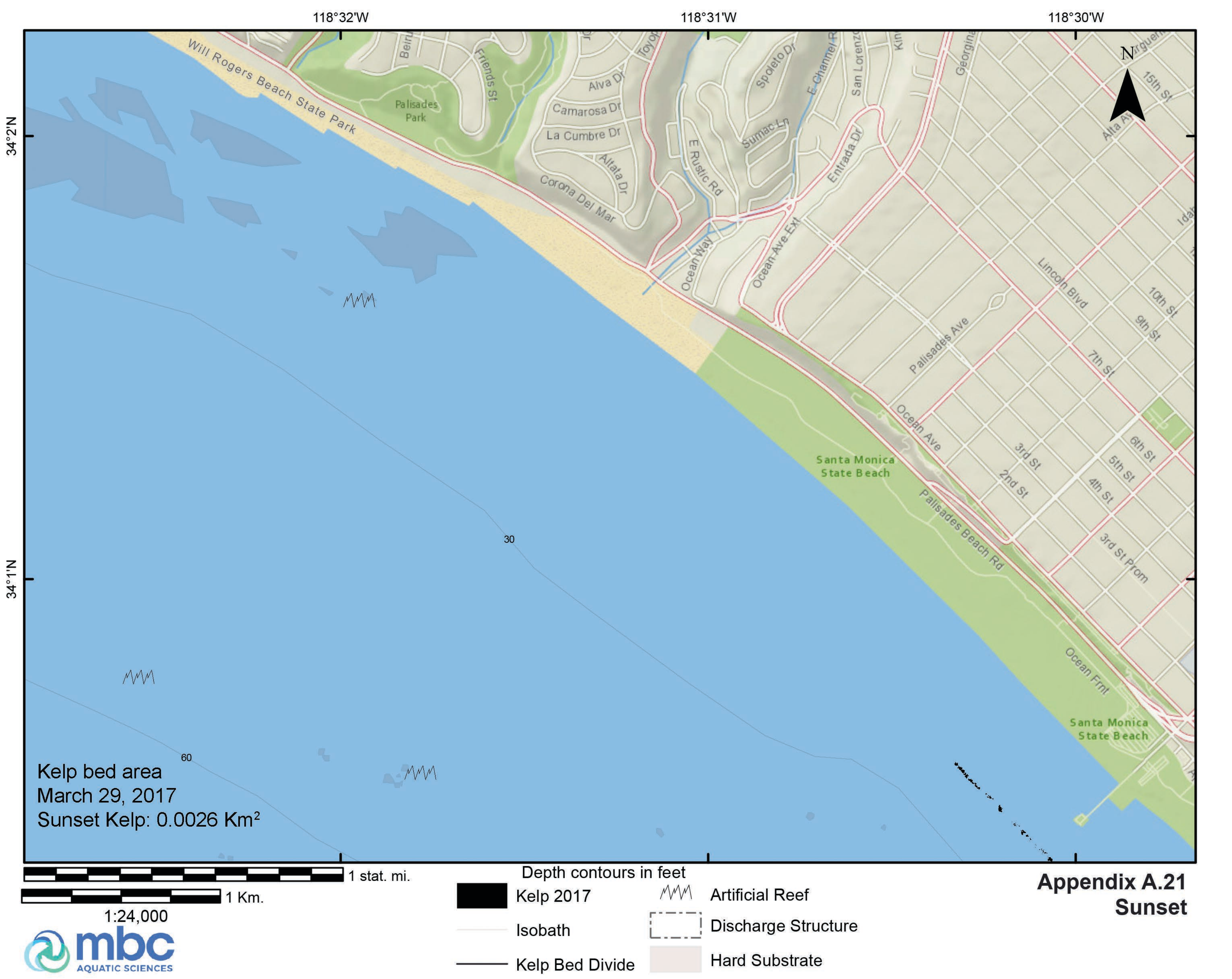
1:24,000

mbc AQUATIC SCIENCES

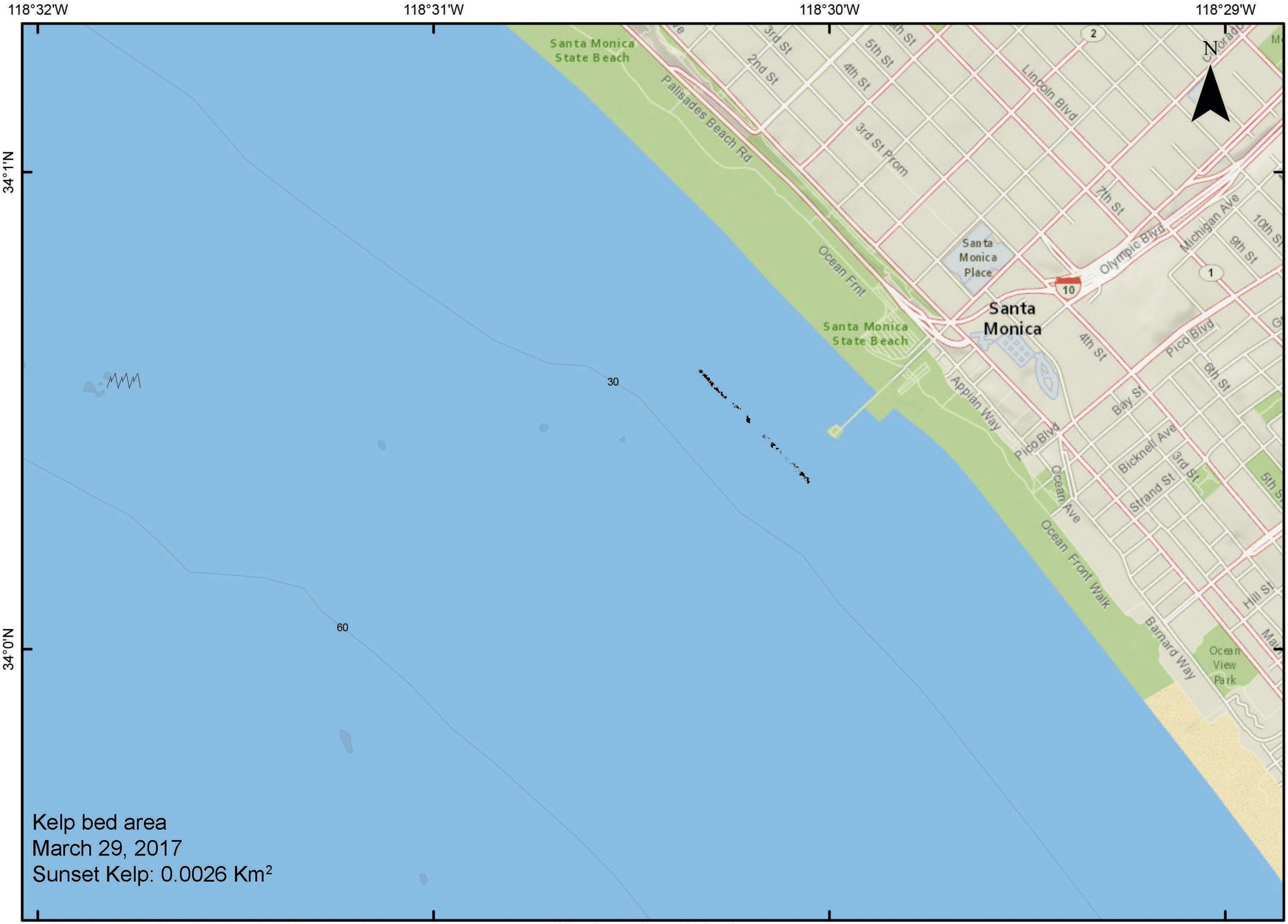
Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.20
Topanga Canyon Rd/ Sunset Blvd



Appendix A.21
Sunset



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1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

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

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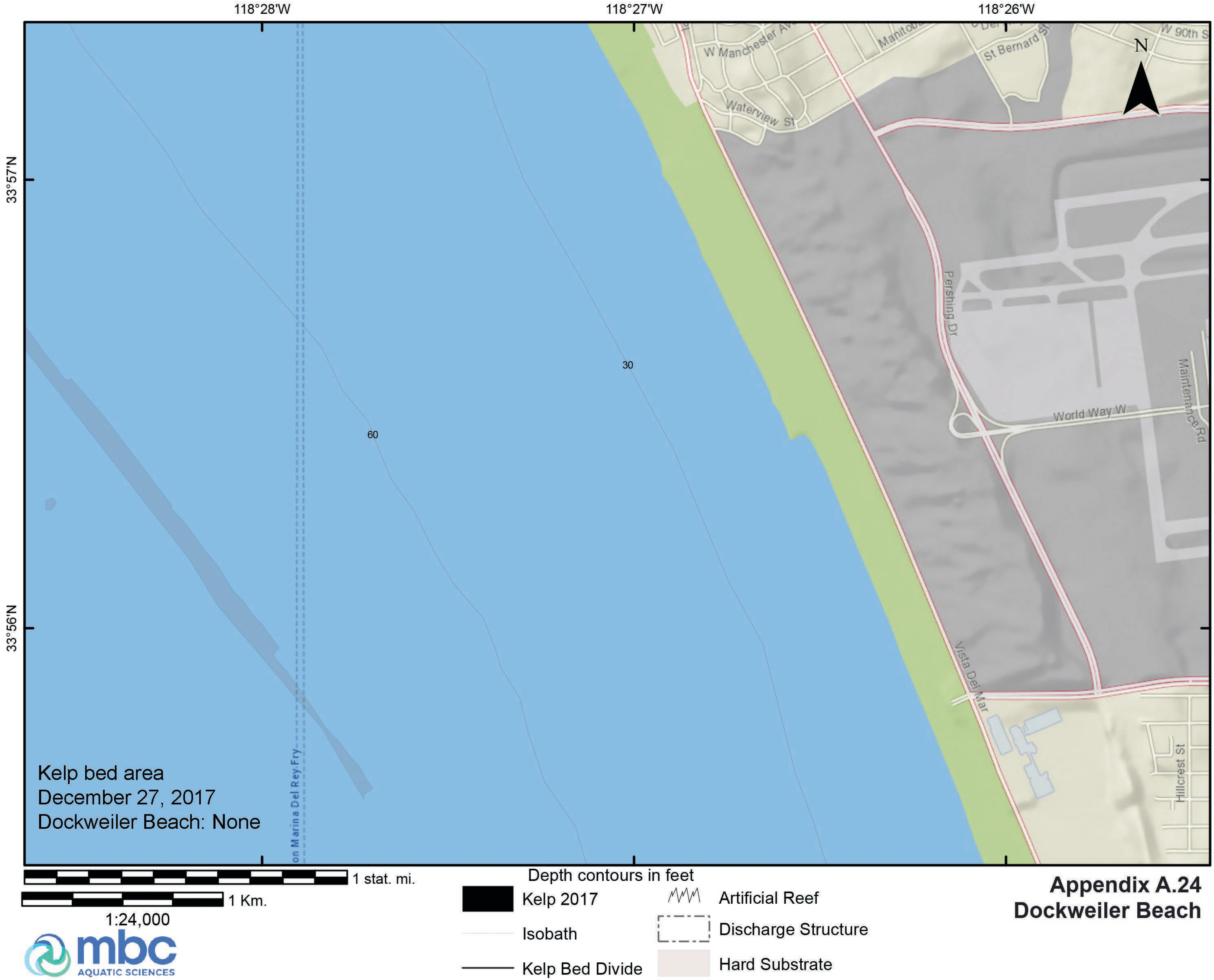
Appendix A.23
Marina del Rey



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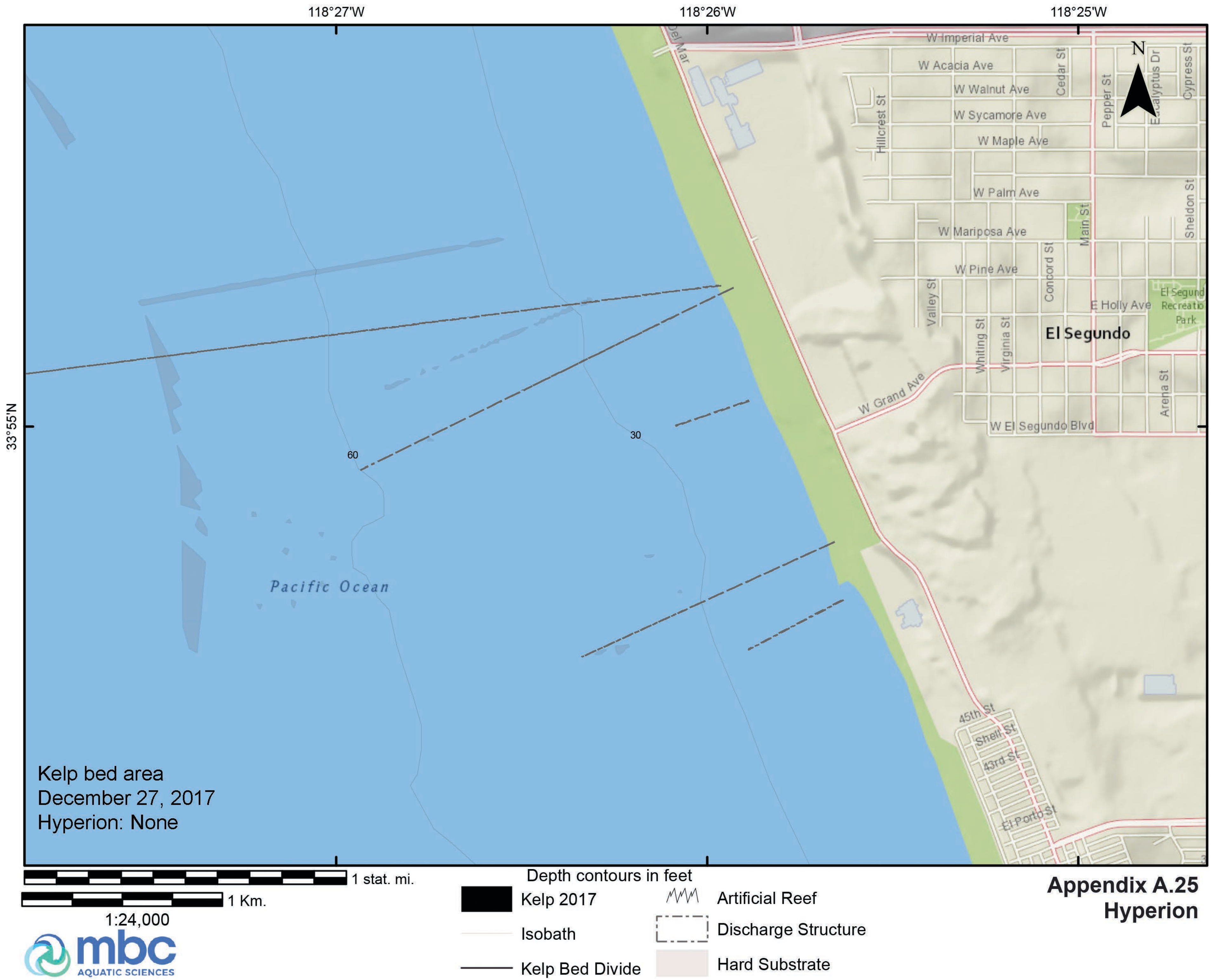
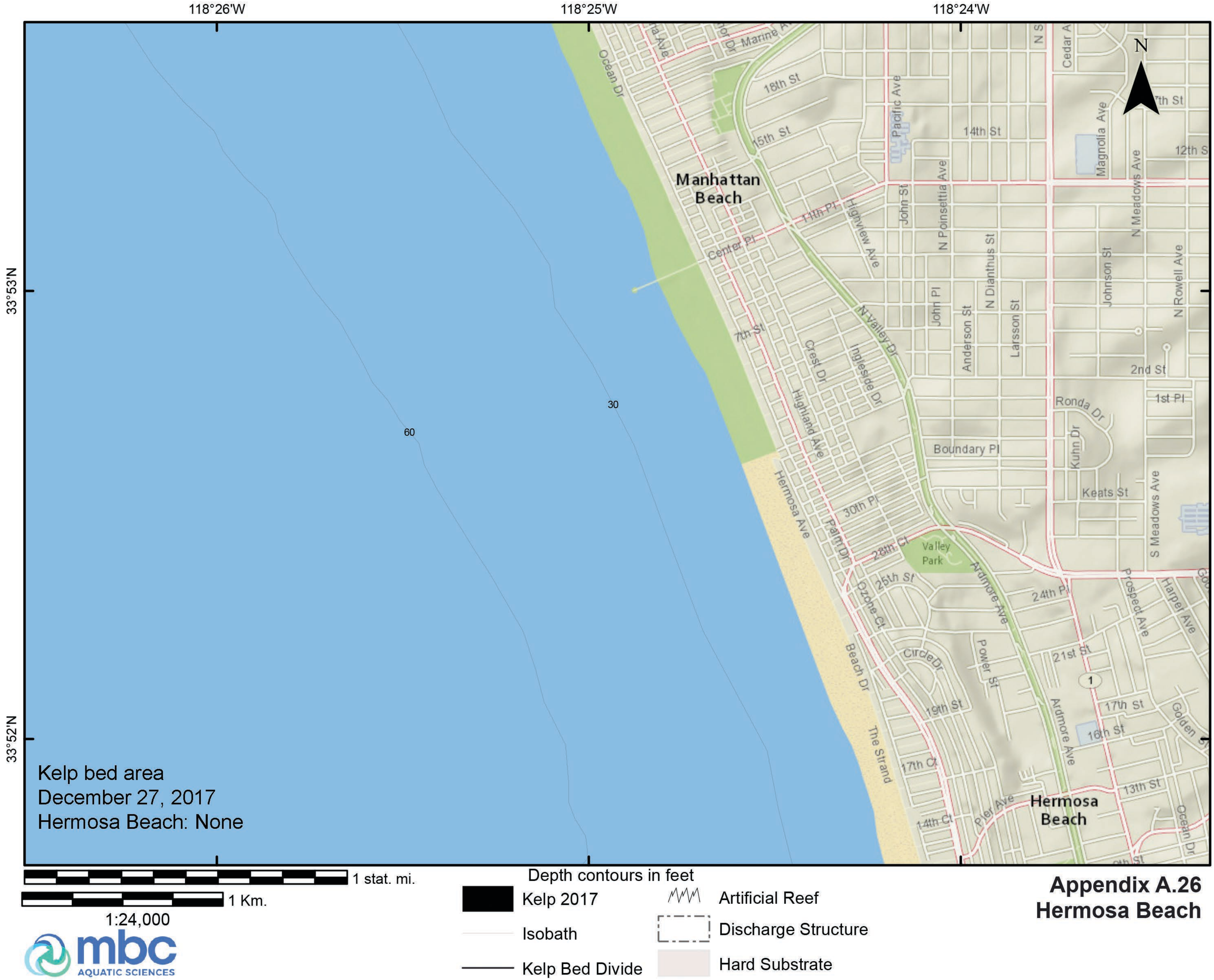
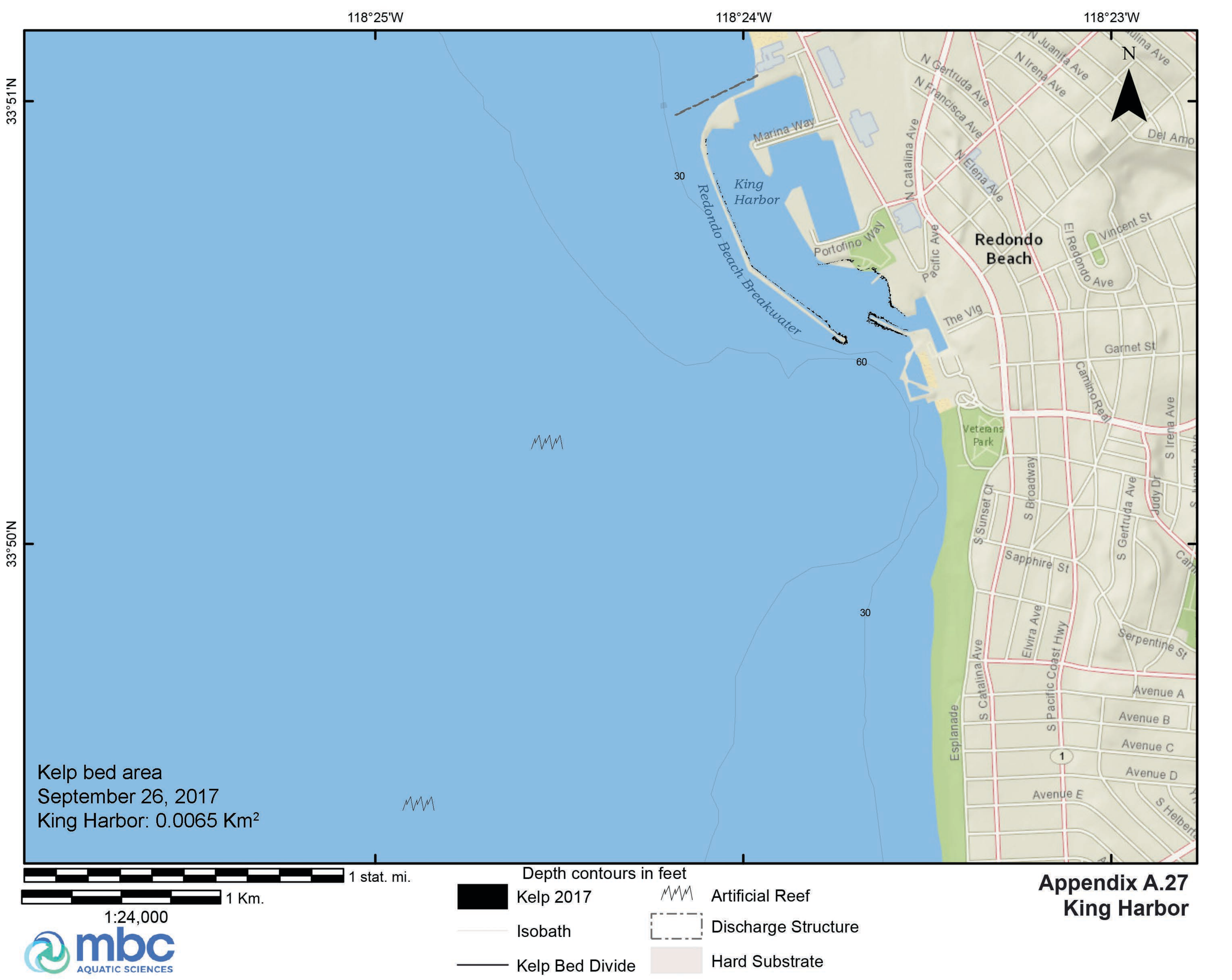
Appendix A.24
Dockweiler Beach



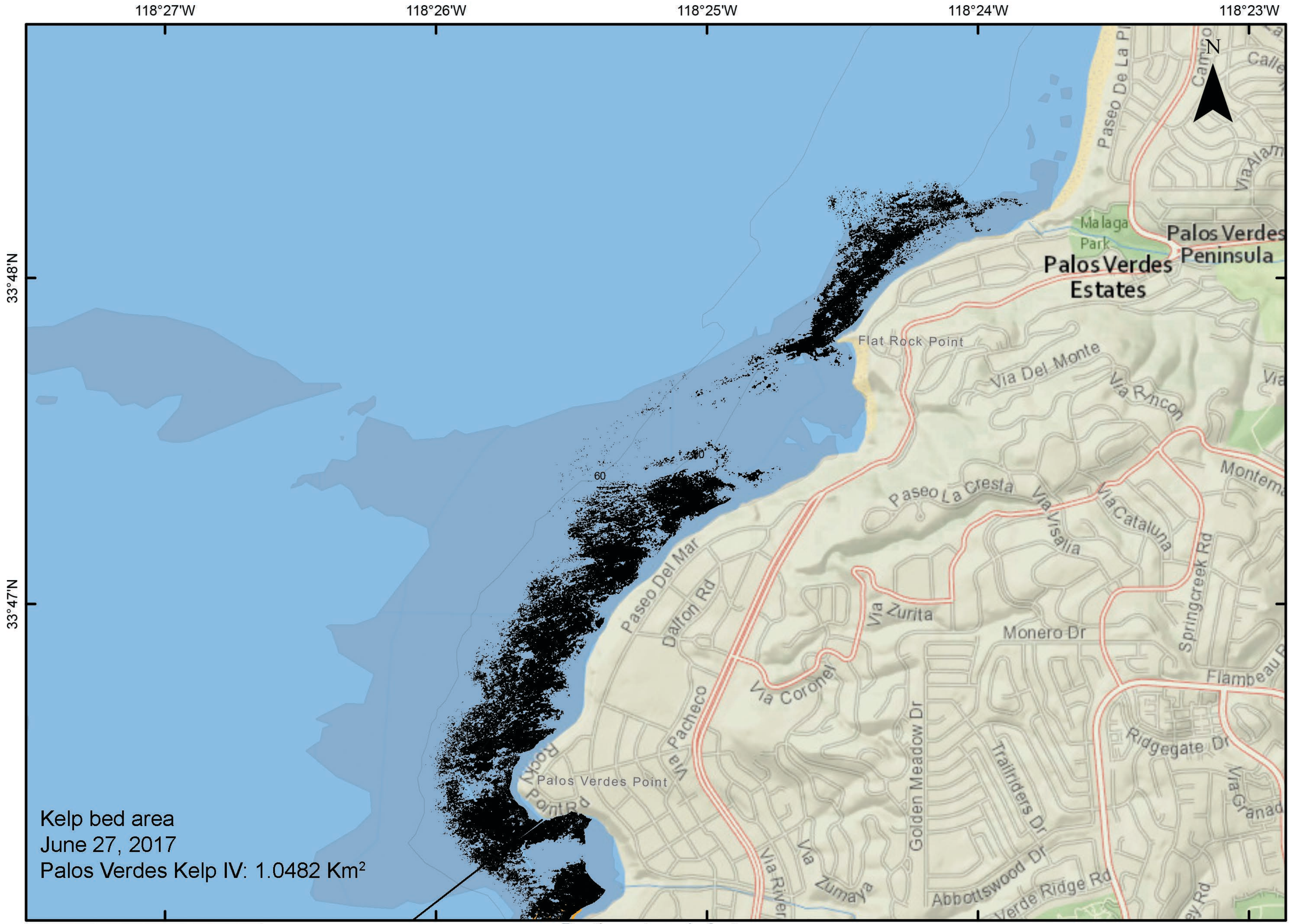
Appendix A.25
Hyperion

Appendix A.26 Hermosa Beach





Appendix A.27
King Harbor



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

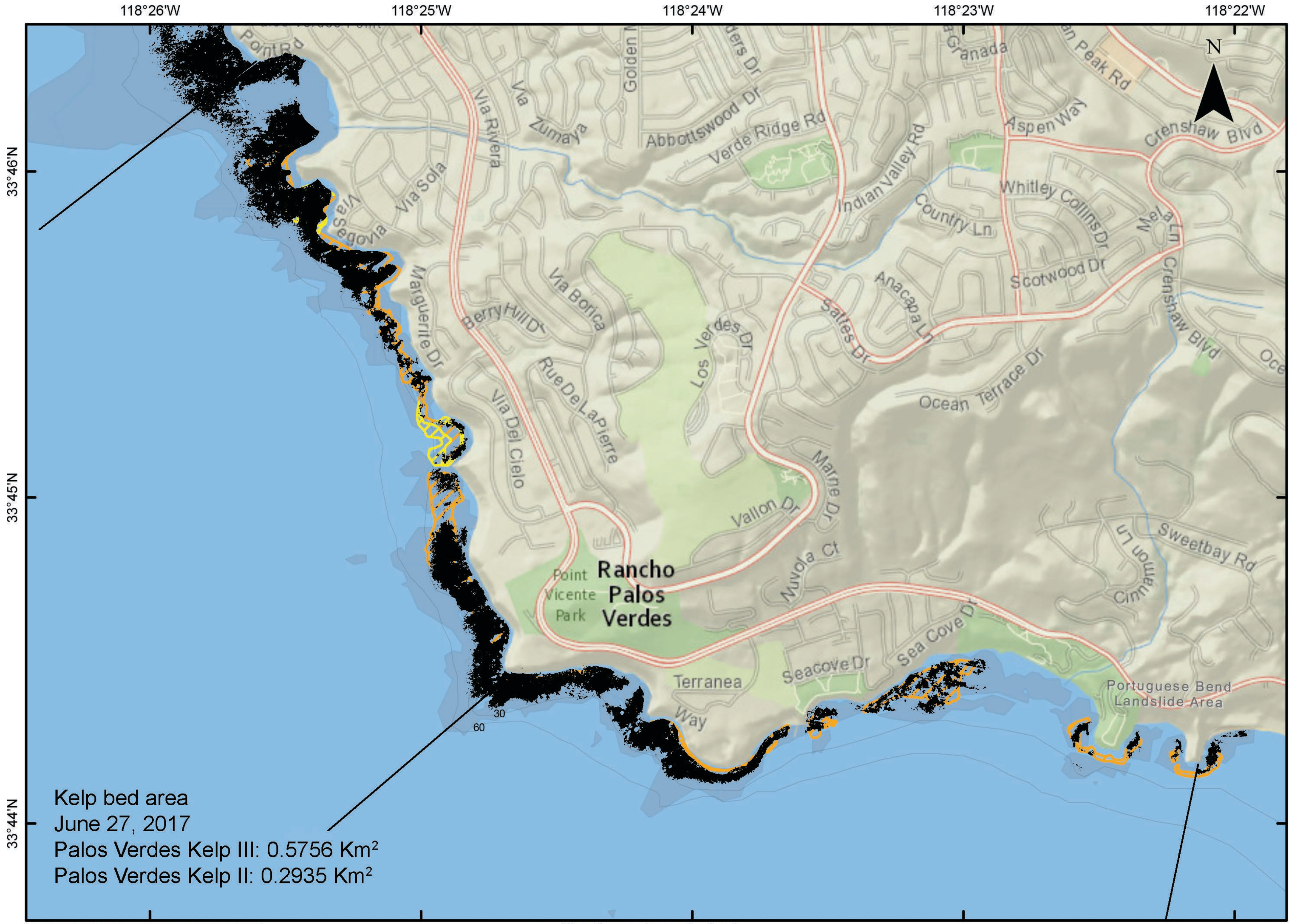
Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Urchin Barrens

- 2013 extent (observed)
- 2010 extent (mapped)

Appendix A.28
Palos Verdes Kelp IV



1 stat. mi.

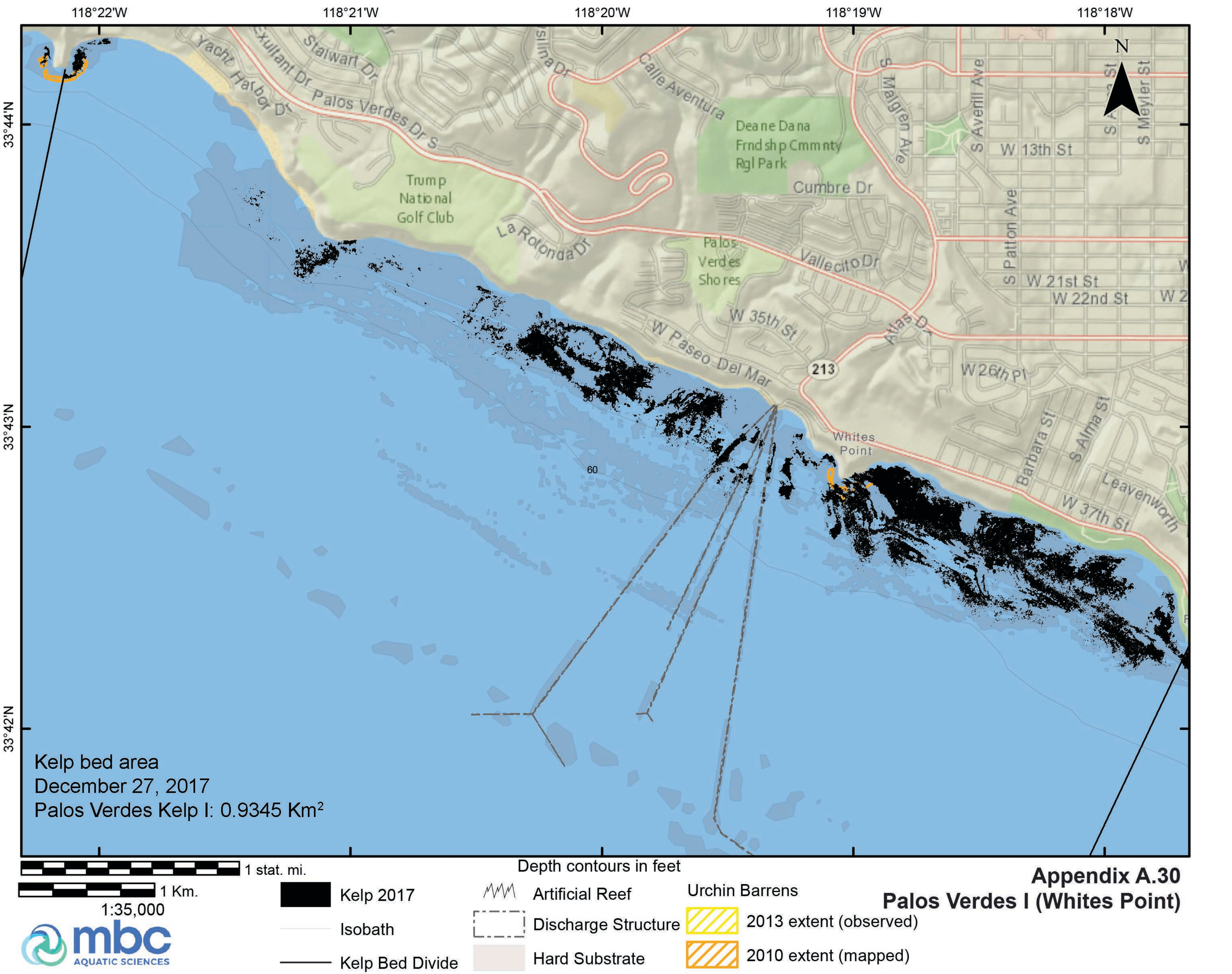
1 Km.

1:35,000

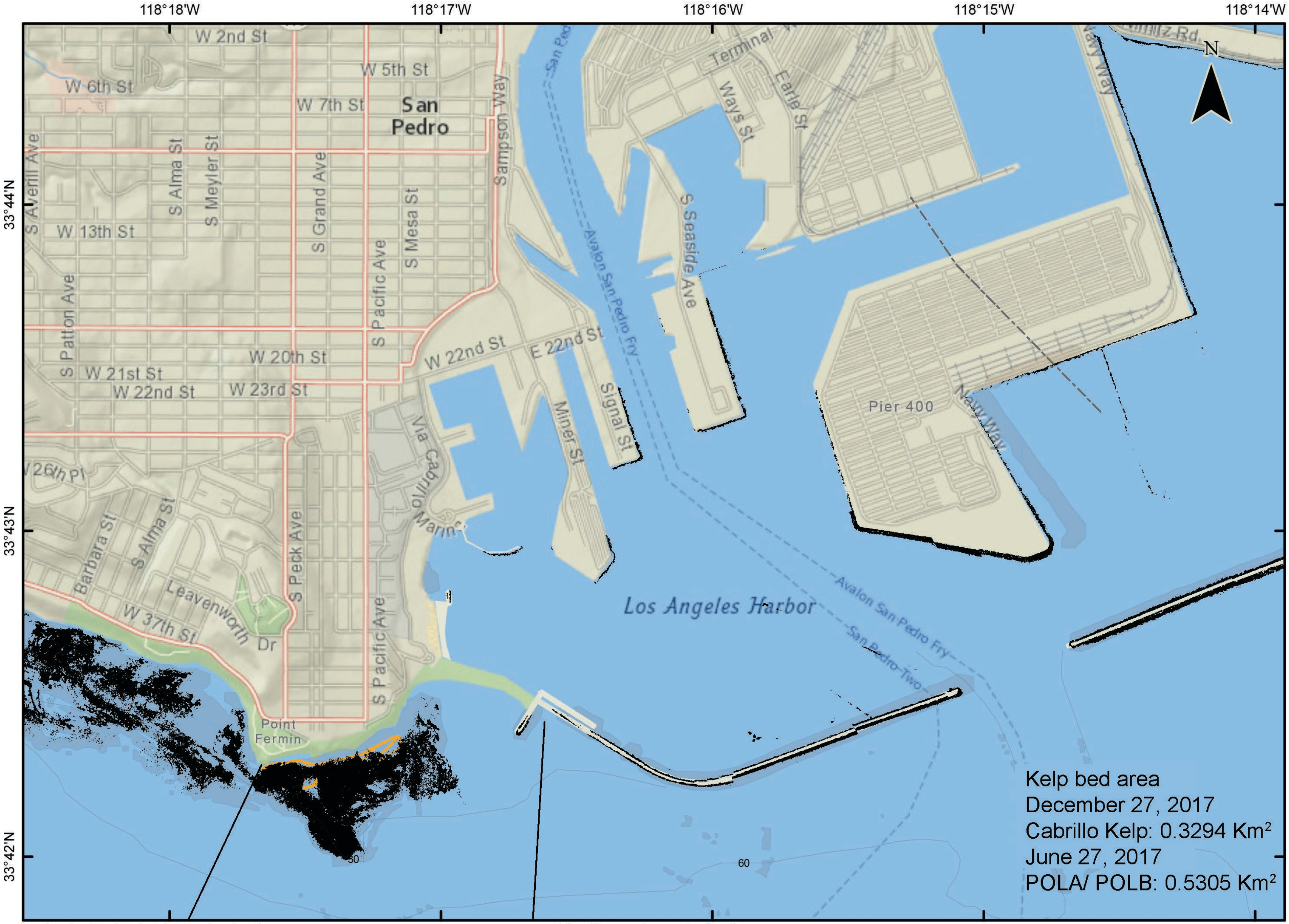
mbc AQUATIC SCIENCES

Kelp 2017	Depth contours in feet	Urchin Barrens
Isobath	Artificial Reef	2013 extent (observed)
Kelp Bed Divide	Discharge Structure	2010 extent (mapped)
	Hard Substrate	

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



Appendix A.30
Palos Verdes I (Whites Point)



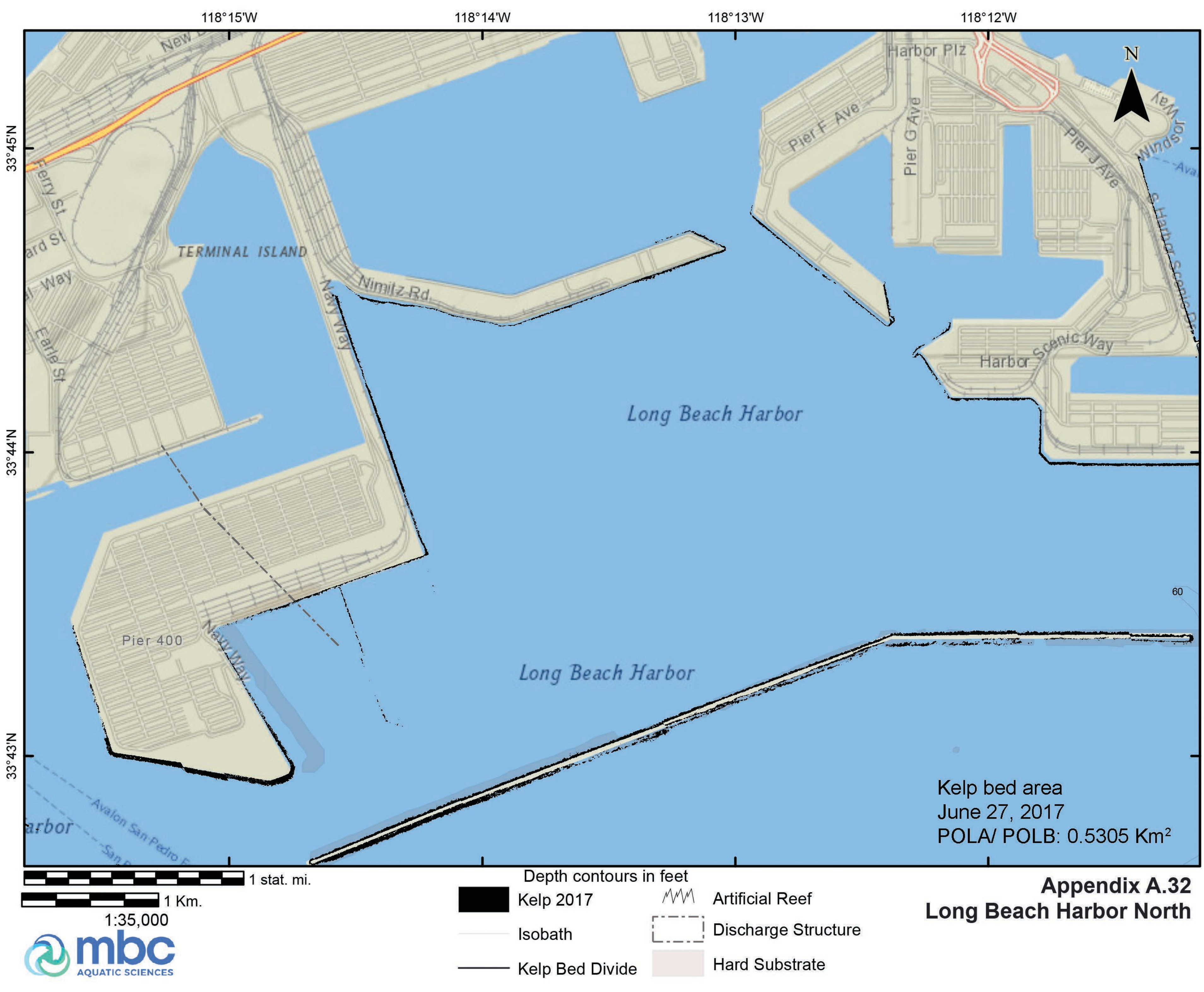
1 stat. mi.
1 Km.
1:35,000

Kelp 2017
Isobath
Kelp Bed Divide

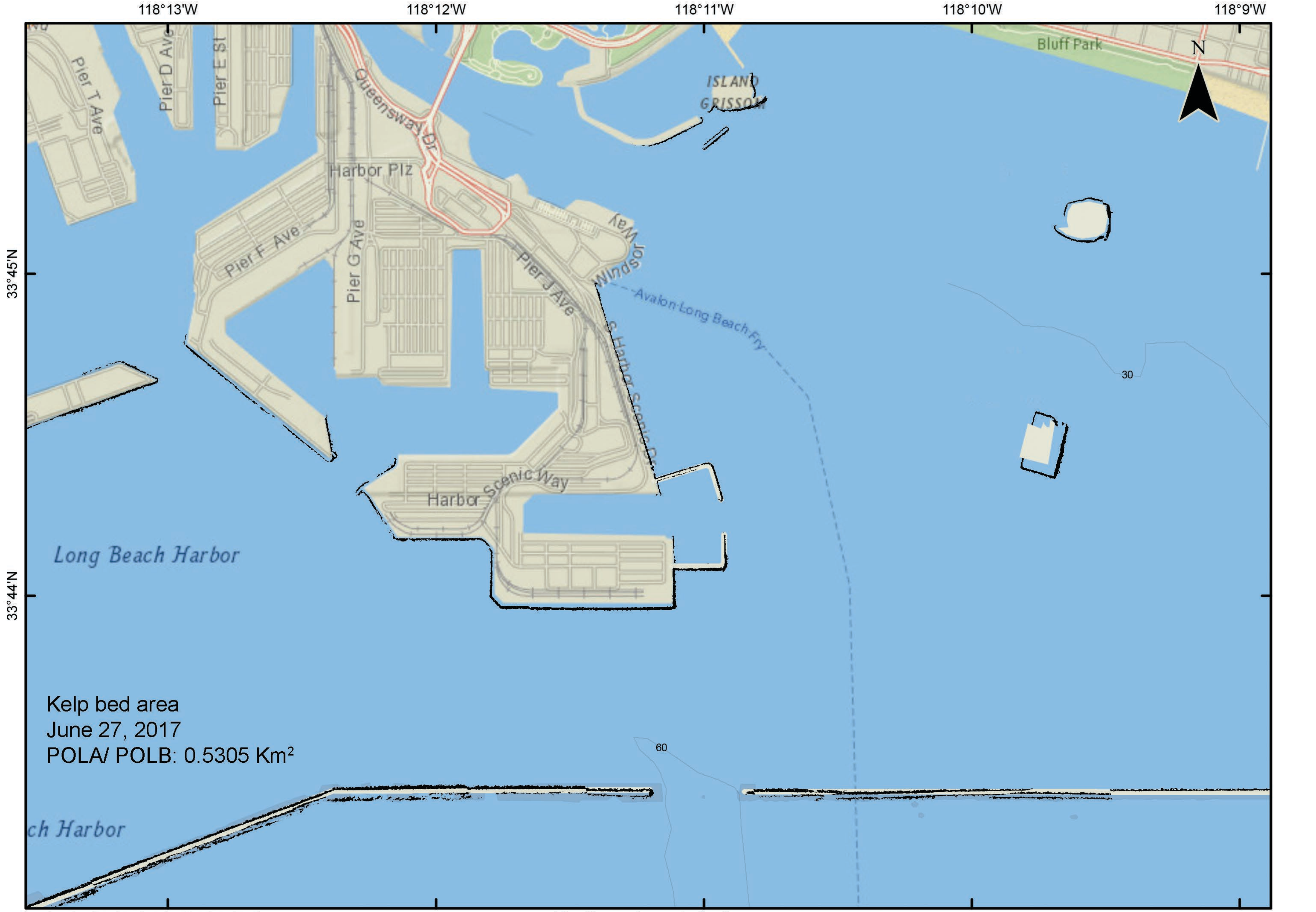
Depth contours in feet
Artificial Reef
Discharge Structure
Hard Substrate

Urchin Barrens
2013 extent (observed)
2010 extent (mapped)

Appendix A.31
Cabrillo Kelp/ POLA



Appendix A.32
Long Beach Harbor North



1 stat. mi.

1 Km.

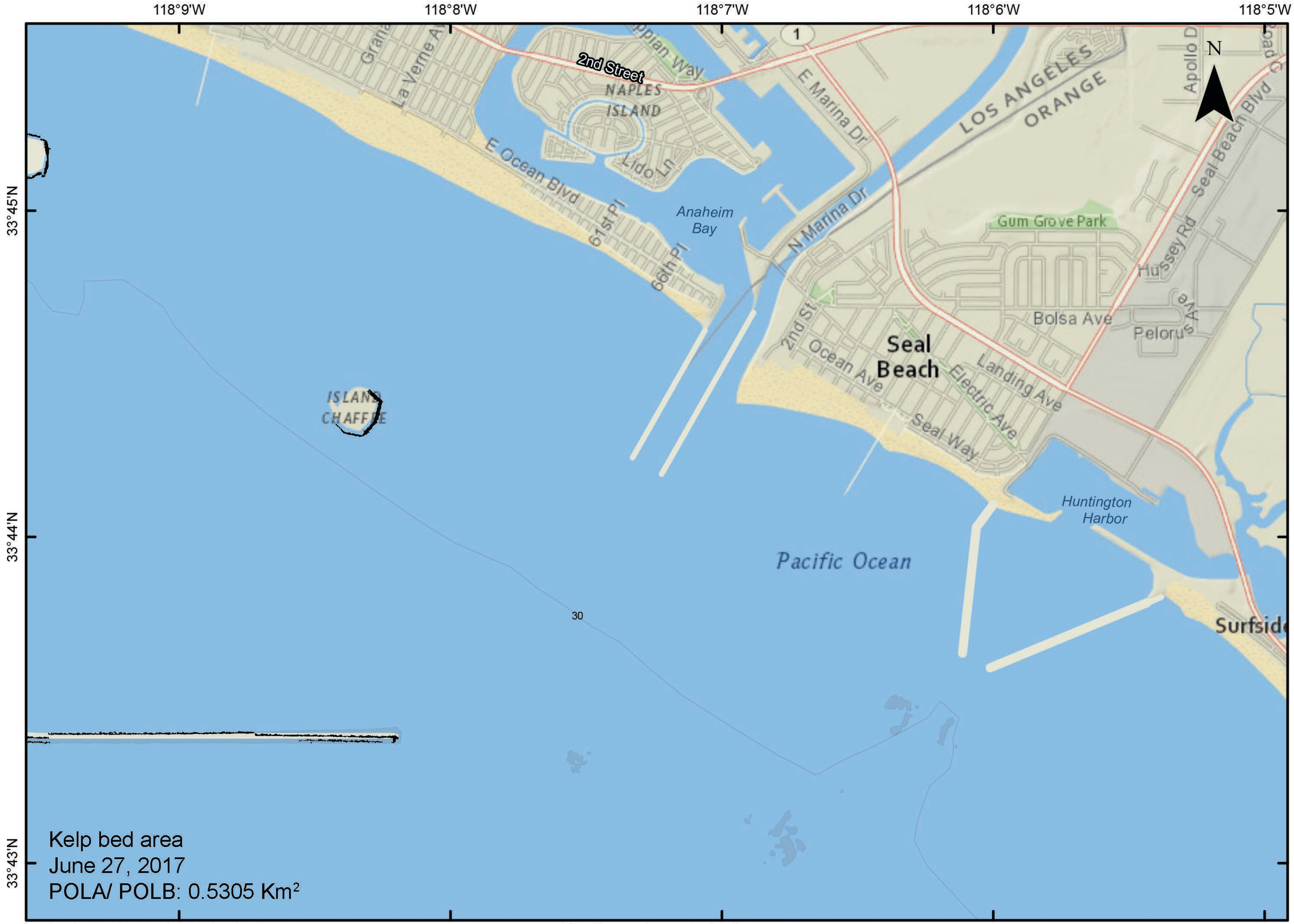
1:35,000

mbc AQUATIC SCIENCES

Depth contours in feet

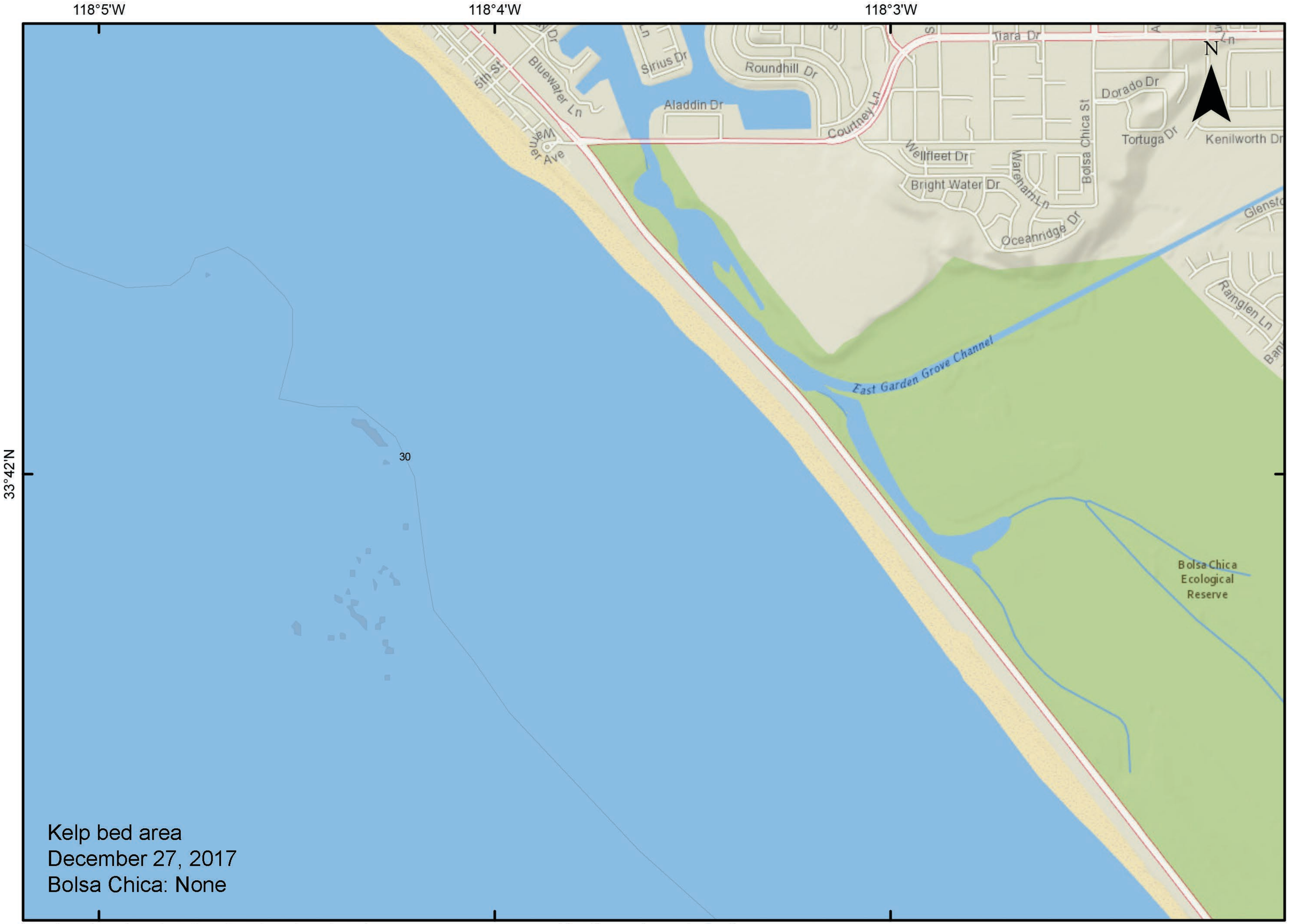
Kelp 2017	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

Appendix A.33
Long Beach Harbor Center



mbc AQUATIC SCIENCES

Appendix A.34
Long Beach Harbor South



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

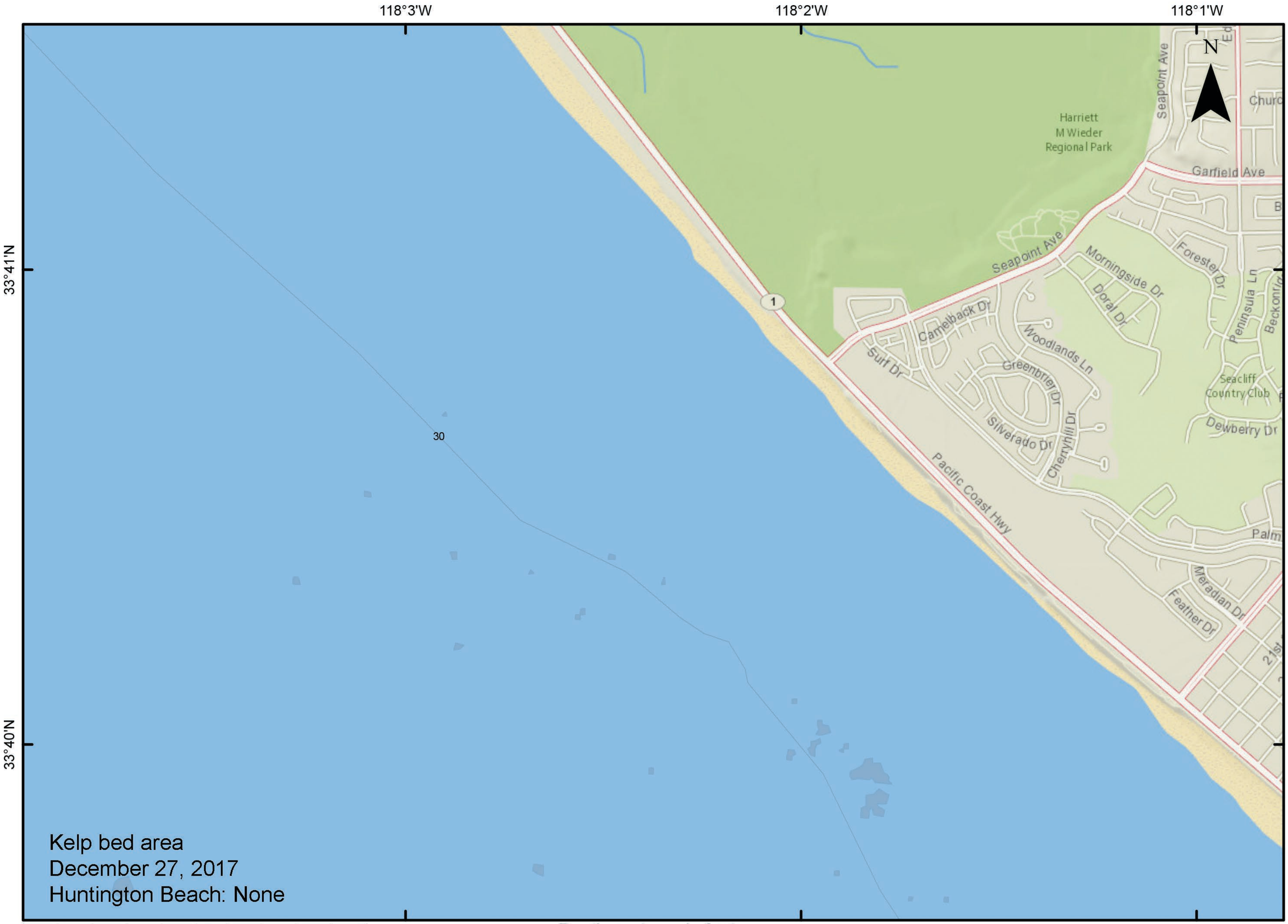
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.35
Bolsa Chica



1 stat. mi.

1 Km.

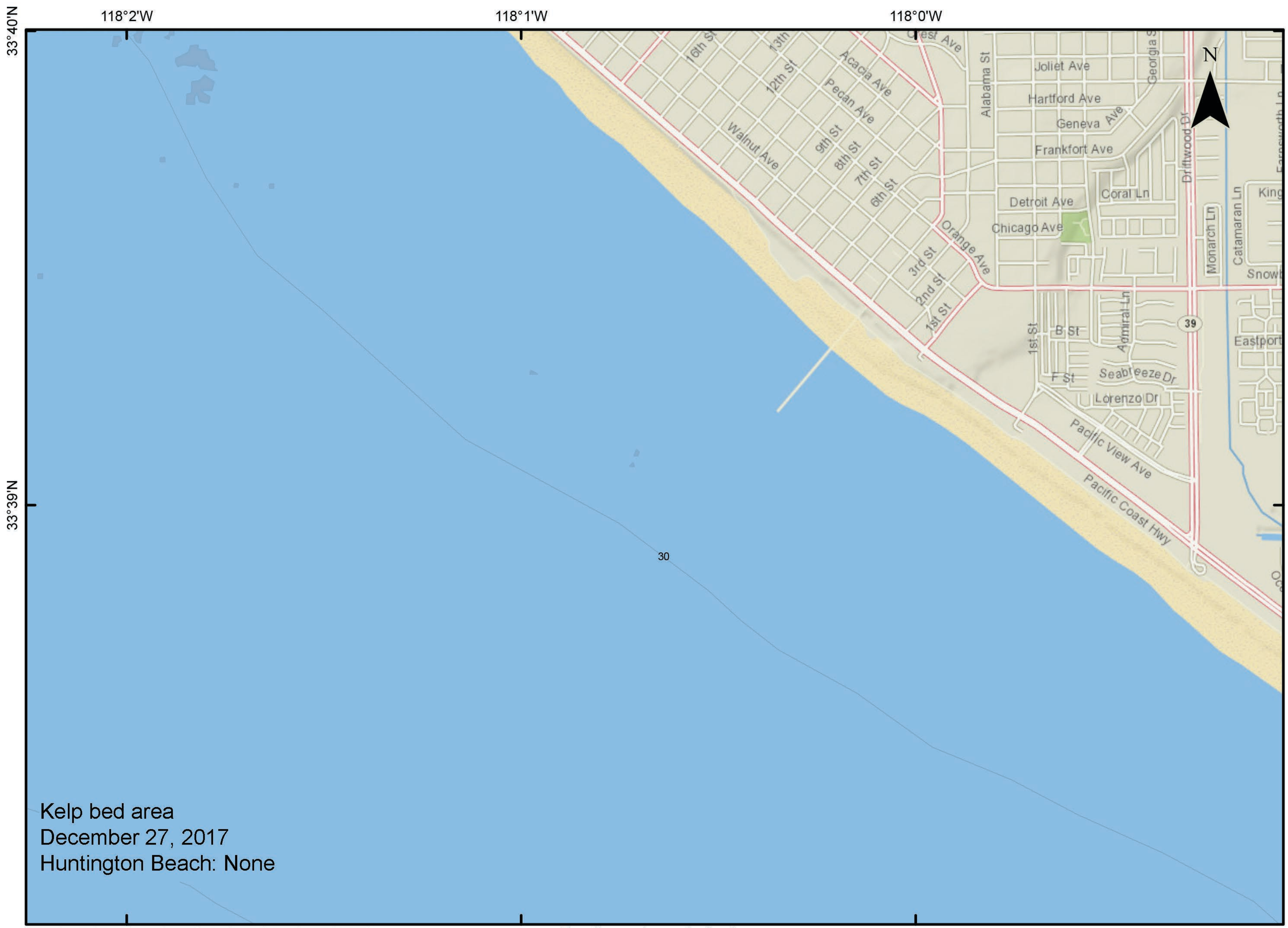
1:24,000

Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.36
Huntington Beach



1 stat. mi.

1 Km.

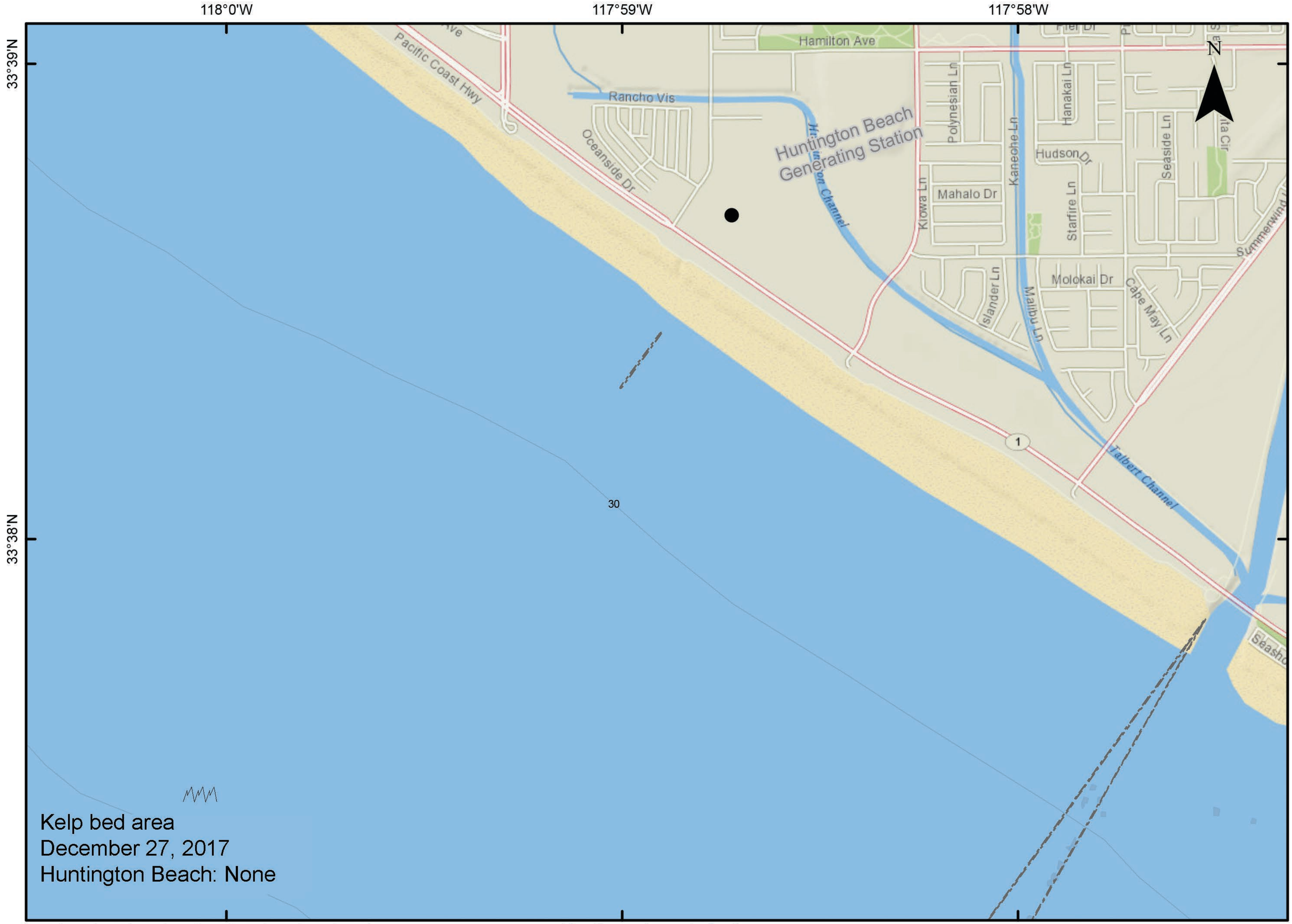
1:24,000

Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.37
Huntington Beach Pier

mbc AQUATIC SCIENCES



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

Kelp Bed Divide

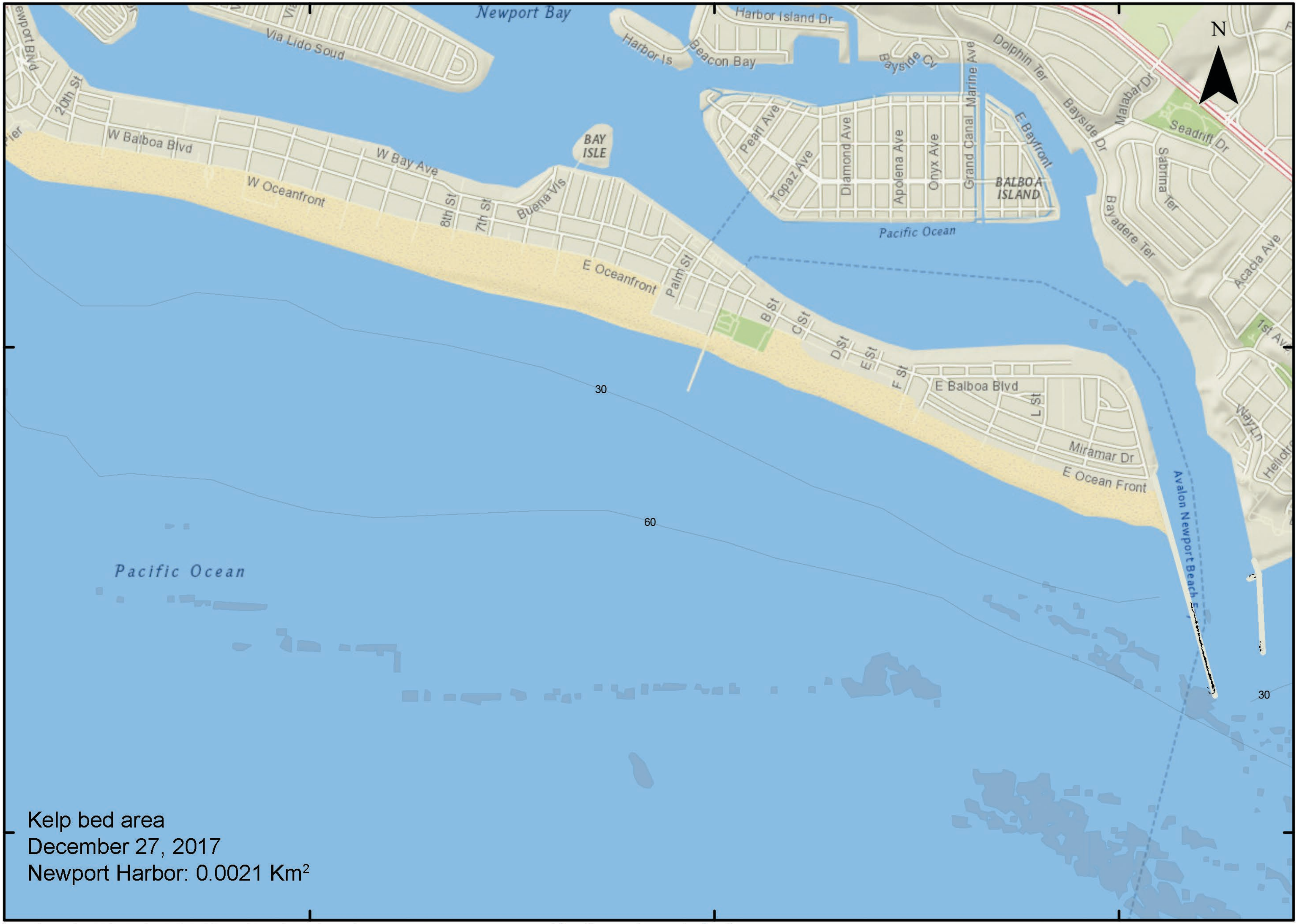
Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.38
Huntington Beach Generating Station

Appendix A.39
Newport Beach

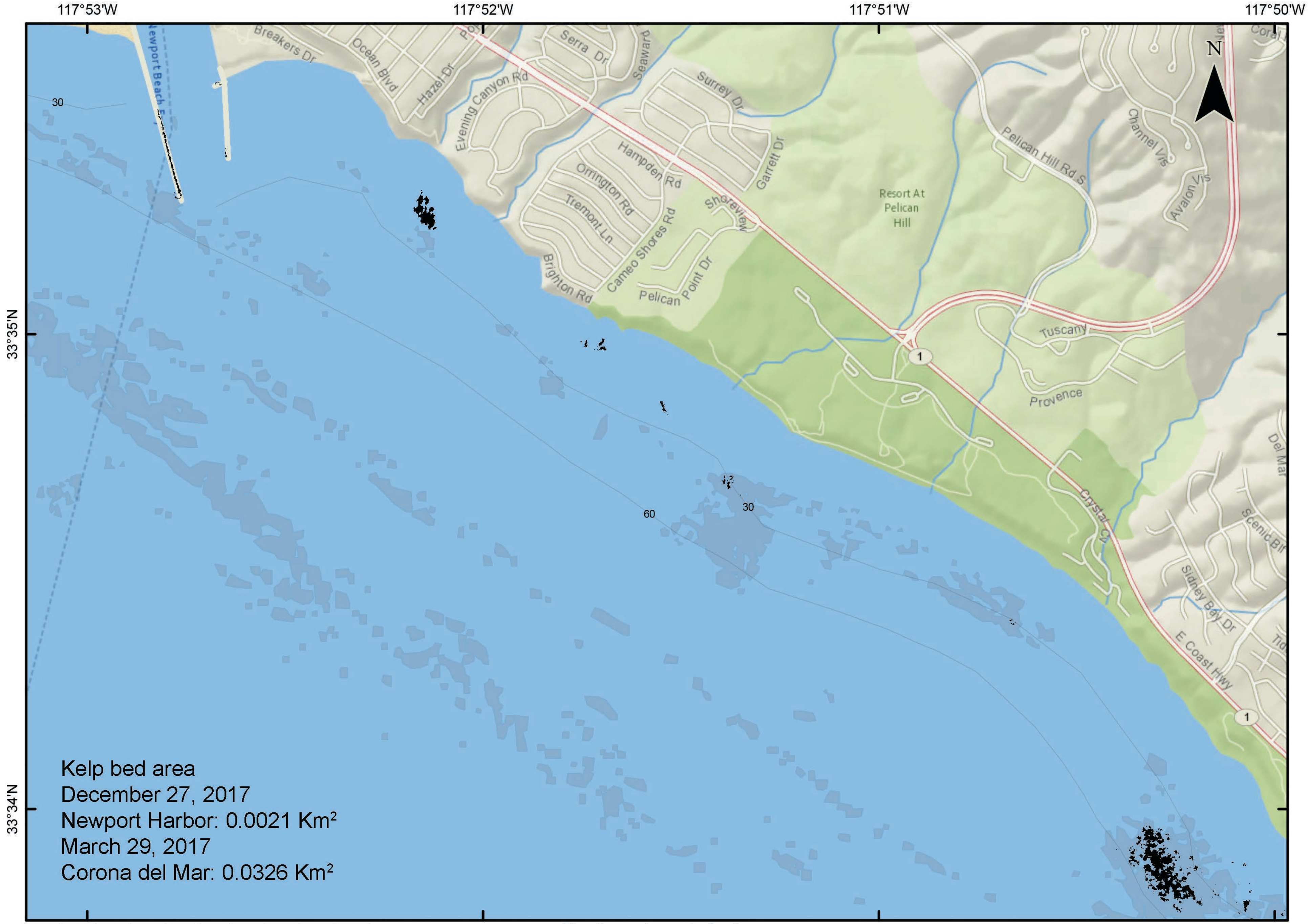


Kelp bed area
December 27, 2017
Newport Harbor: 0.0021 Km^2

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

Depth contours in feet
Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.40
Newport Harbor



1 stat. mi.

1 Km.

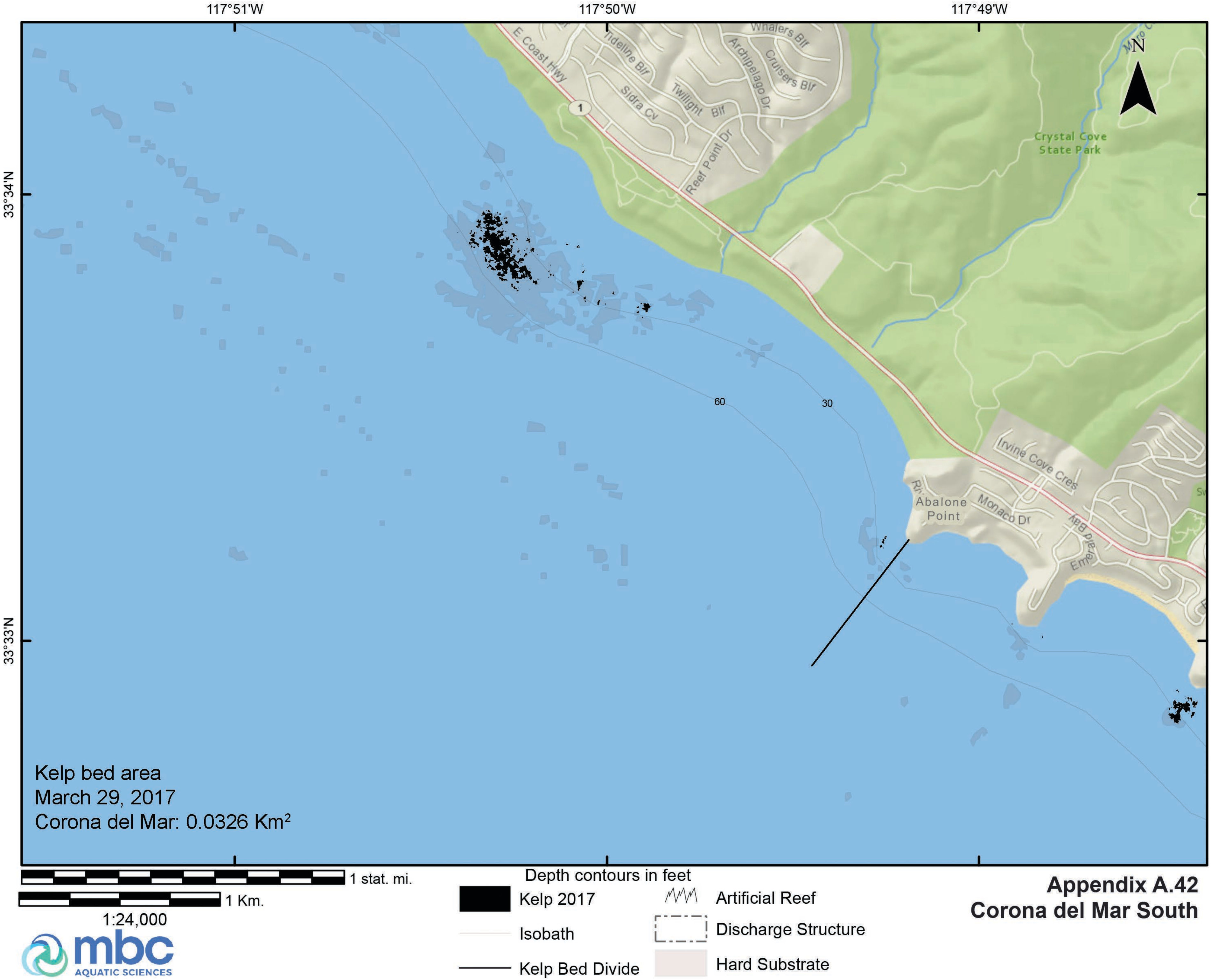
1:24,000

Depth contours in feet

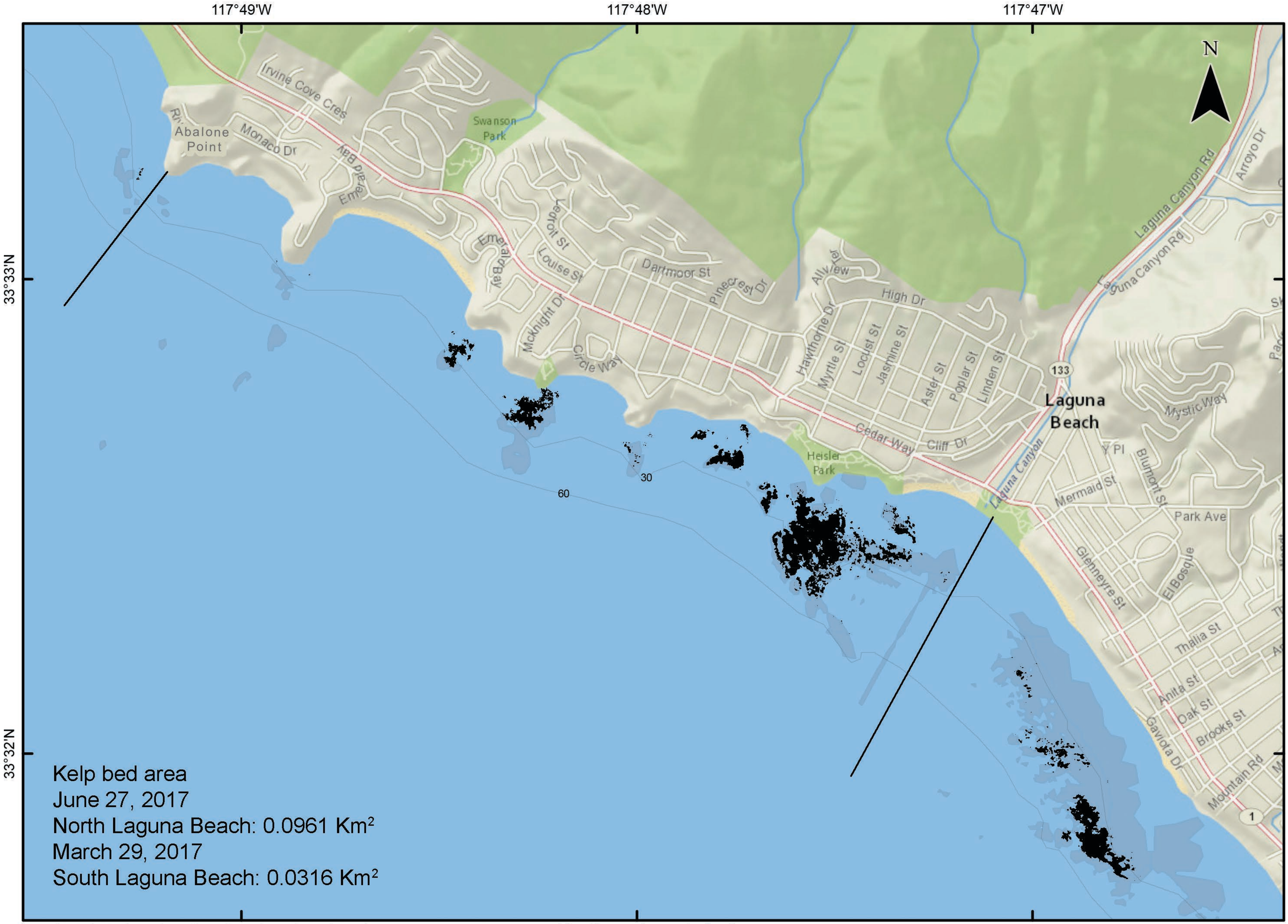
- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.41
Corona del Mar North



Appendix A.42
Corona del Mar South



1 stat. mi.

1 Km.

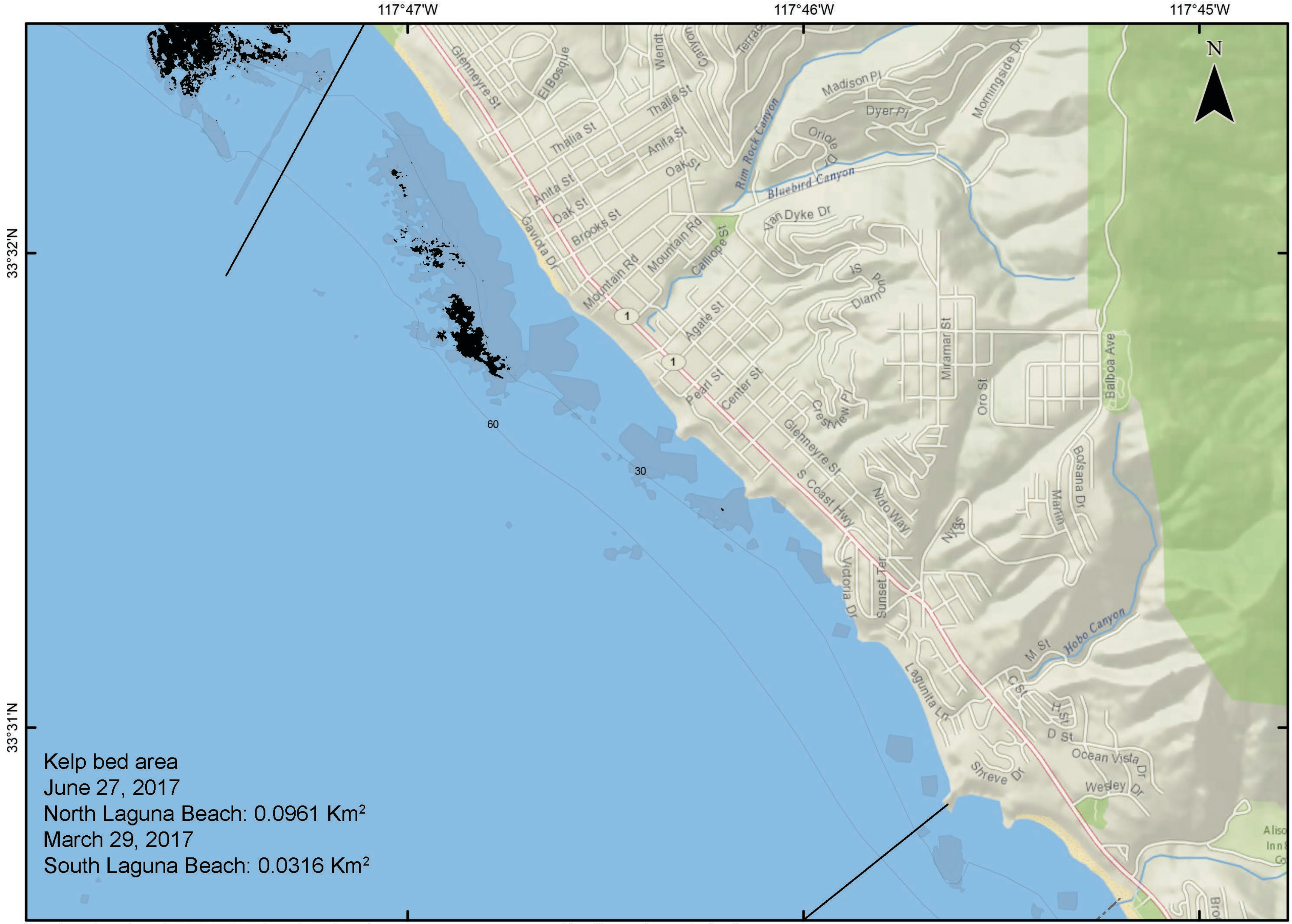
1:24,000

Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.43
Laguna North

MBC Aquatic Sciences



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

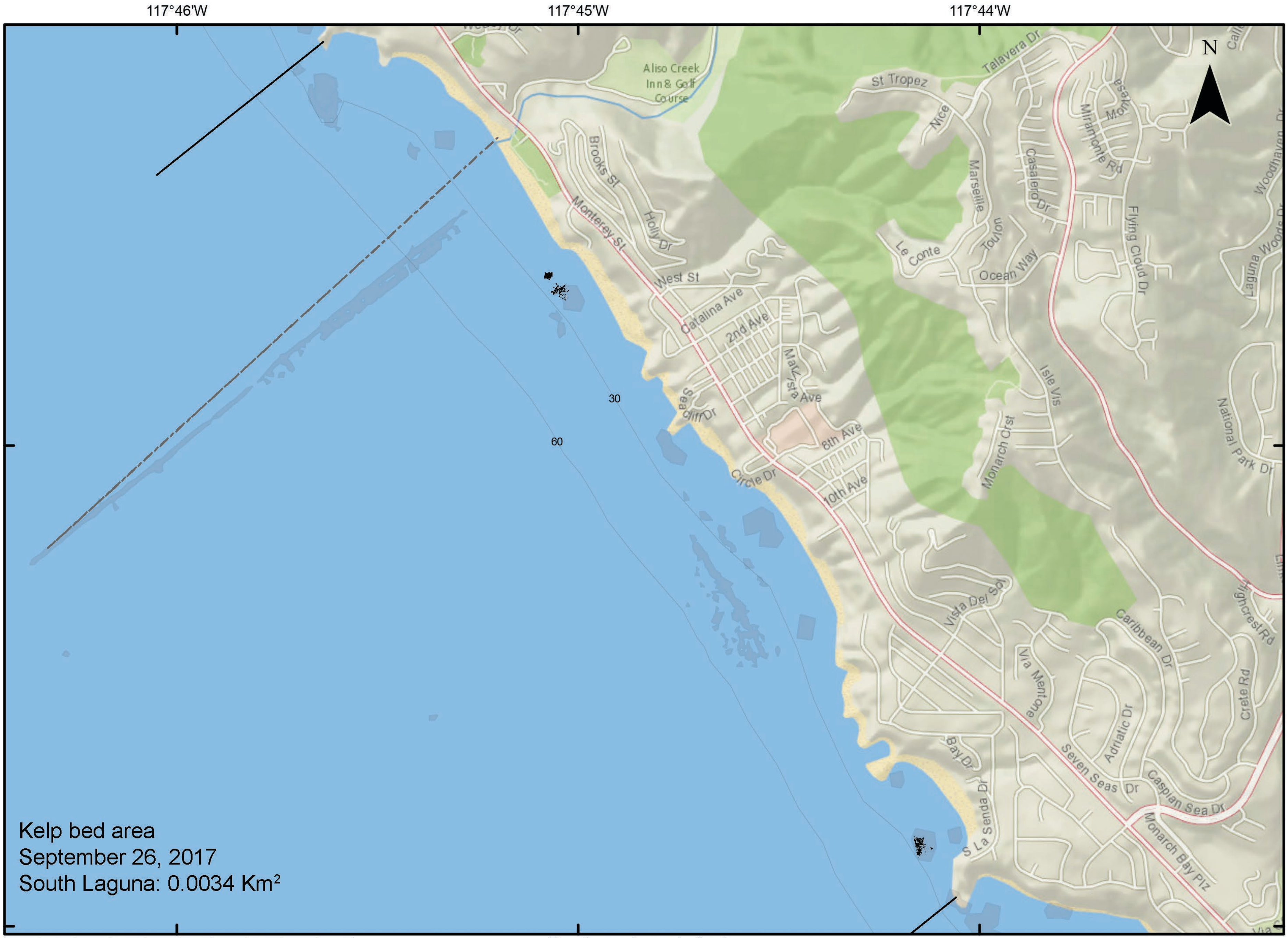
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.44
Laguna South



1 stat. mi.

1 Km.

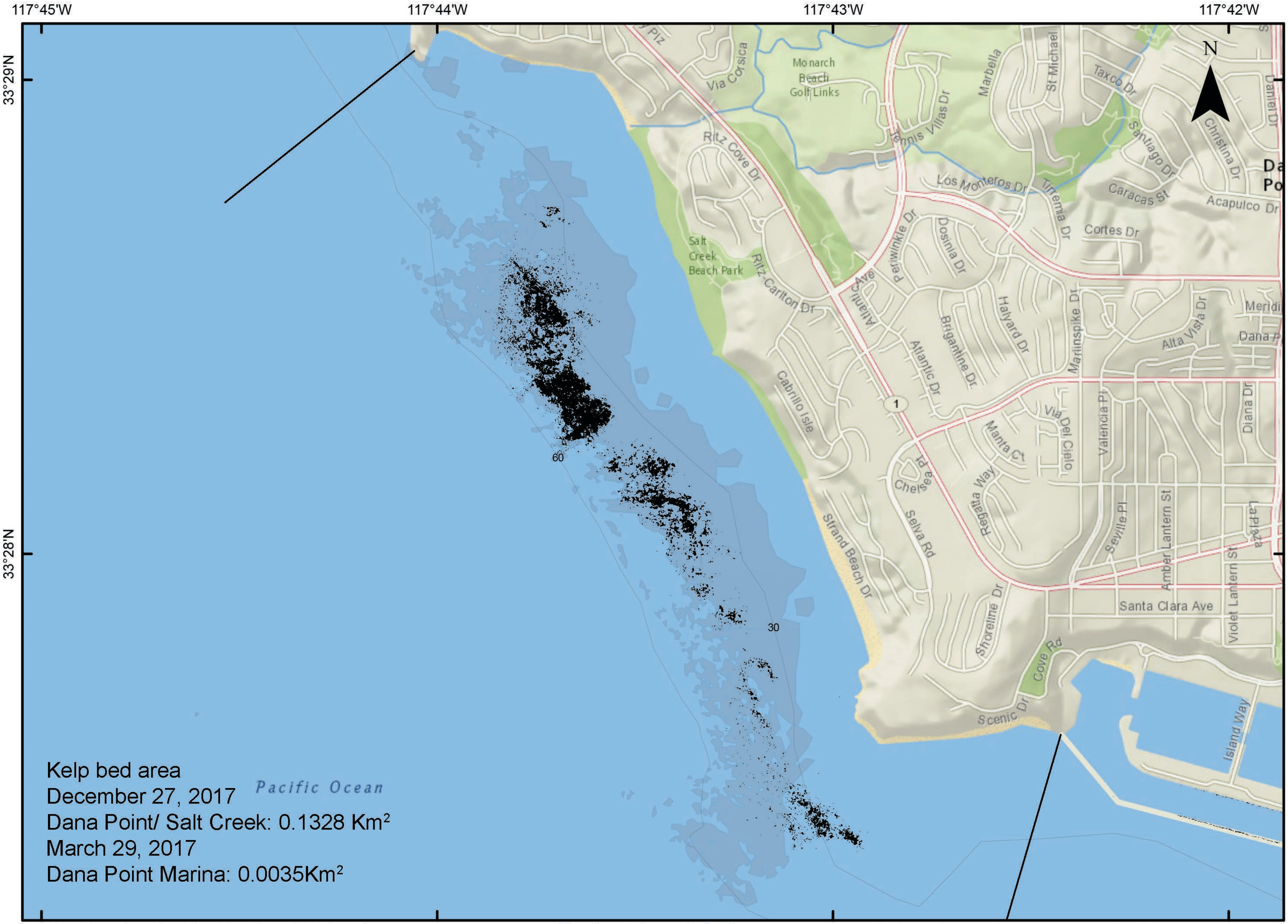
1:24,000

mbc AQUATIC SCIENCES

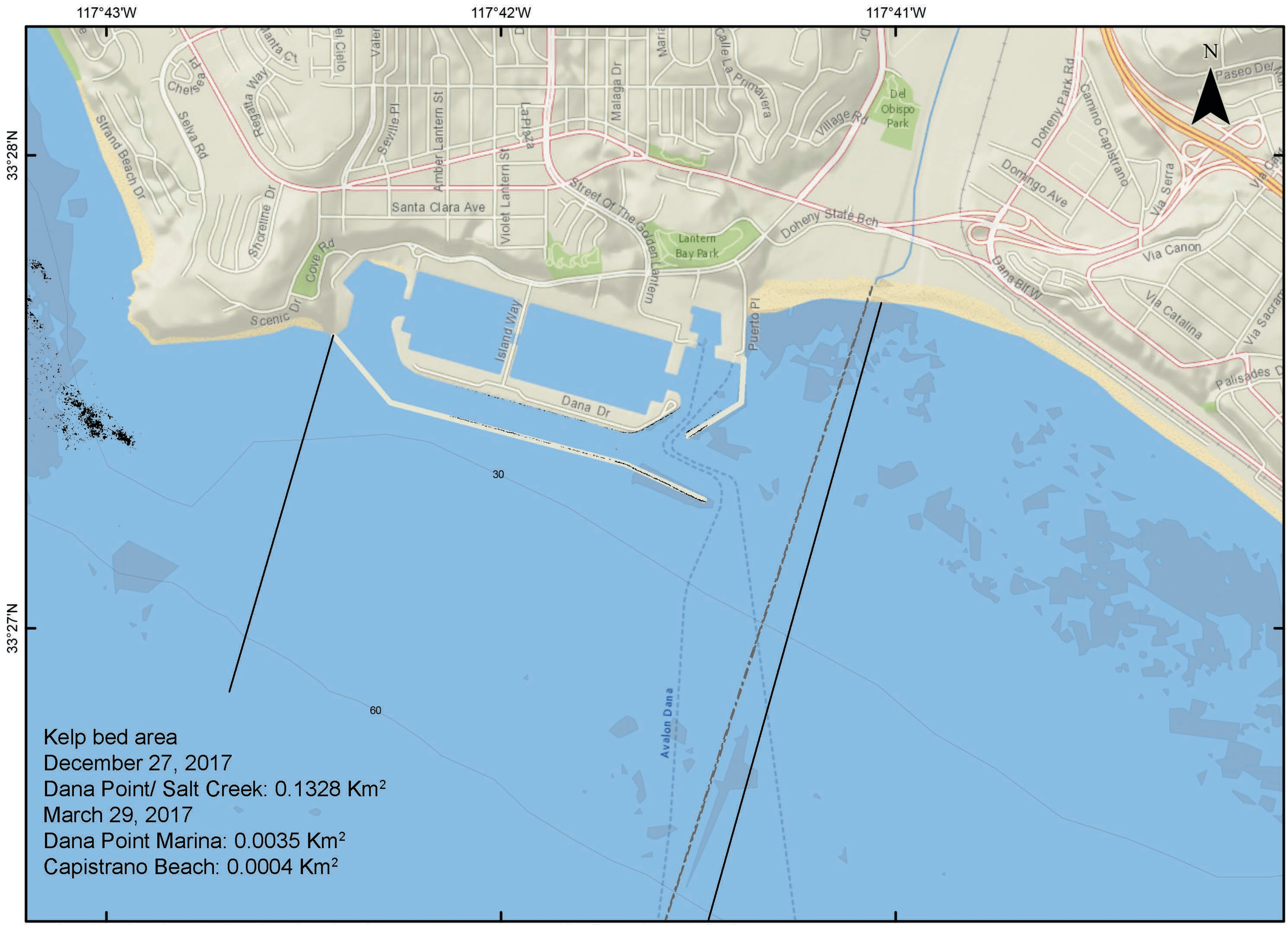
Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.45
Laguna South



Appendix A.46
Dana Point/Salt Creek



1 stat. mi.

1 Km.

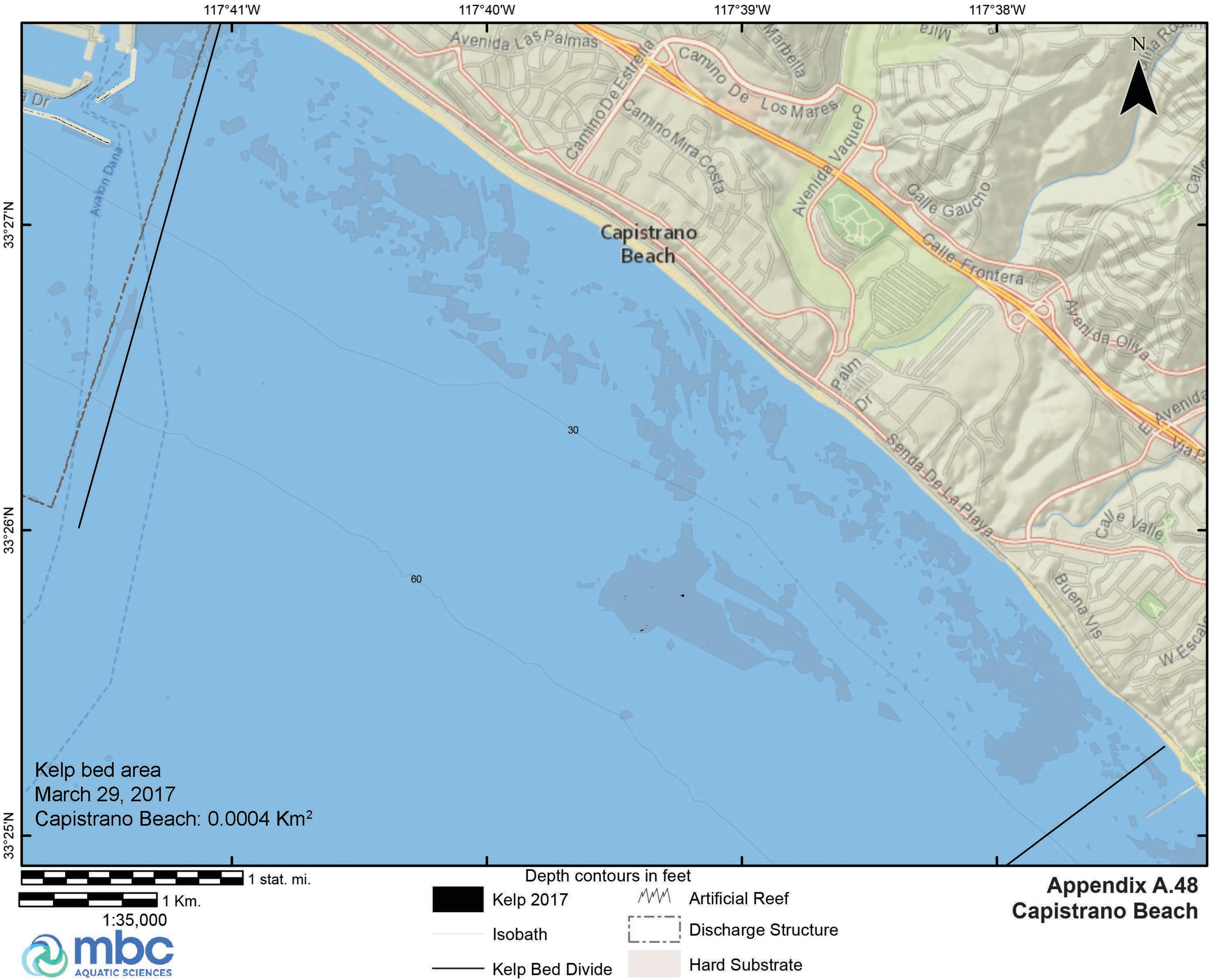
1:24,000

Depth contours in feet

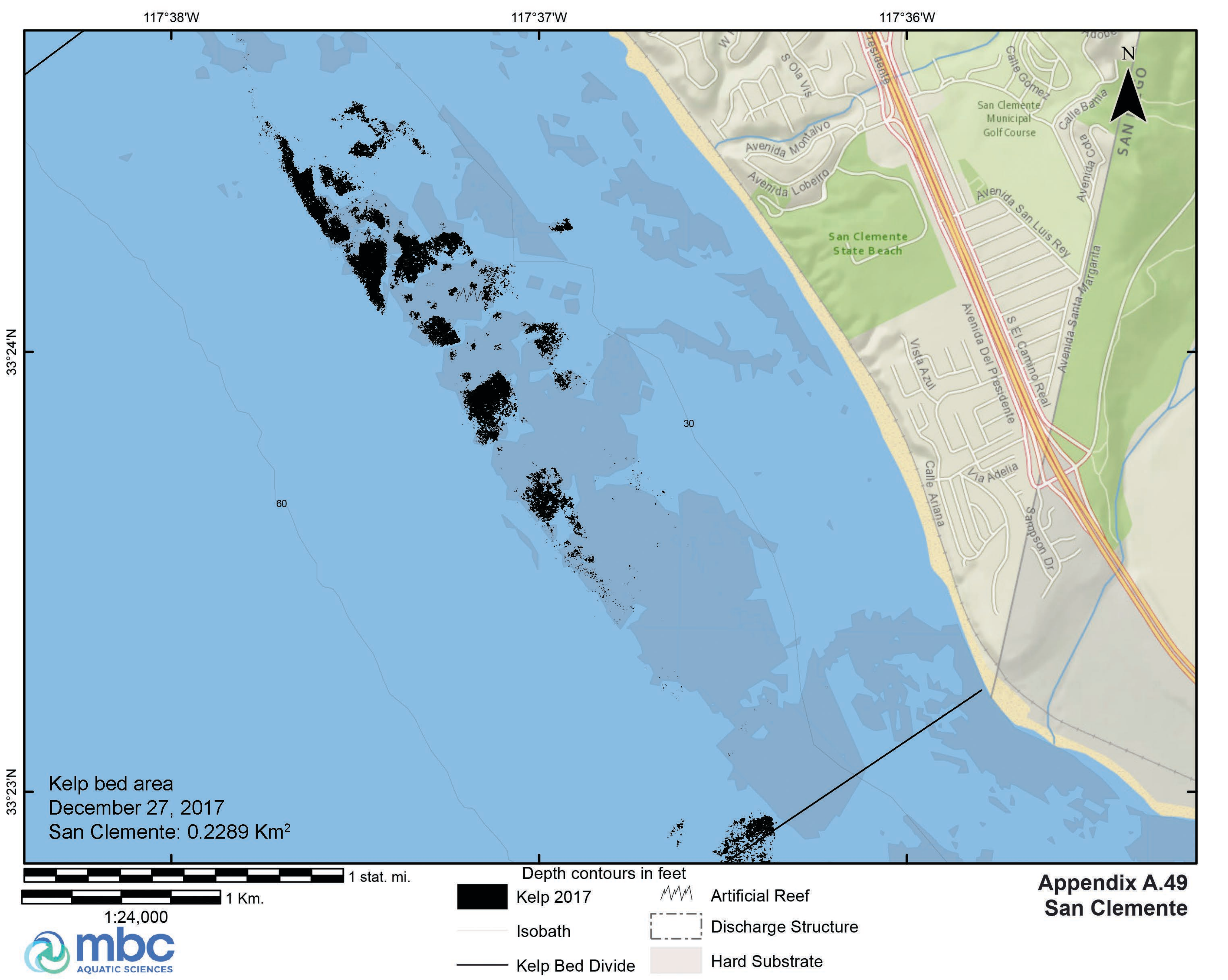
- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

mbc AQUATIC SCIENCES

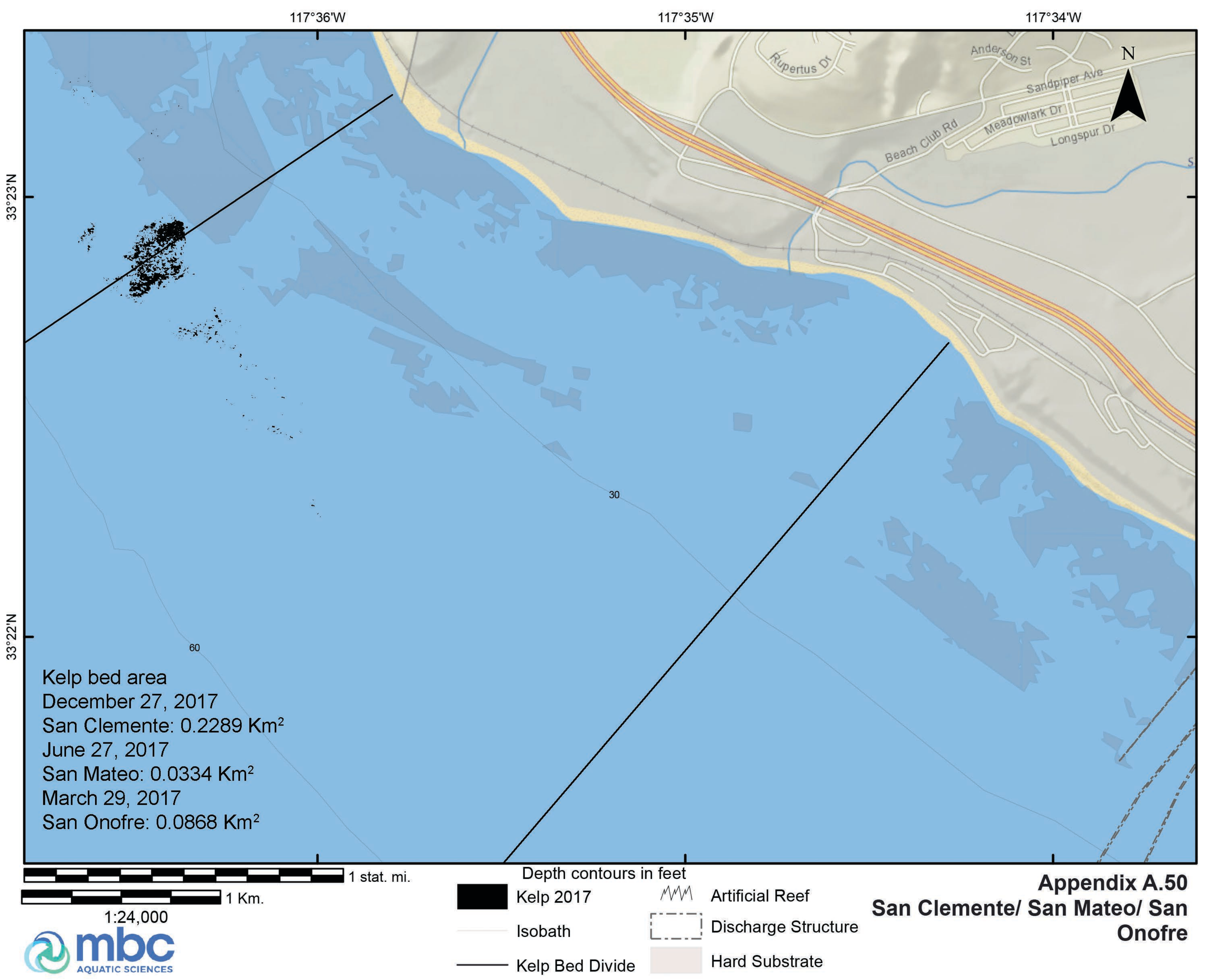
Appendix A.47
Salt Creek/ Dana Point Marina/ Capistrano Beach



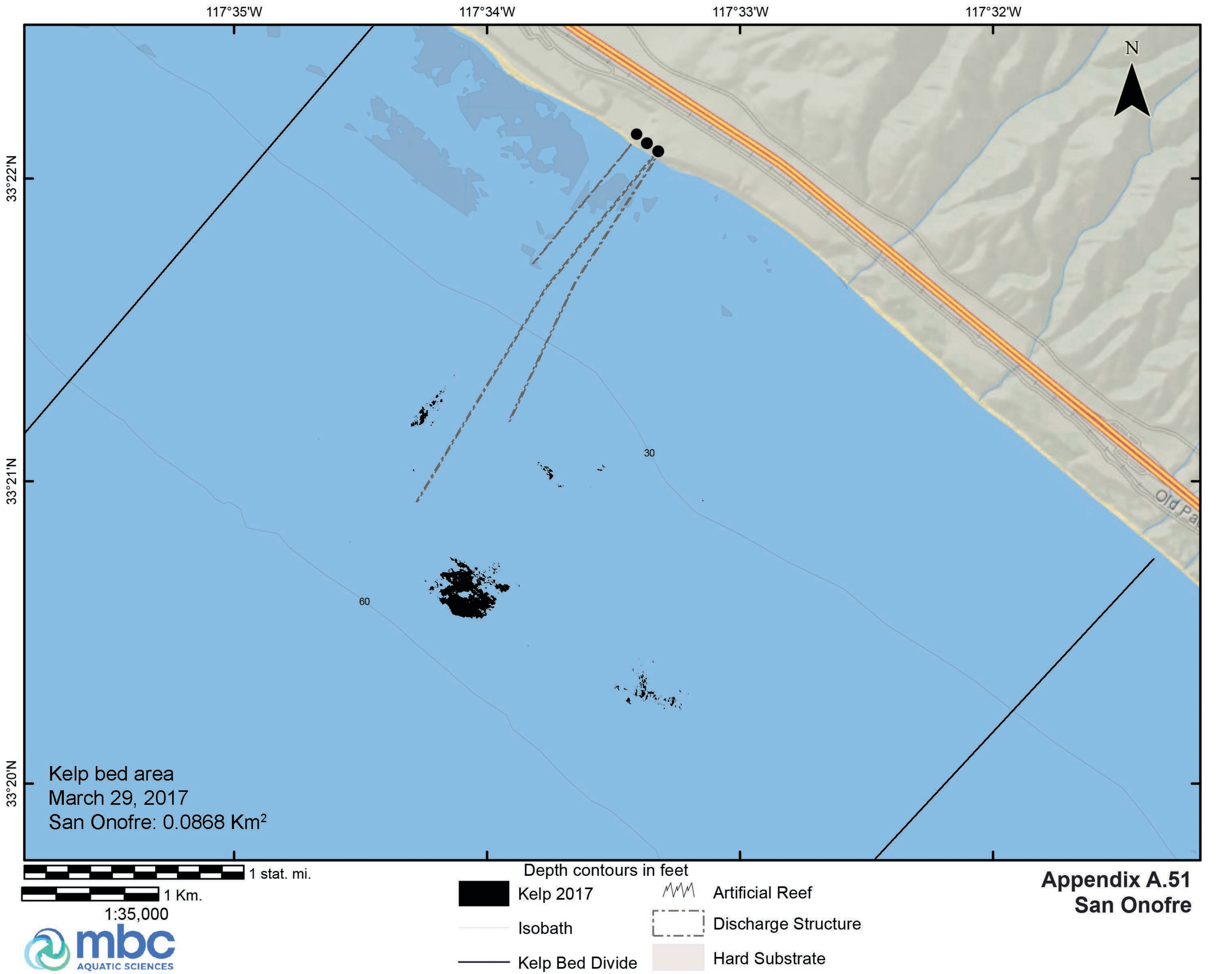
Appendix A.48
Capistrano Beach



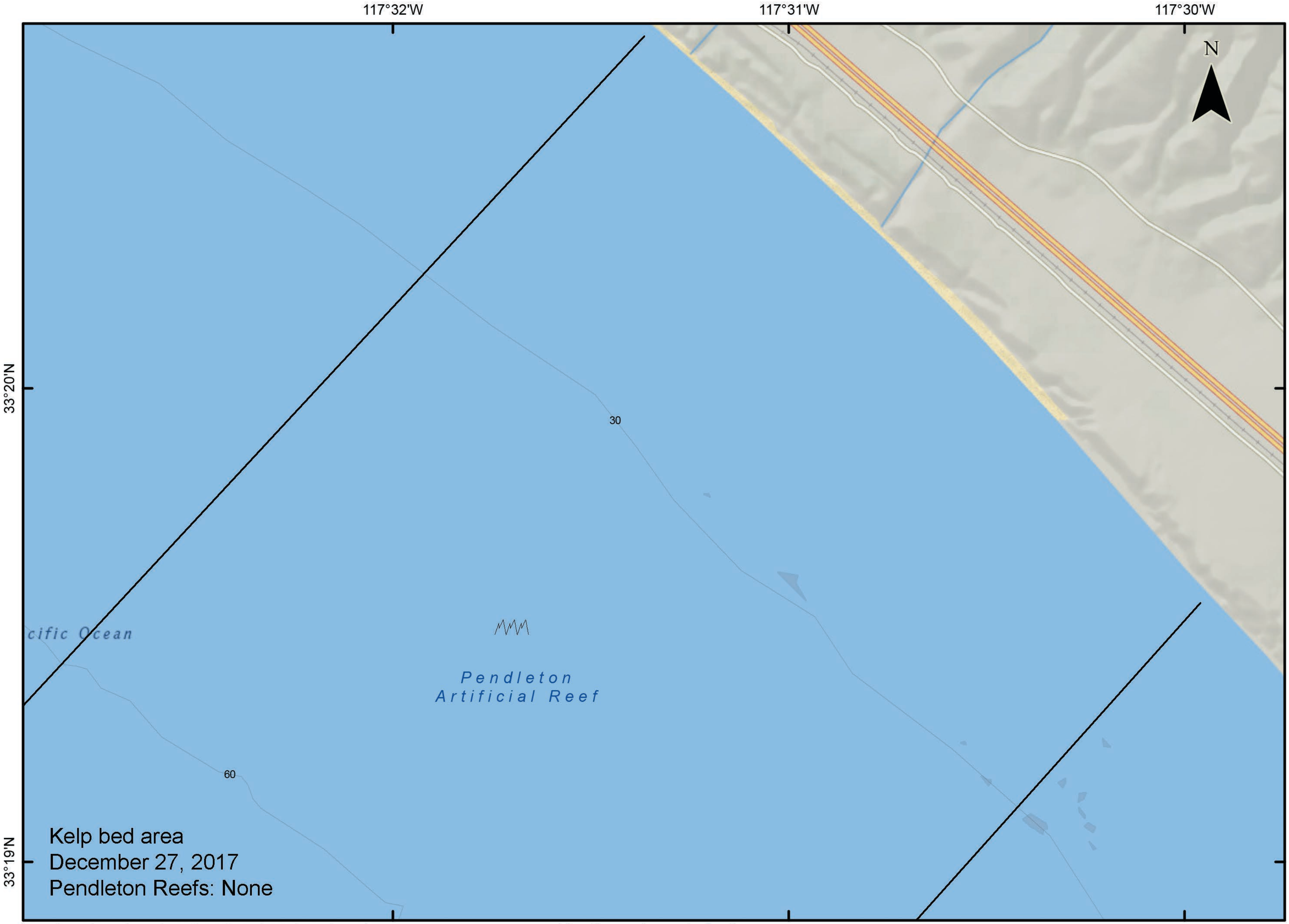
Appendix A.49
San Clemente



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



Appendix A.51
San Onofre

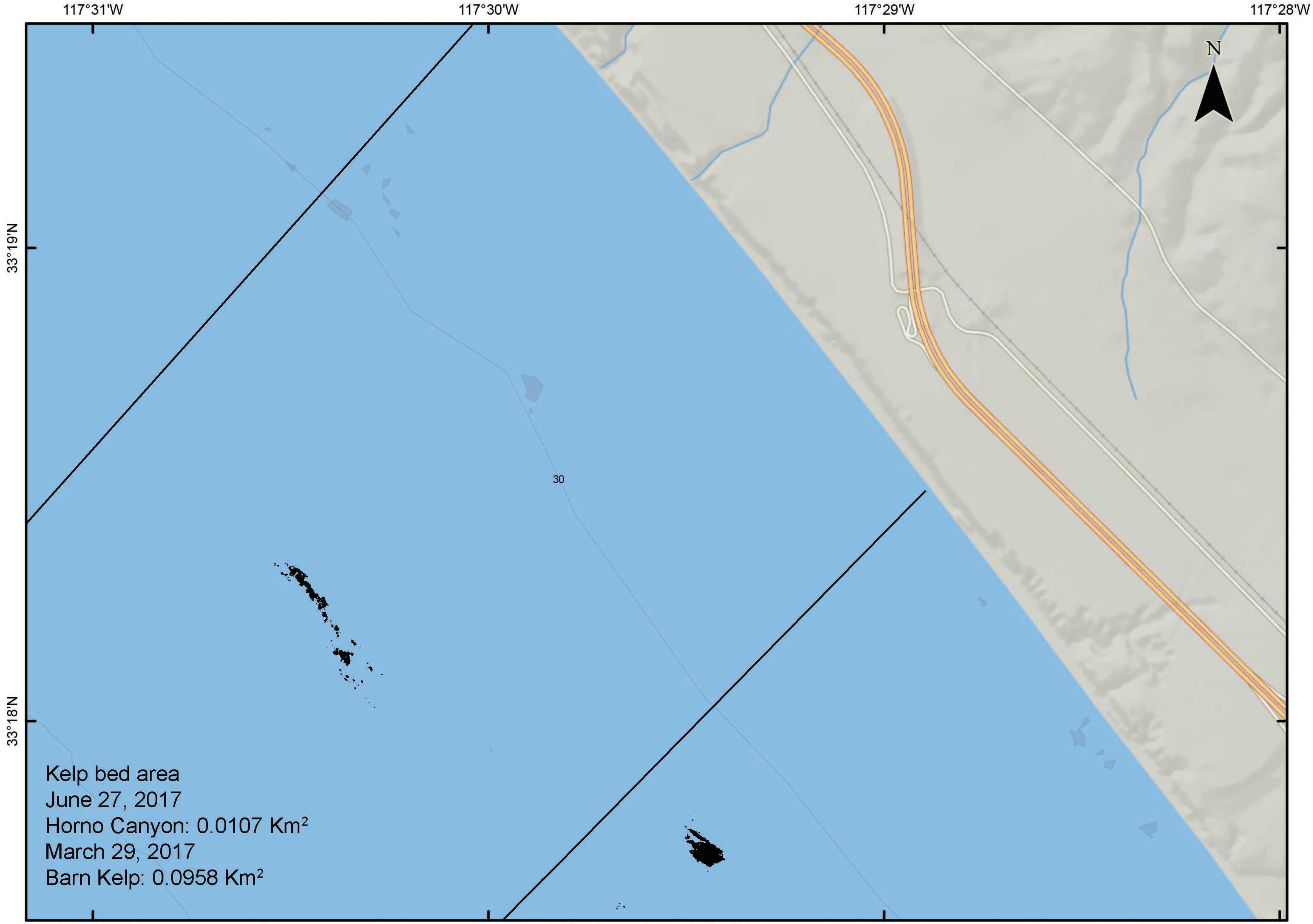


1 stat. mi.
1 Km.
1:24,000

Depth contours in feet
Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.52
Pendleton Reef

mbc AQUATIC SCIENCES



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

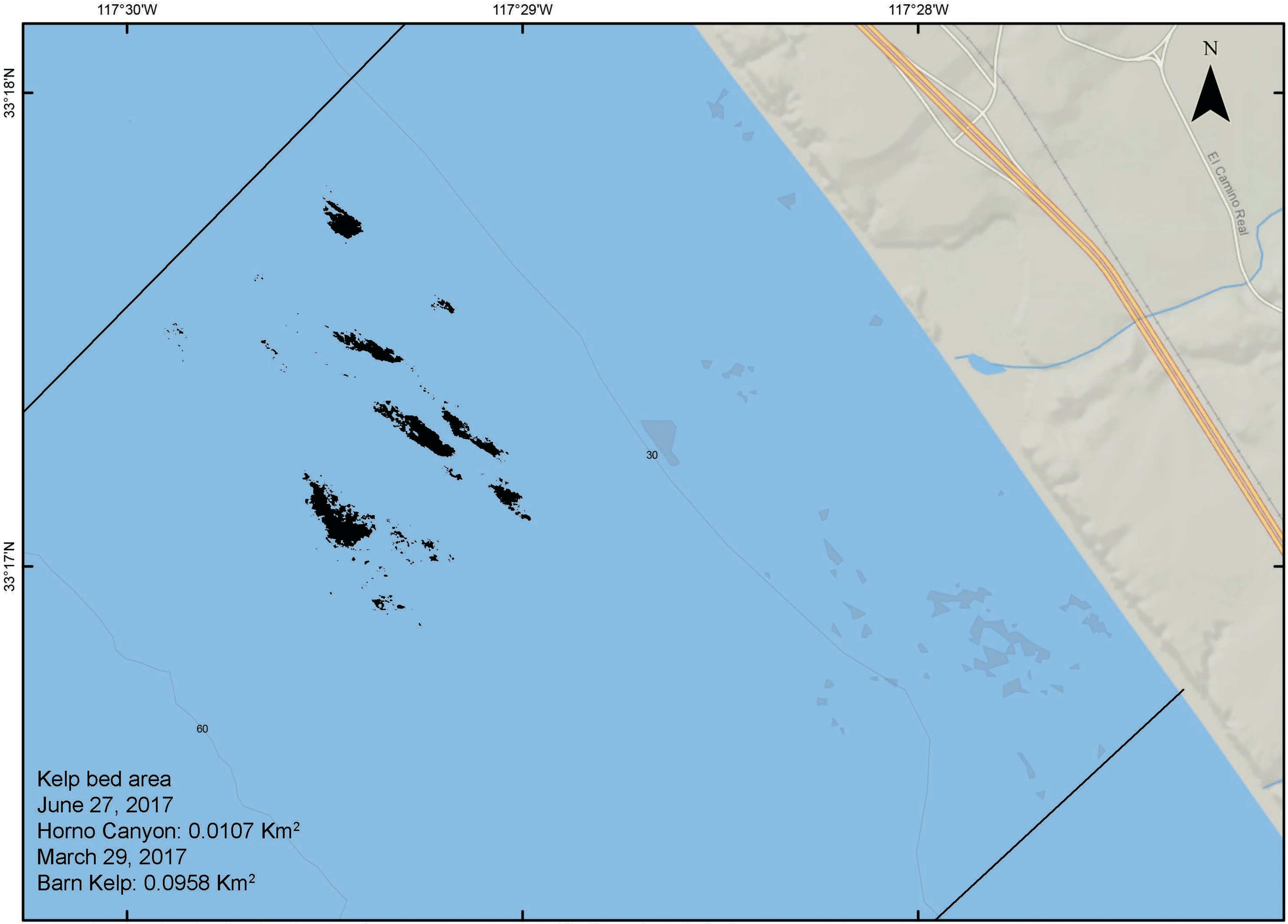
Kelp Bed Divide

Artificial Reef

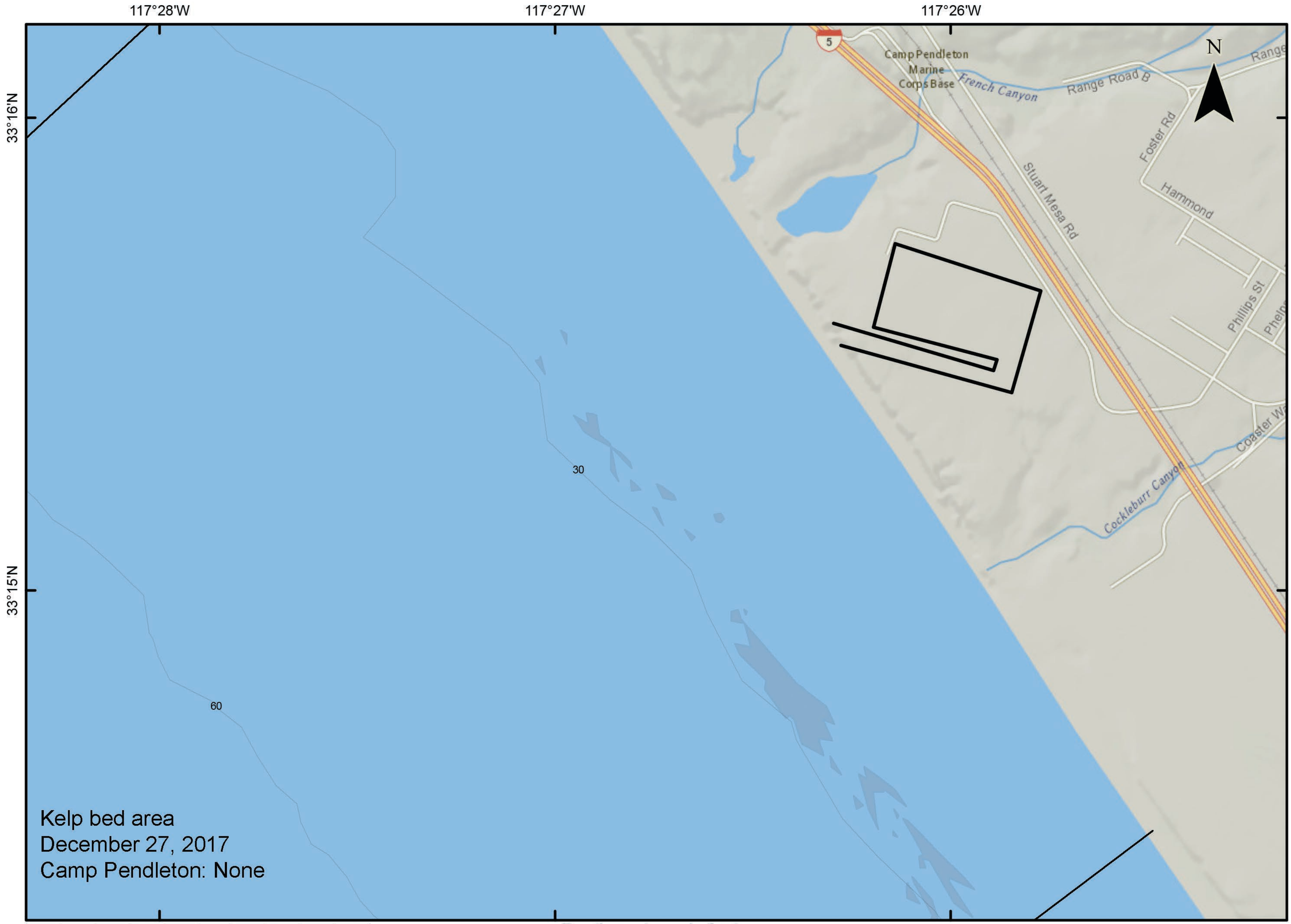
Discharge Structure

Hard Substrate

Appendix A.53
Horno Canyon/ Barn Kelp



Appendix A.54
Horno Canyon/ Barn Kelp



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp 2017

Isobath

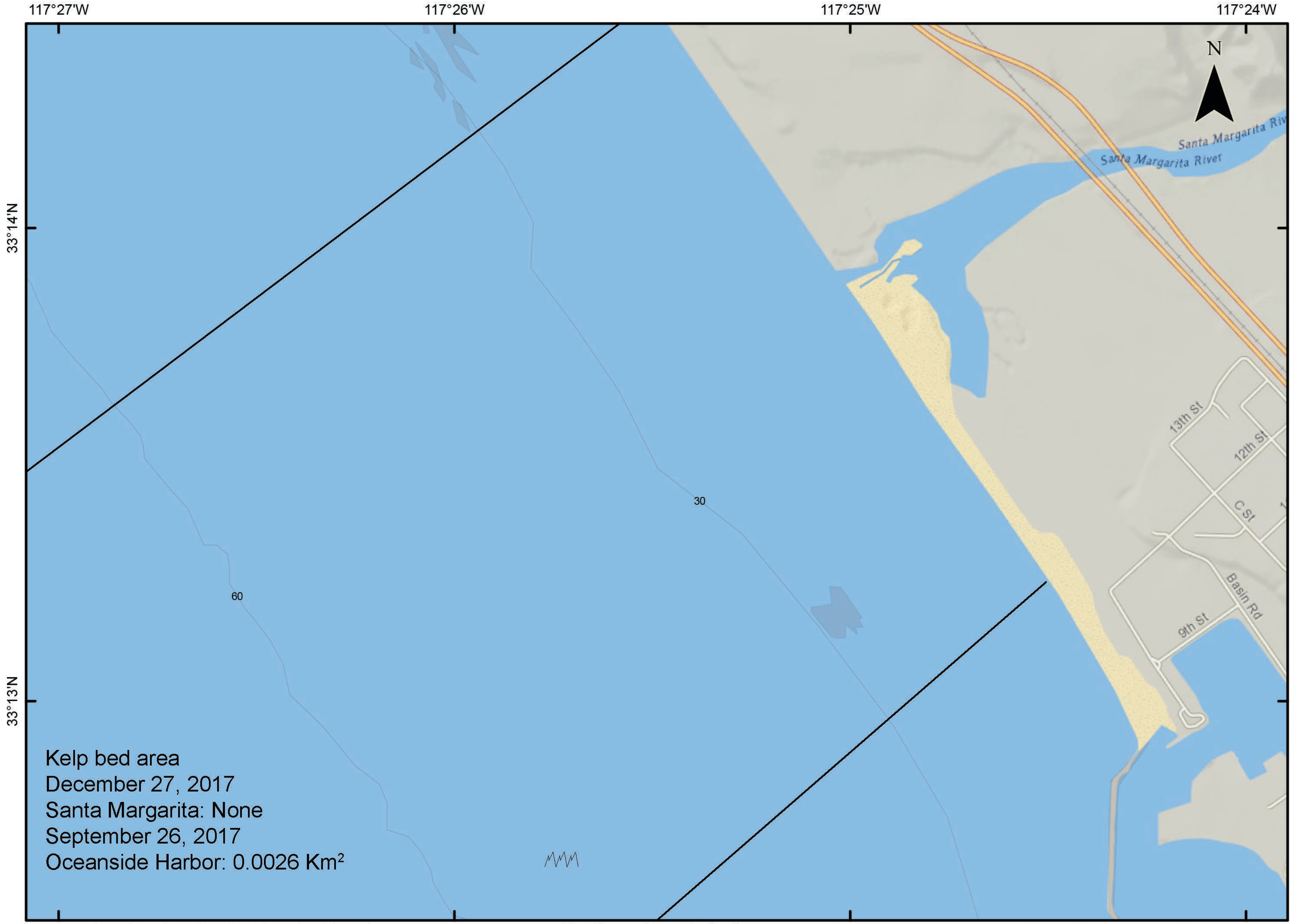
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.55
Camp Pendleton



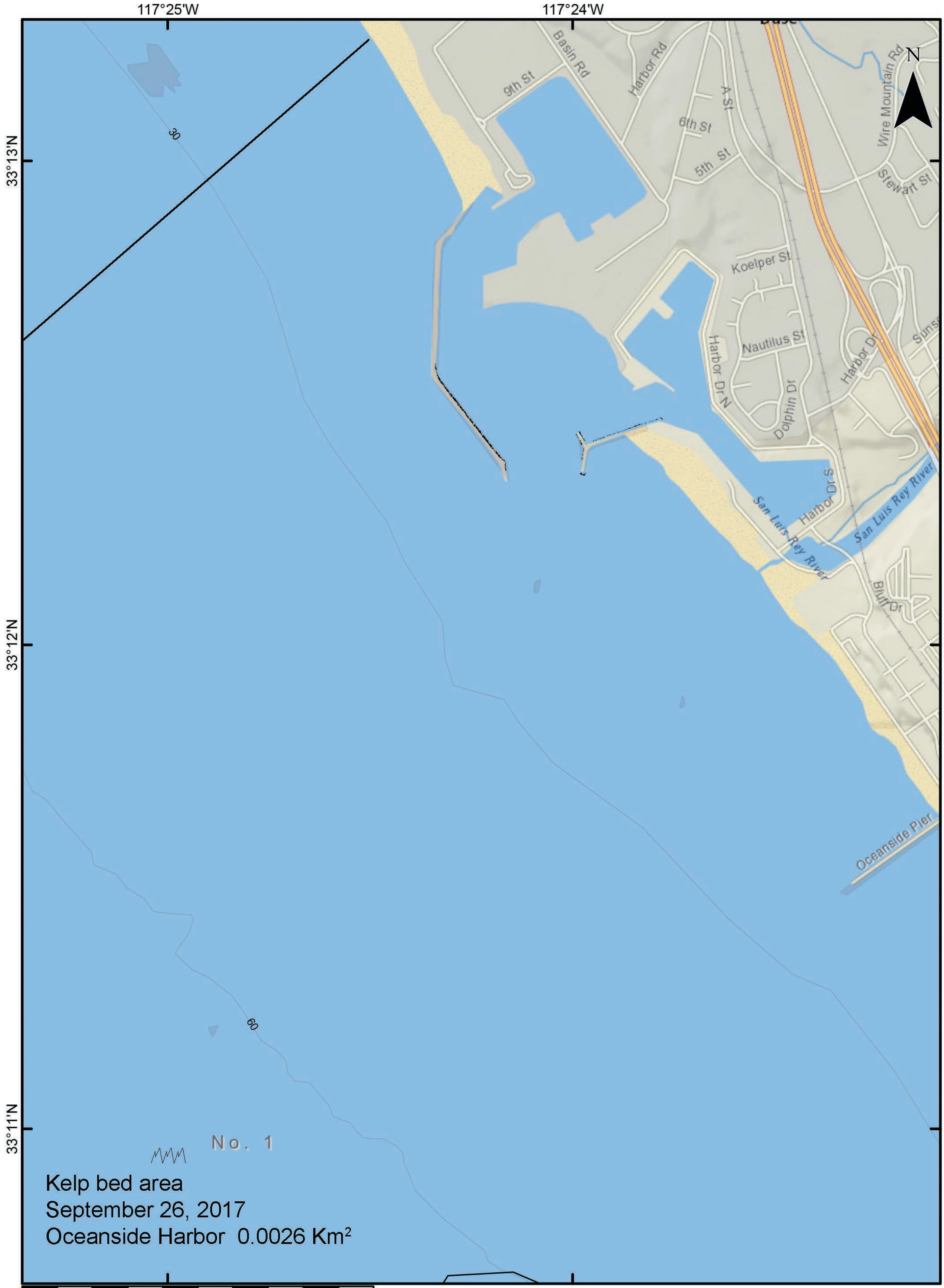
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

Kelp 2017
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.56
Santa Margarita/ Oceanside Harbor



1 stat. mi. Depth contours in feet

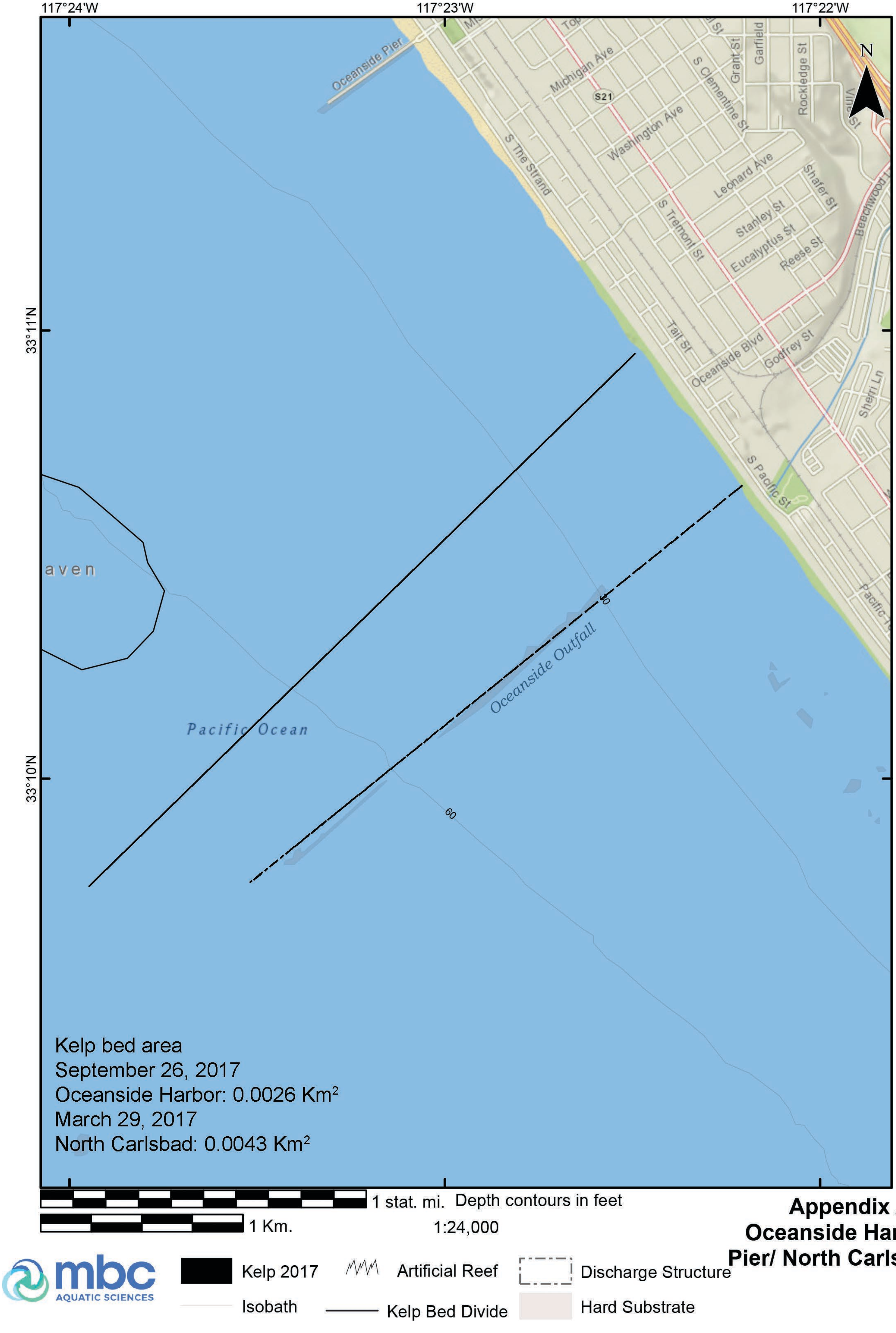
1 Km.

1:24,000

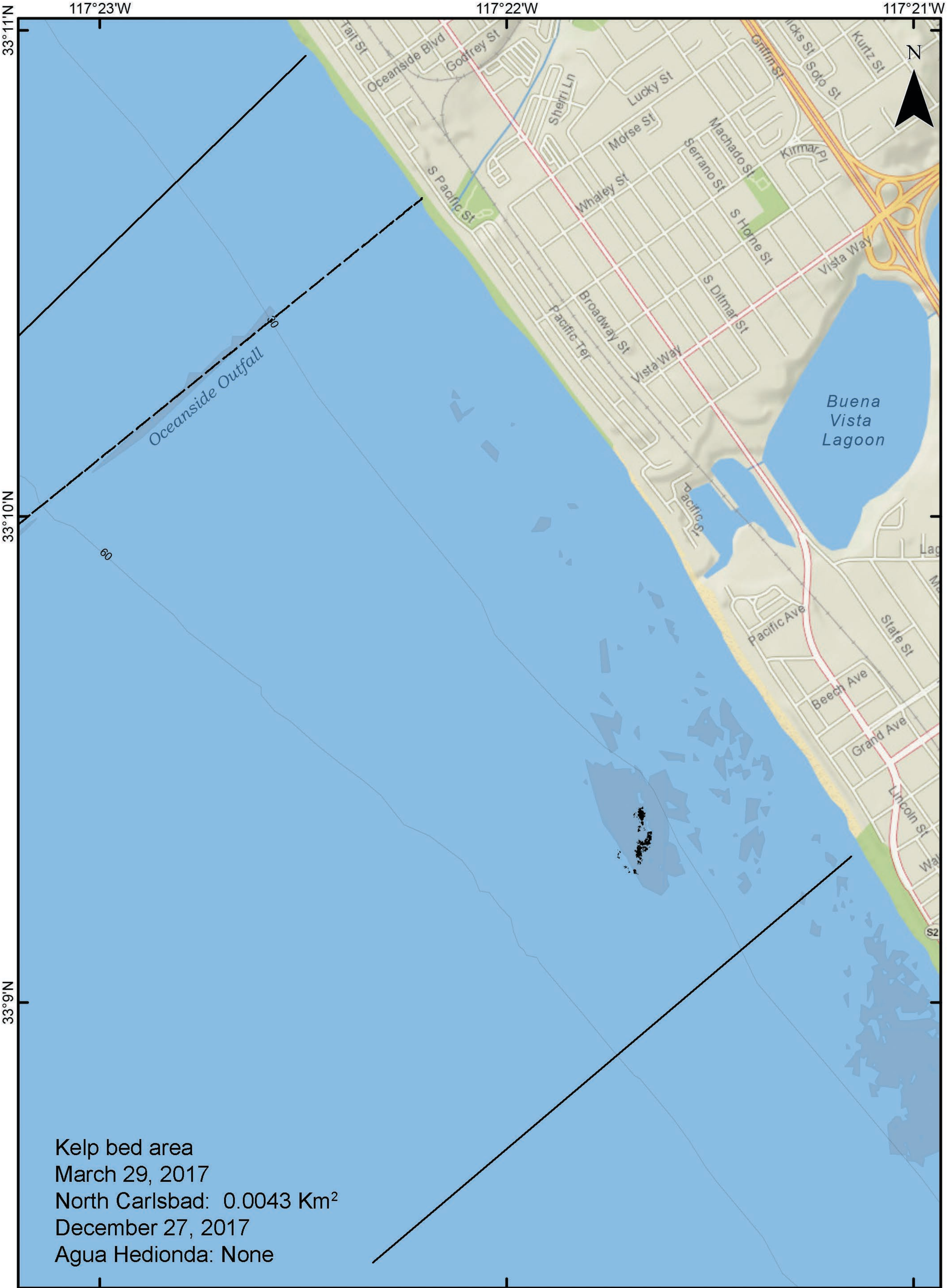
Appendix A.57
Oceanside Harbor and Pier

mbc AQUATIC SCIENCES

Kelp 2017	Artificial Reef	Discharge Structure
Isobath	Kelp Bed Divide	Hard Substrate



Appendix A.58
Oceanside Harbor/ Pier/ North Carlsbad



1 stat. mi. Depth contours in feet

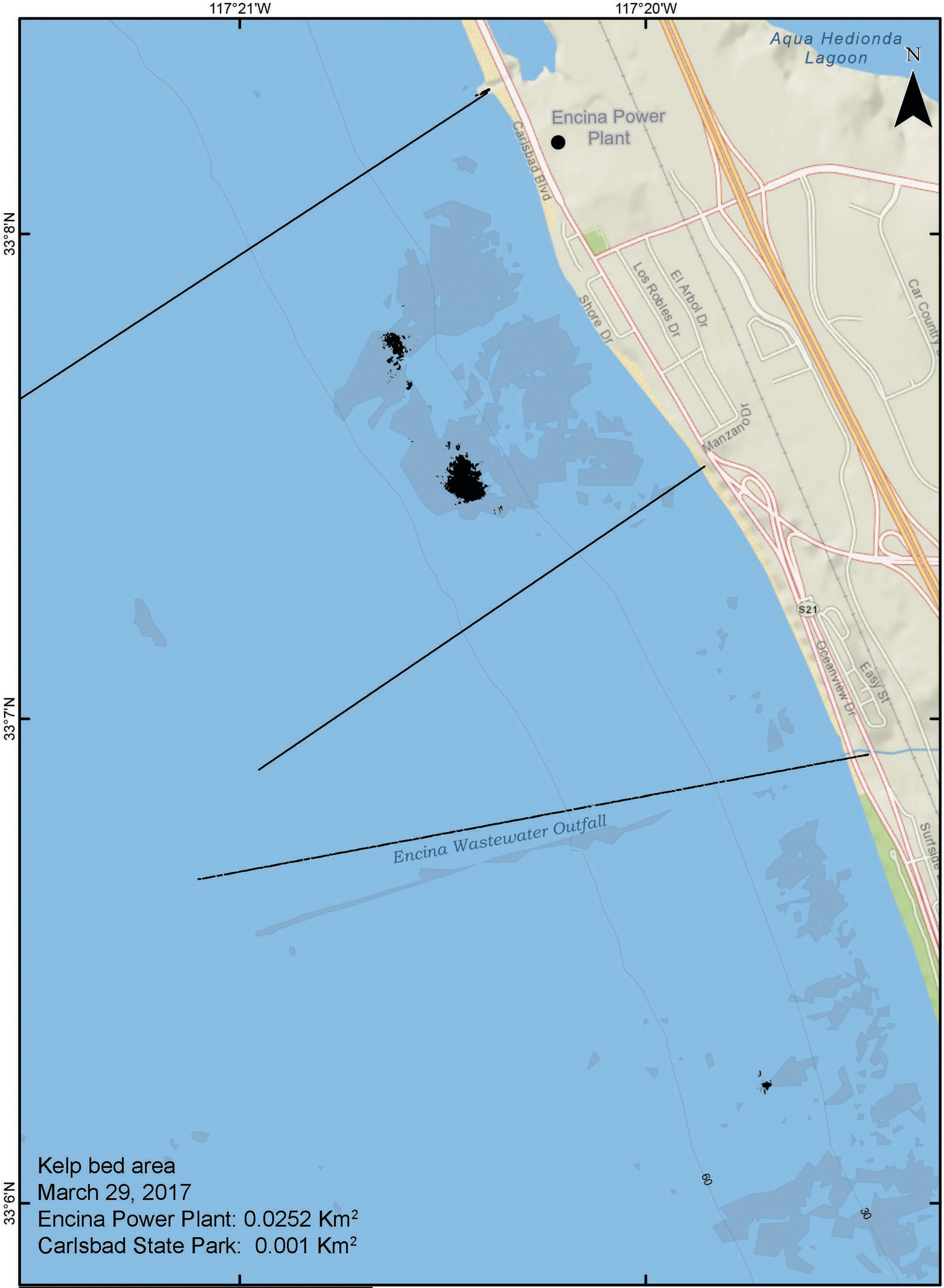
1 Km. 1:24,000

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

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



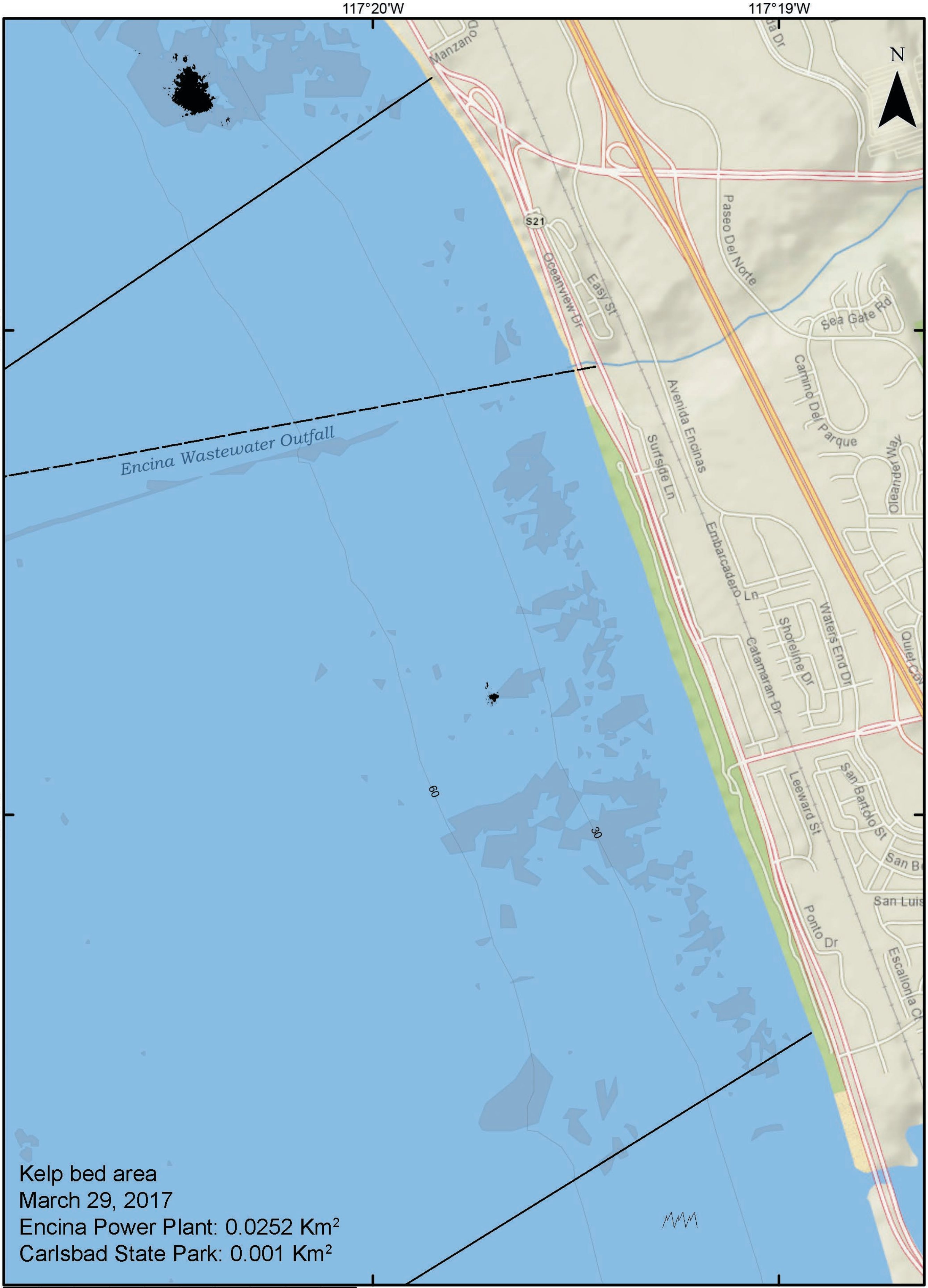
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.60
Encina Power Plant/
Carlsbad State Park

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



1 stat. mi. Depth contours in feet

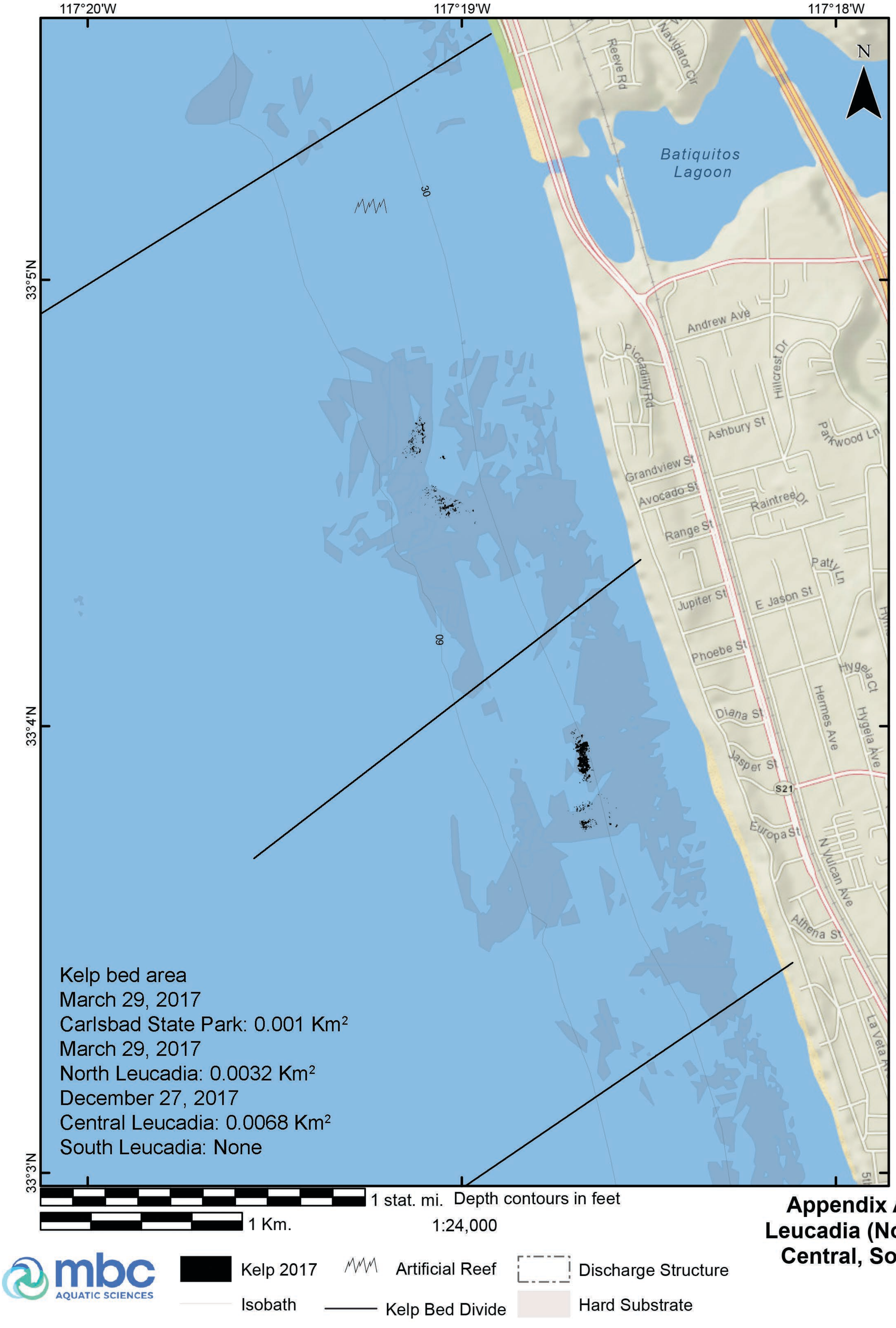
1 Km. 1:24,000

mbc AQUATIC SCIENCES

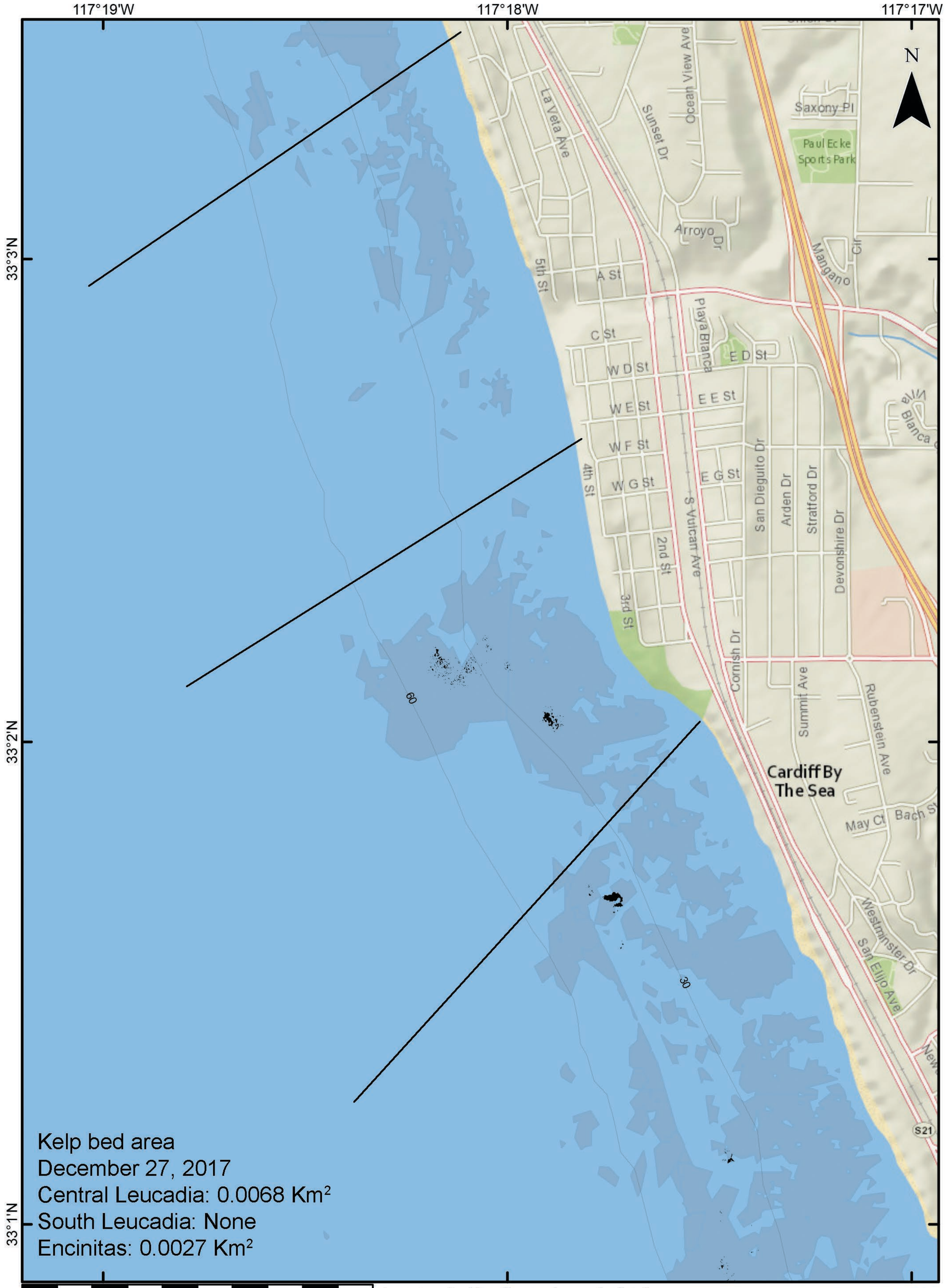
Kelp 2017 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

Appendix A.61
Encina Power Plant/ Carlsbad State Park



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



1 stat. mi. Depth contours in feet

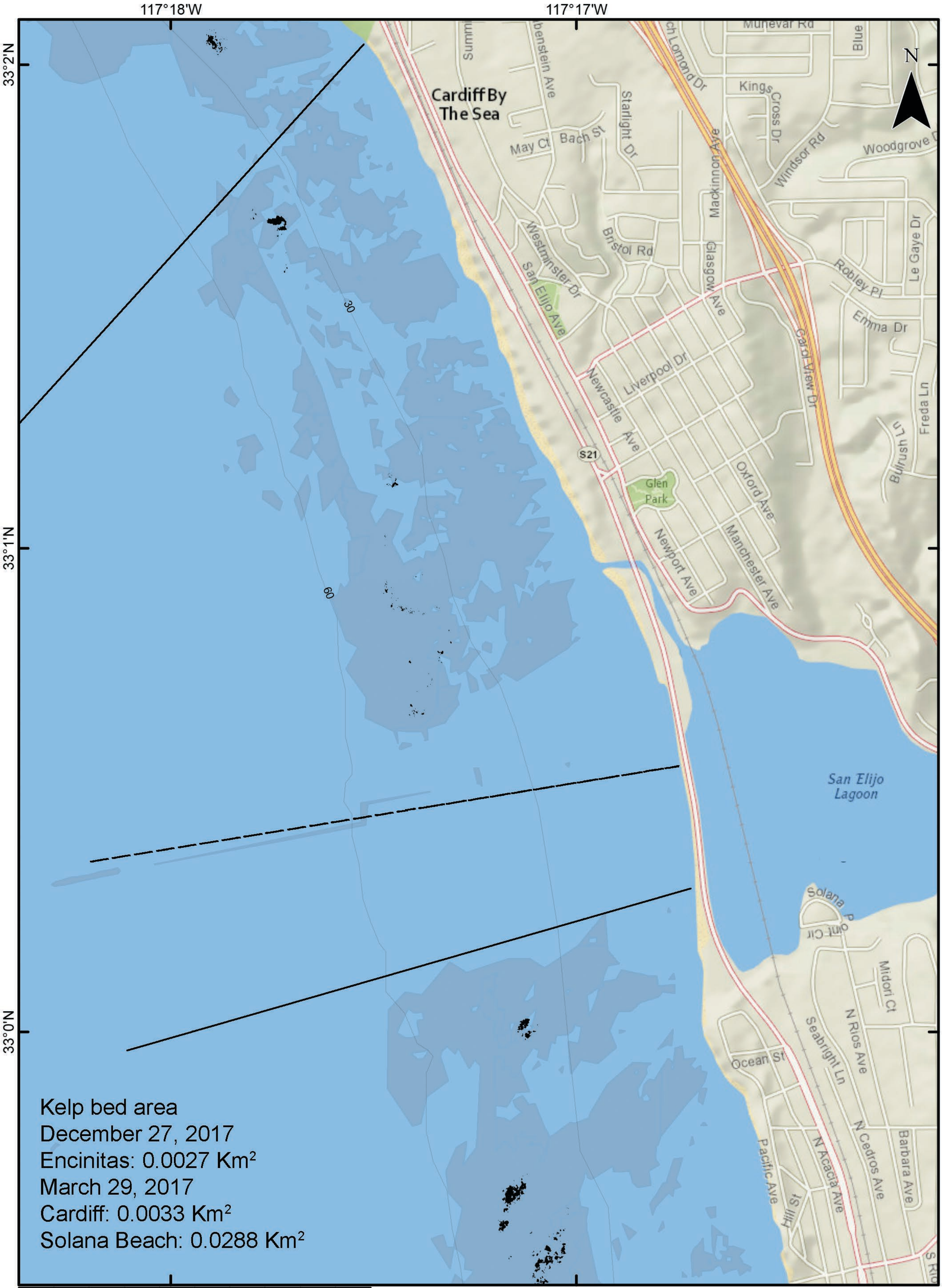
1 Km. 1:24,000

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

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



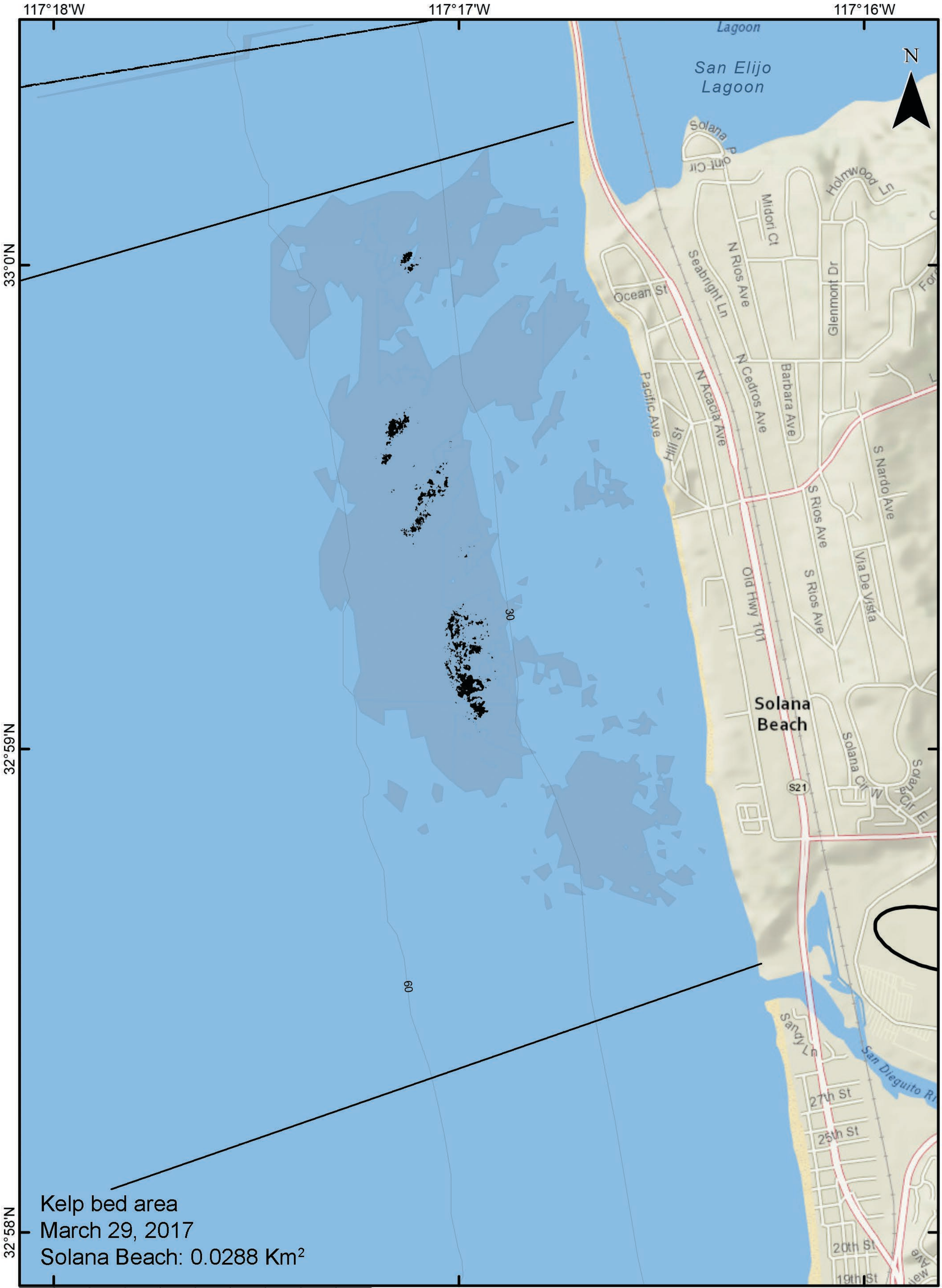
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.64
Encinitas/ Cardiff/ Solana Beach

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



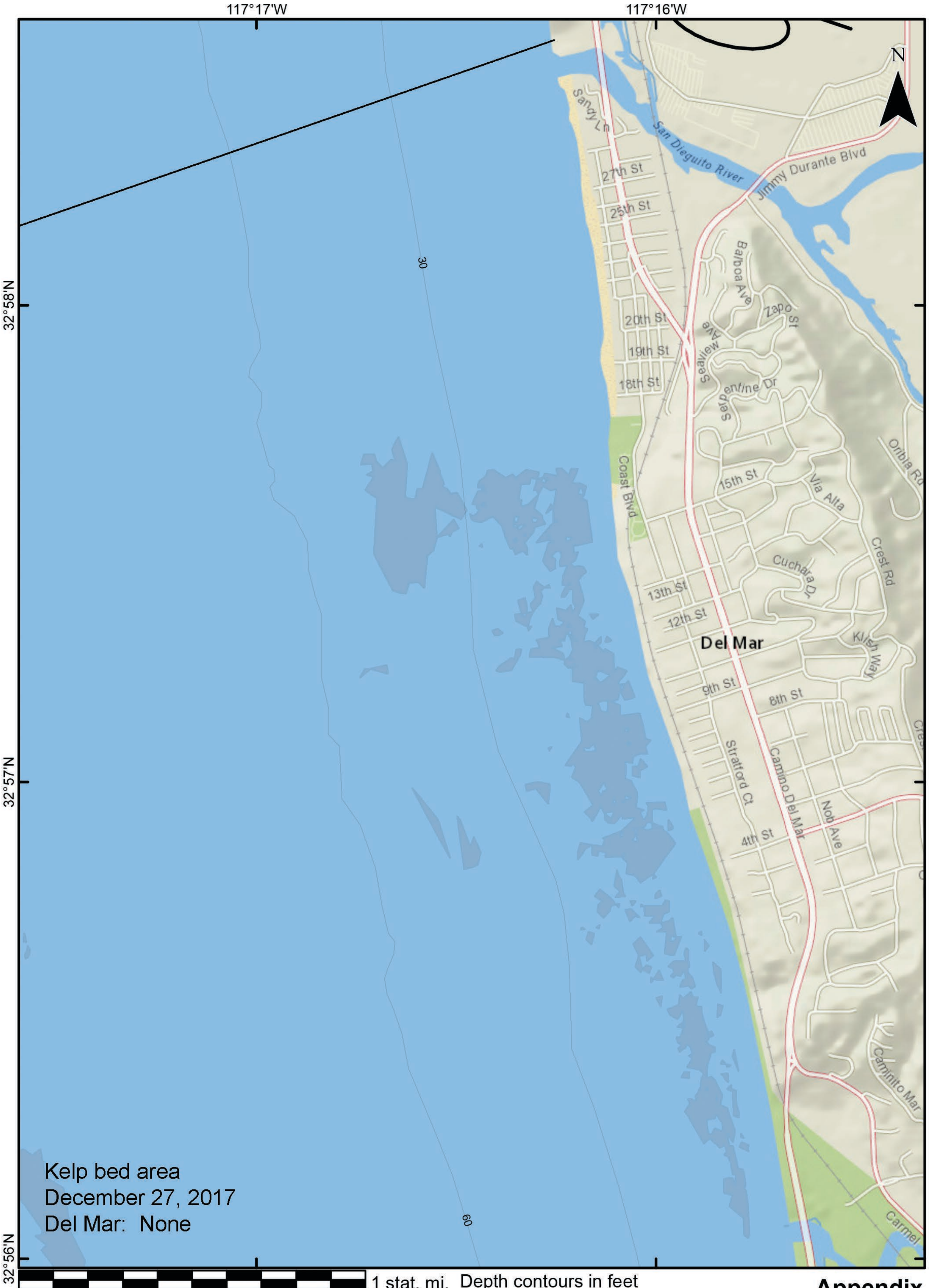
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.65
Solana Beach

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate

mbc AQUATIC SCIENCES



1 stat. mi. Depth contours in feet

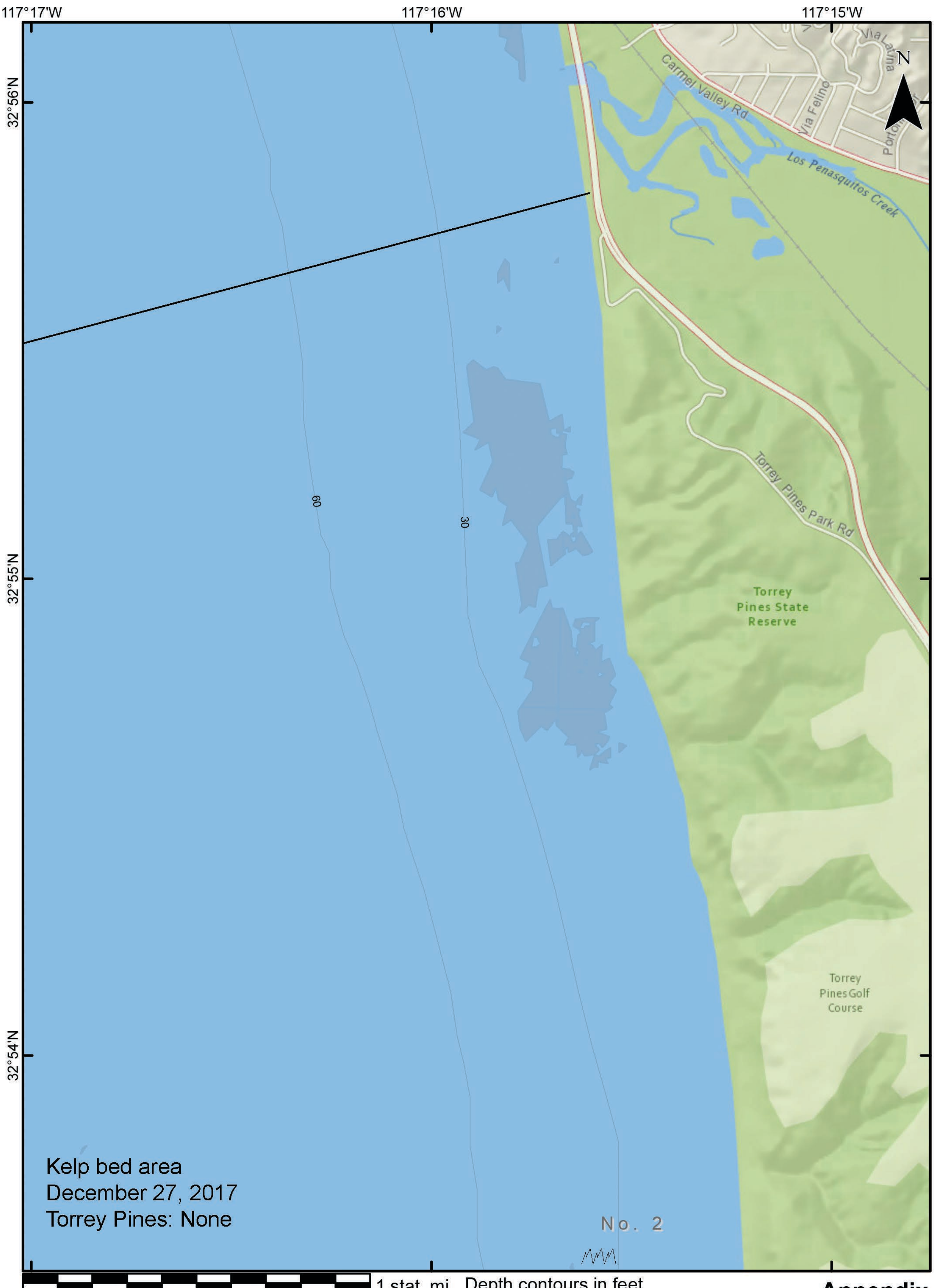
1 Km. 1:24,000

Appendix A.66
Del Mar

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure

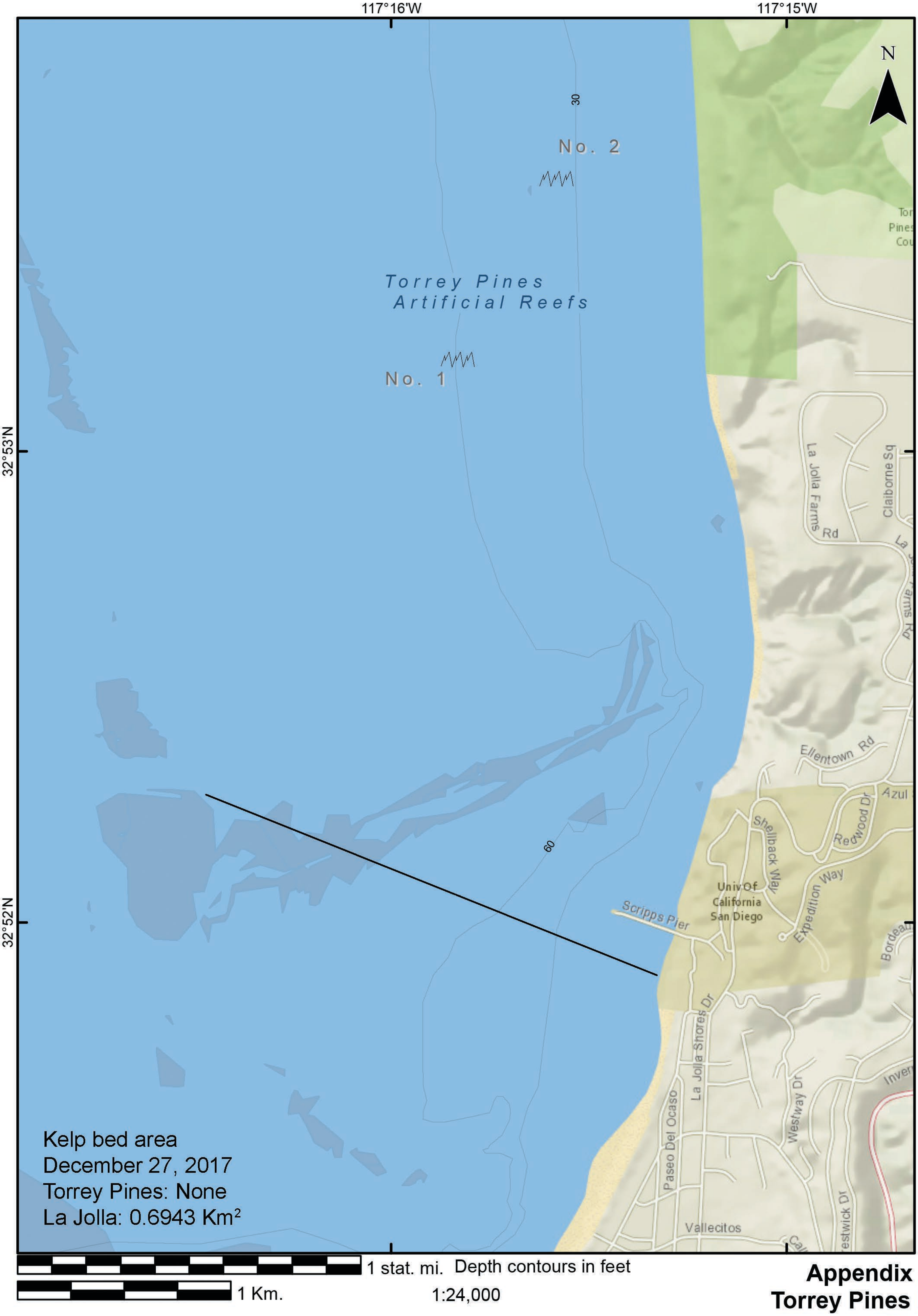
Isobath | Kelp Bed Divide | Hard Substrate



Appendix A.67
Torrey Pines (North)

mbc AQUATIC SCIENCES

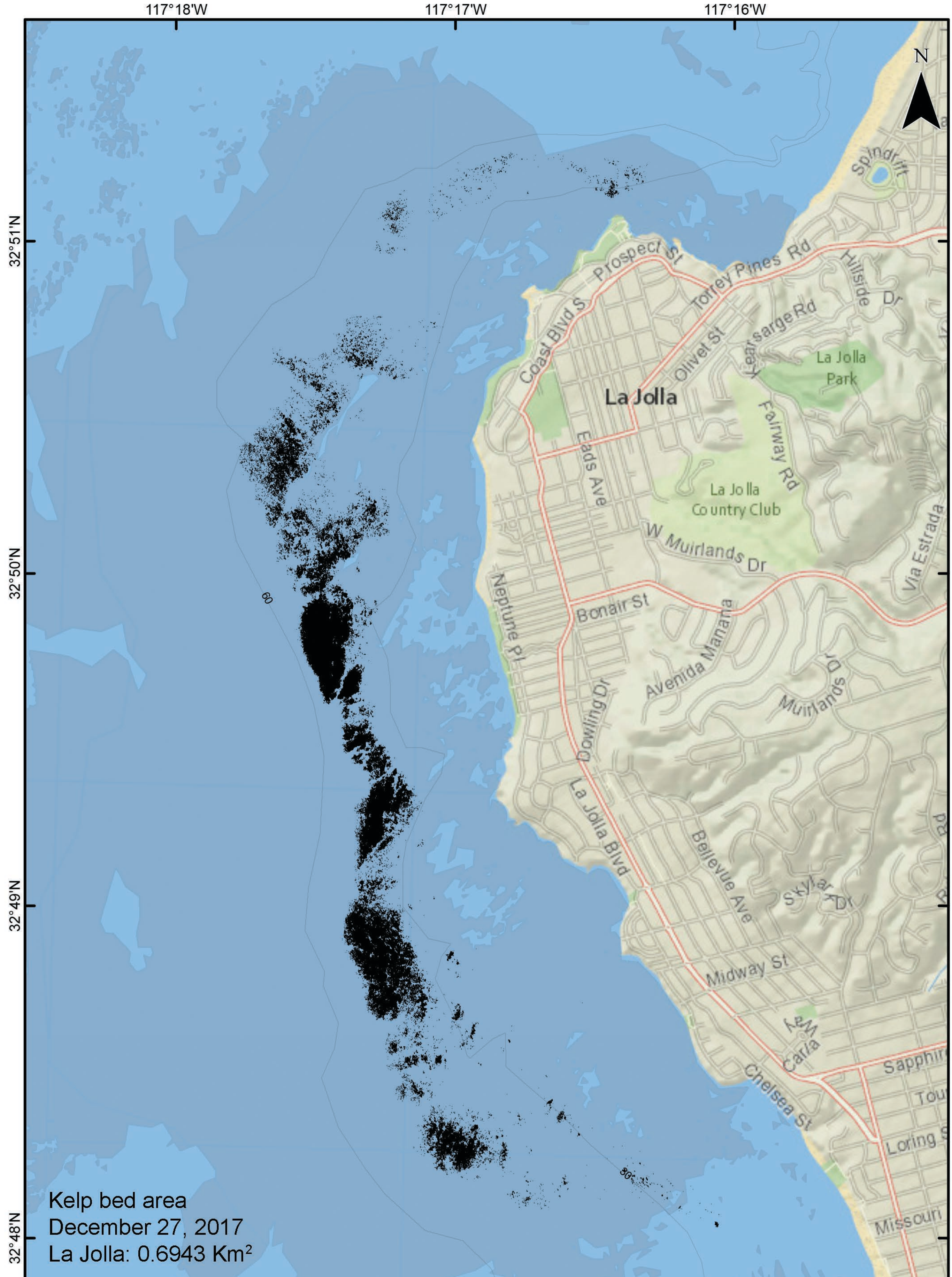
Kelp 2017
Artificial Reef
Discharge Structure
Isobath
Kelp Bed Divide
Hard Substrate



Appendix A.68
Torrey Pines Reef (South)

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure | Isobath | Kelp Bed Divide | Hard Substrate



1 stat. mi.

1 Km.

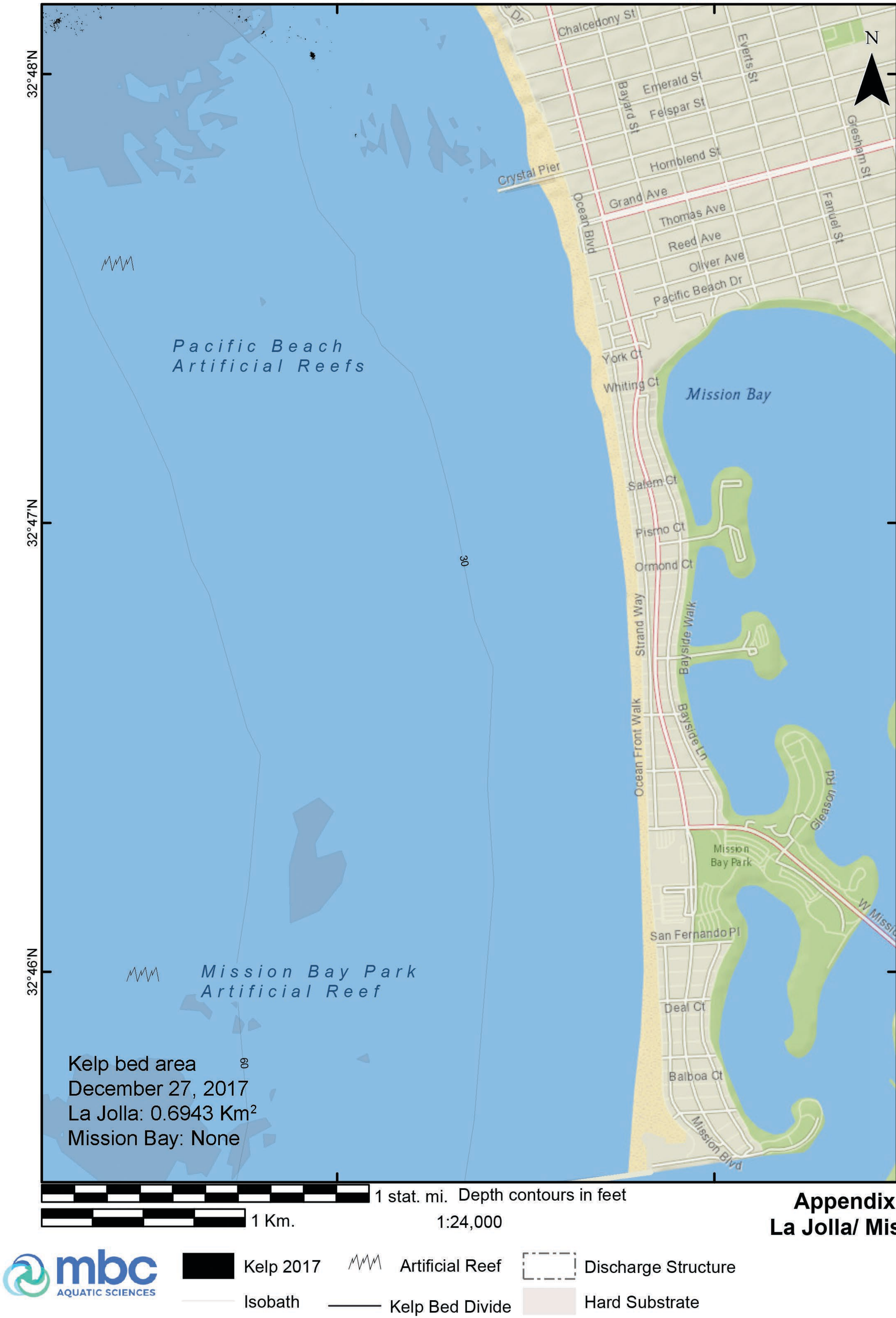
Depth contours in feet

1:35,000

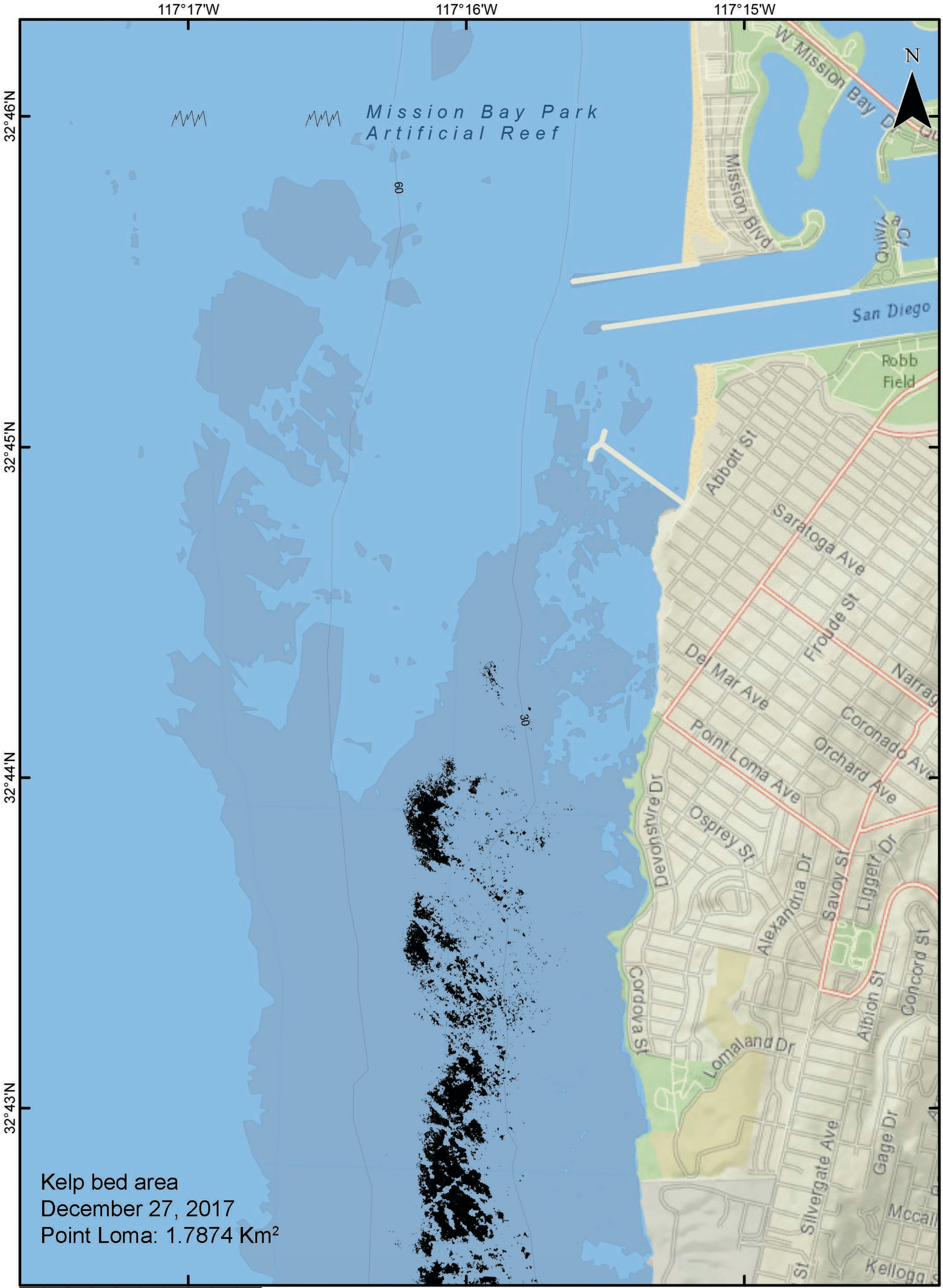
Appendix A.69
La Jolla

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



Appendix A.70
La Jolla/ Mission Bay



1 stat. mi.

1 Km.

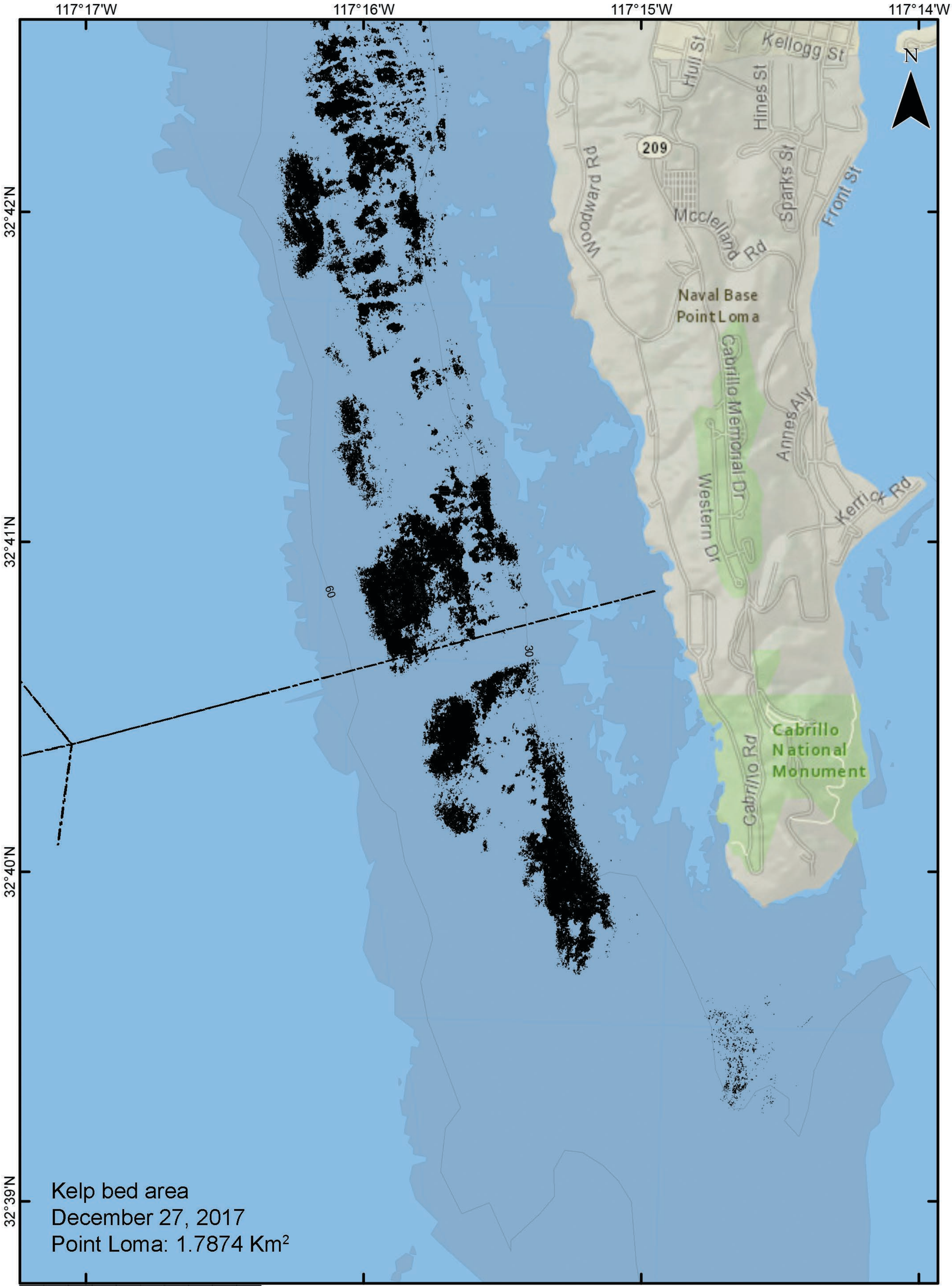
Depth contours in feet

1:35,000

Appendix A.71
Point Loma (Sunet Cliffs)

mbc AQUATIC SCIENCES

Kelp 2017	Artificial Reef	Discharge Structure
Isobath	Kelp Bed Divide	Hard Substrate



1 stat. mi.

1 Km.

Depth contours in feet

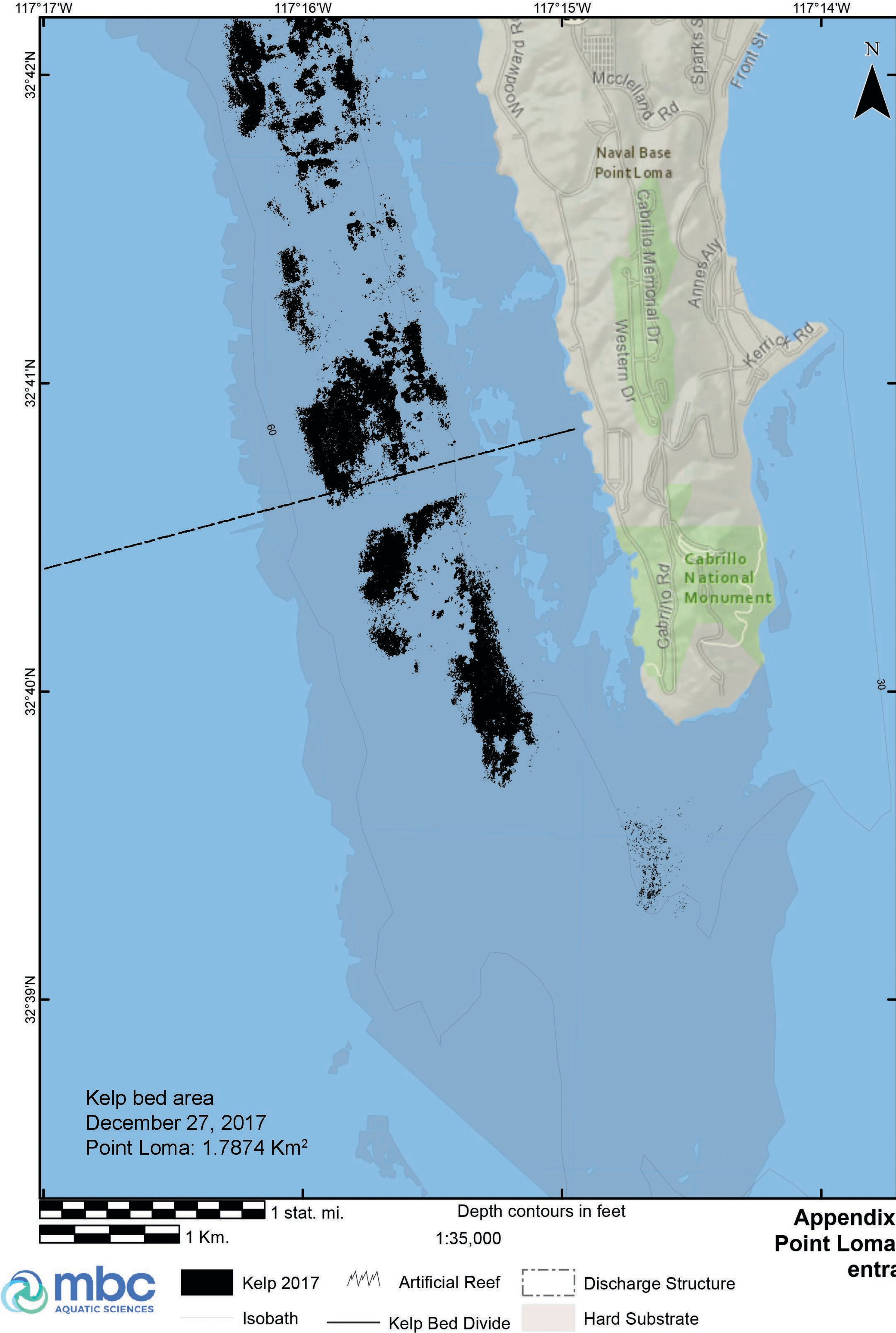
1:35,000

Appendix A.72
Point Loma (end of peninsula)

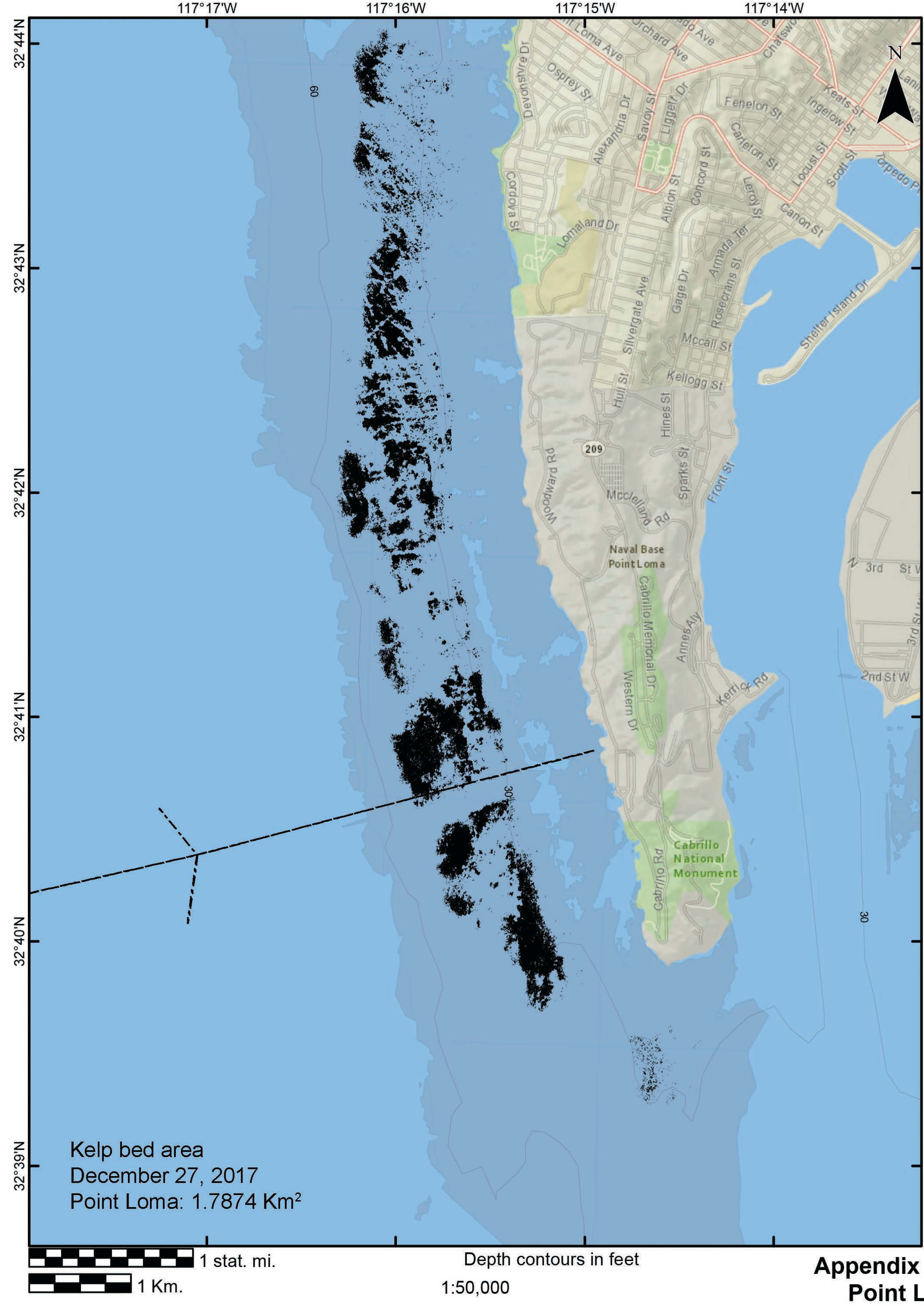
mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

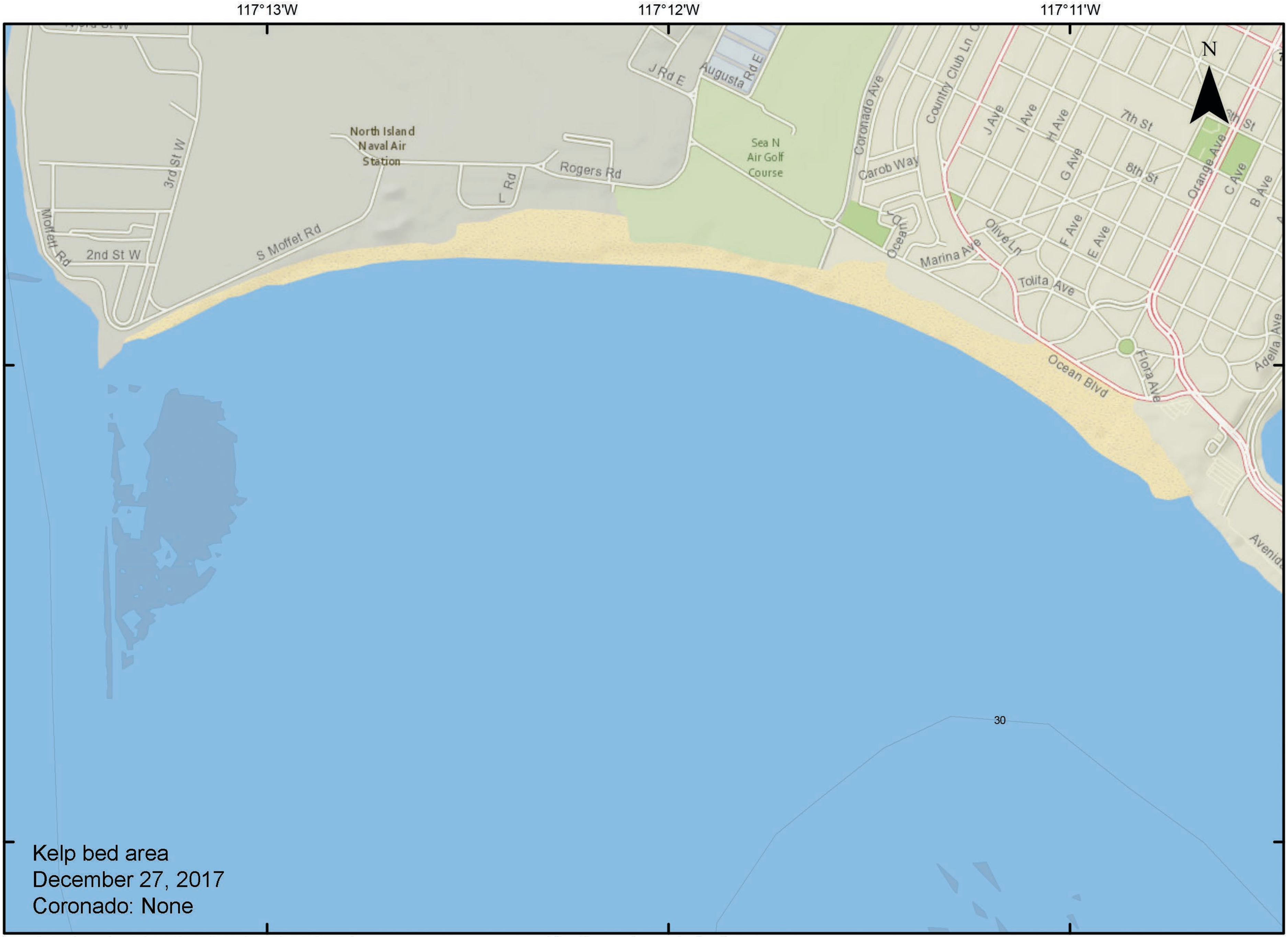


Appendix A.73
Point Loma (bay entrance)



Appendix A.74
Point Loma

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

- Kelp 2017
- Isobath
- Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

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

1 stat. mi. Depth contours in feet

1 Km. 1:24,000

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

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate

1 stat. mi. Depth contours in feet

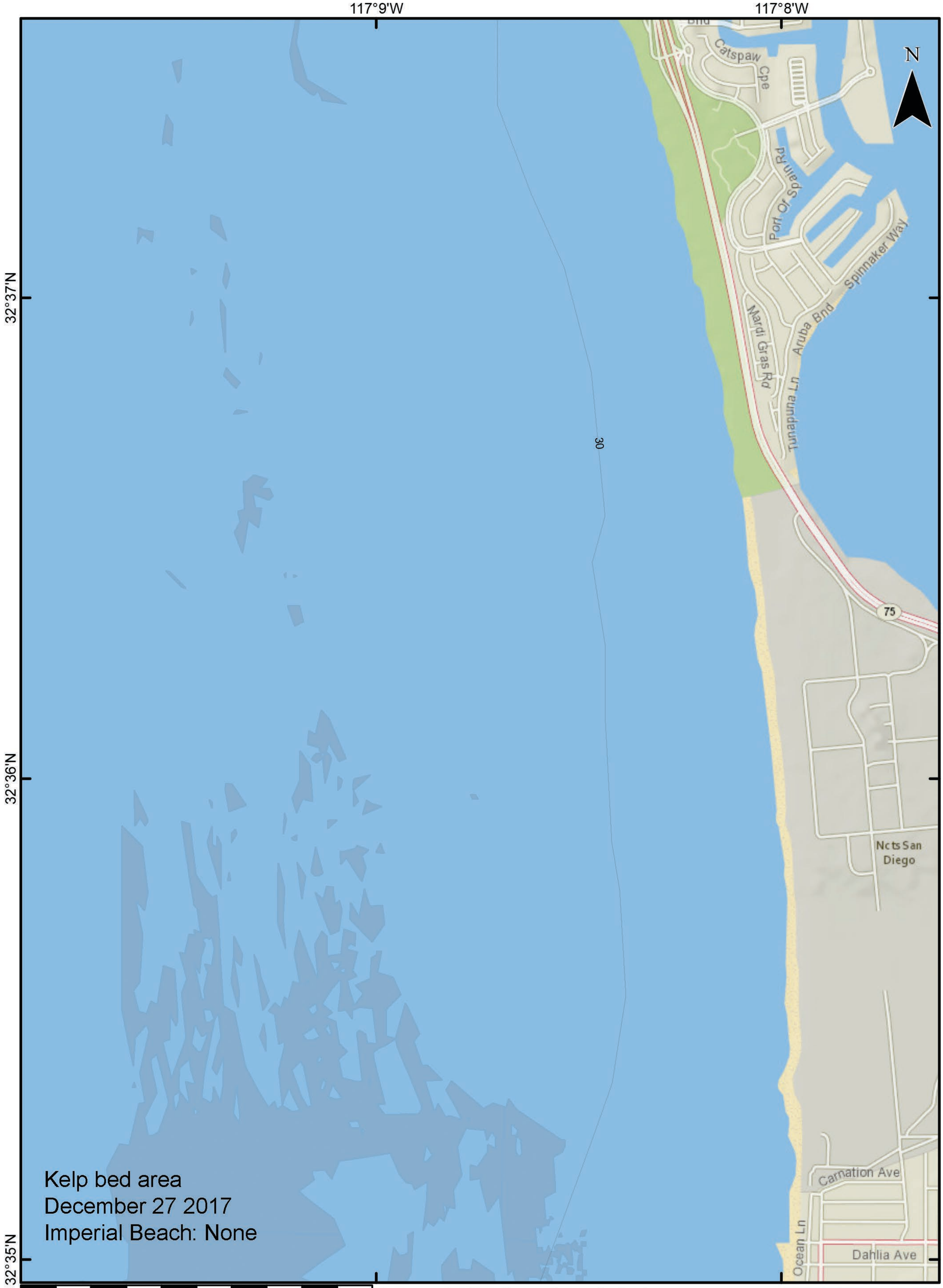
1 Km. 1:24,000

Kelp 2017 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

mbc AQUATIC SCIENCES

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



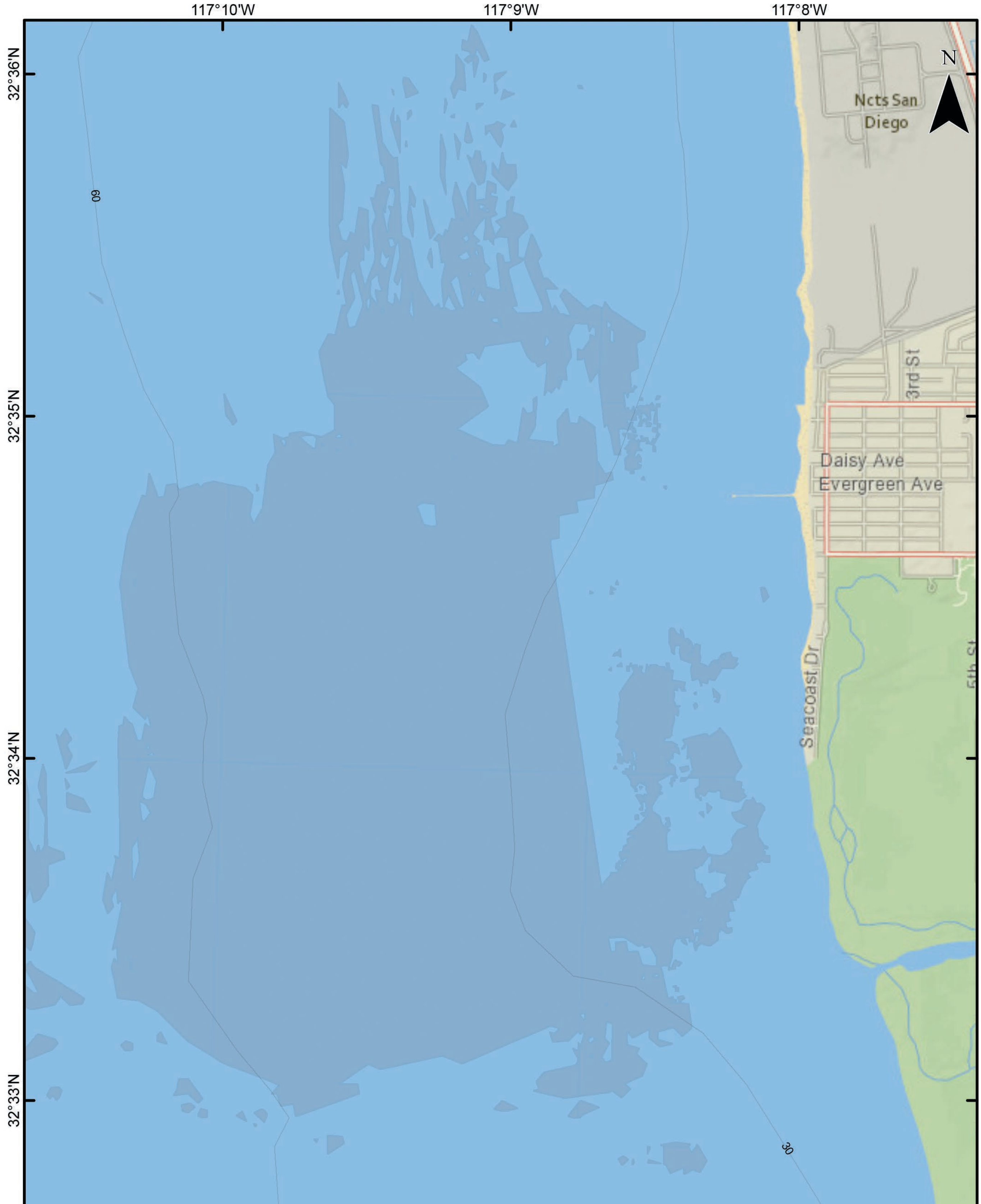
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.78
Imperial Beach

mbc AQUATIC SCIENCES

Kelp 2017 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



1 stat. mi.

1 Km.

Depth contours in feet

1:35,000

Appendix A.79
Imperial Beach

mbc AQUATIC SCIENCES

Kelp 2017

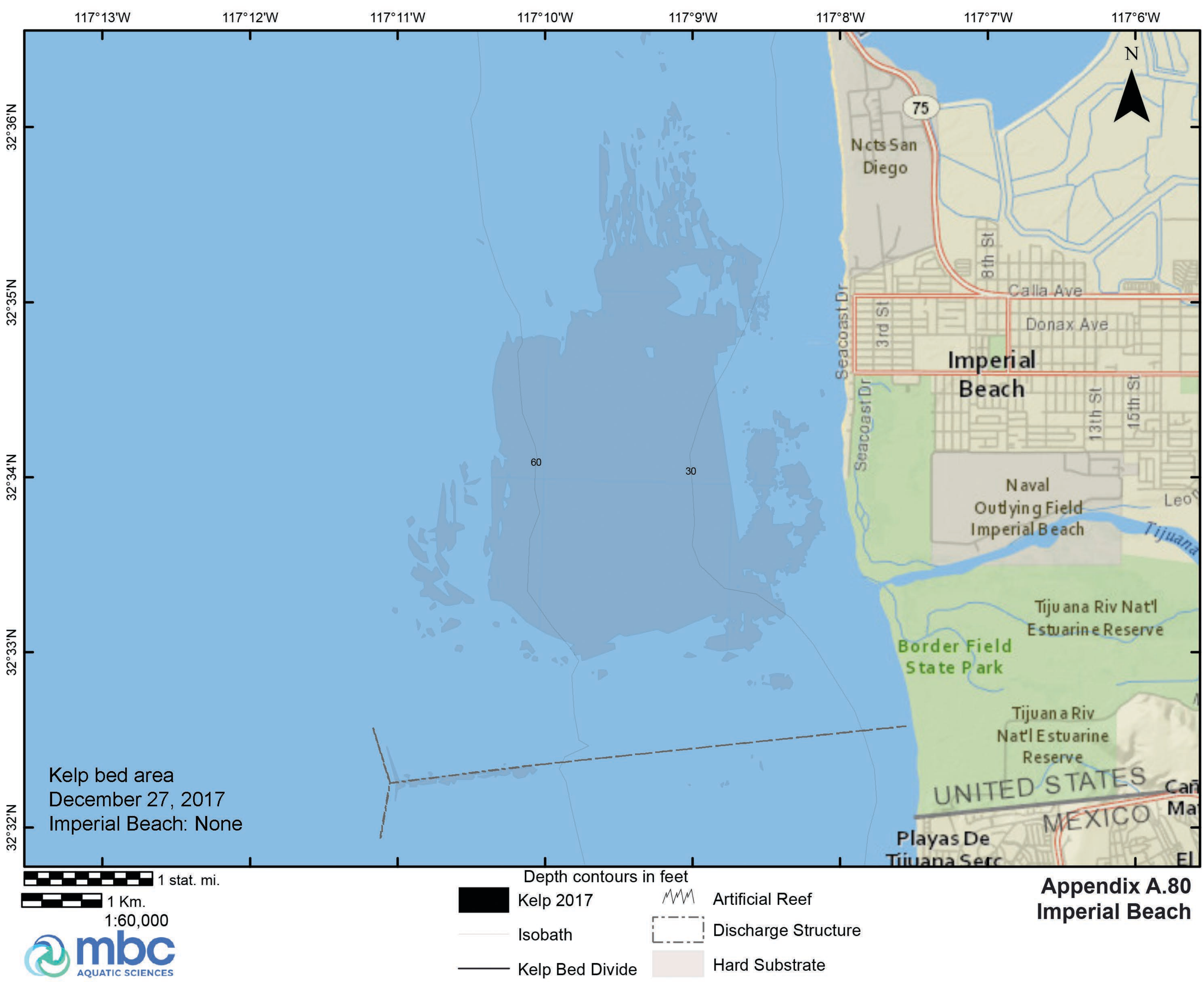
Artificial Reef

Discharge Structure

Isobath

Kelp Bed Divide

Hard Substrate



Appendix A.80
Imperial Beach

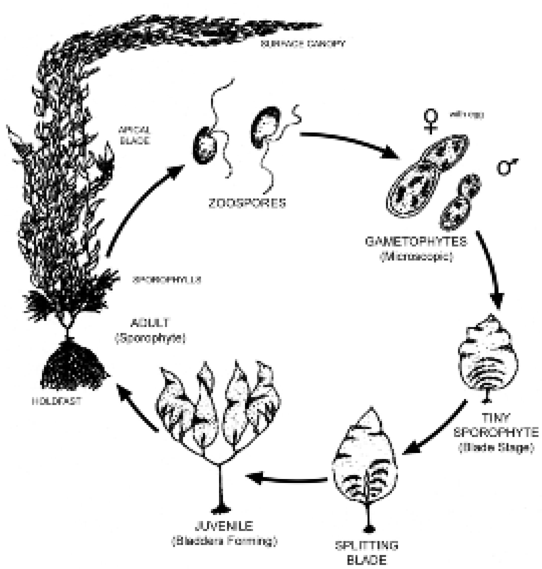
APPENDIX B

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

LIFE HISTORY OF GIANT KELP

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

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



Appendix B.1 Life cycle for giant kelp.

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

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

HISTORICAL KELP SURVEYS

Giant kelp bed size and health are known to be highly variable but there has been a downward trend in canopy coverage since the inception of surveying in 1911 (Crandall 1912). In 1911, a mapping expedition of canopy-forming kelps along most of the Pacific coast was conducted to determine the amount of potash (potassium carbonate, an essential ingredient in explosives at the time) potentially available from the kelp. Using rowboats, compass, and sextants to triangulate positions, U.S. Army Captain William Crandall produced one of the most complete surface density kelp maps of the west coast of North America. Using this methodology, all of the existing kelp beds in the Central Region and Region Nine areas were mapped and these measurements have been used to define a baseline for southern California kelp beds (Appendices B.2, B.3, and B.4).

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

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

In 1964, Dr. Wheeler North, working for the State Water Quality Control Board (1964), re-measured Crandall's Palos Verdes charts and found the 2.66 square nautical miles (Nm^2 [9.12 km^2]) Crandall reported to be very similar to his measurement of 2.42 Nm^2, but North's measurement did not include much of Malaga Cove (that added an additional 0.130 Nm^2 of kelp to the Palos Verdes beds), resulting in North's measurement of about 2.55 Nm^2 (Appendices B.5-B.11; Crandall Maps).

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

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

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

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

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

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

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

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

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

Appendix B.3 Historical canopy coverage of the kelp beds from Deer Creek to Laguna Beach (Newport/Irvine Coast) from 1911 through 2017. Values represent an estimate of coverage utilizing varying methods over the years.

	Canopy Area (km²)									
Kelp Bed	1911	1928	1945	1955	1963	1967	1972	1975	1977	1980
Deer Creek	ND	ND	ND	p	p	p	p	p	p	ND
Leo Carillo	2.515	ND	ND	p	p	p	p	p	p	ND
Nicolas Canyon	1.258	ND	ND	p	p	p	p	p	p	ND
El Pesc/La Piedra	0.252	ND	ND	p	p	p	p	p	p	ND
Lechuza	0.126	ND	ND	p	p	p	p	p	p	ND
Total F&W 17	4.151a	ND	ND	3.010	ND	4.144	2.589	1.606	1.579	ND
Pt. Dume	0.686	ND	ND	p	p	p	p	p	p	ND
Paradise Cove	1.372	ND	ND	p	p	p	p	p	p	ND
Escondido Wash	0.583	ND	ND	p	p	p	p	p	p	ND
Latigo Canyon	0.446	ND	ND	p	p	p	p	p	p	ND
Puerco/Amarillo	0.343	ND	ND	p	p	p	p	p	p	ND
Malibu Pt.	ND	ND	ND	p	p	p	p	p	p	ND
Total F&W 16	3.43a	ND	ND	2.140	1.780	2.538	1.813	1.502	1.528	ND
La Costa	0.021	ND	ND	p	p	p	ND	p	p	ND
Las Flores	0.014	ND	ND	p	p	p	ND	p	p	ND
Big Rock	0.017	ND	ND	p	p	p	ND	p	p	ND
Las Tunas	0.017	ND	ND	p	p	p	ND	p	p	ND
Topanga	0.017	ND	ND	p	p	p	ND	p	p	ND
Sunset	0.960	ND	ND	p	p	p	ND	p	p	ND
Total F&W 15	1.355a	ND	ND	0.020	0.000	0.026	ND	0.026	0.000	ND
Malaga Cove-PV Pt. (IV)	5.934	ND	ND	p	p	p	ND	p	p	0.940
PV Pt-PT. Vic (III)	0.240	ND	ND	p	p	p	ND	p	p	0.215
Total F&W 14	6.174	ND	ND	0.820	0.030	1.062	ND	0.009	0.026	1.155
Pt Vic to Pt Insp (II)	p	ND	ND	p	p	p	ND	p	p	0.190
Pt Insp to Cabr (I)	p	ND	ND	p	p	p	ND	p	p	1.052
Cabrillo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total F&W 13	2.950	ND	ND	0.080	0.150	0.000	ND	0.259	0.104	1.342
Total PV	9.124a	9.912a	5.591a	0.900	0.180	1.062	ND	0.268	0.130	2.497
POLA-POLB Harbor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Horseshoe	ND	1.94b	ND	ND	ND	ND	ND	ND	ND	ND
Huntington Flats	ND	ND	ND	ND	ND	—	—	—	—	—
Newport-Irvine Coast	0.755	ND	ND	0.680	0.000	0.086	0.100	0.160	0.160	0.148
Total F&W 10	0.755	—	—	0.680	0.000	0.086	0.100	0.160	0.160	0.148
TOTAL	18.815c	11.852c	5.591	6.750	1.960	7.856	4.502c	3.562	3.397	2.681c

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

a = Earlier measurement in naut mi^2 converted to km^2
b = Estimate in mid-1920s
c = Total is not inclusive of all beds in region
d = Ecoscan (1990) indicates 2.003 km^2 from a July 1989 survey.
Used Wilson (1989) results for PV showing the kelp beds at greatest extent.

Sources: Crandall (1912); 1928, 1945, 1955 from SWQCB (1964); 1955, 1963 from Neushul (1981); 1967, 1972, 1975, 1977 from Hodder and Mel (1978); Ecoscan (1990) and Wilson (1989), North (2000); TMLandsat 7 (2002); Veisze et al. (2004); MBC (2004a-2012a, 2013-2017).

Appendix B.3 (Cont.).

Kelp Bed	Canopy Area (km²)									
	1984	1989	1999	2000	2002	2003	2004	2005	2006	2007
Deer Creek	ND	p	p	ND	ND	0.089	0.107	0.053	0.026	0.046
Leo Carillo	ND	p	p	ND	ND	0.318	0.399	0.171	0.150	0.145
Nicolas Canyon	ND	p	p	ND	ND	0.308	0.362	0.195	0.038	0.473
El Pesc/La Piedra	ND	p	p	ND	ND	0.243	0.314	0.141	0.063	0.255
Lechuza	ND	p	p	ND	ND	0.105	0.104	0.041	0.022	0.106
Total F&W 17	ND	0.914	0.530	ND	ND	1.063	1.286	0.600	0.298	1.025
Pt. Dume	ND	p	p	ND	ND	0.012	0.029	0.028	0.053	0.065
Paradise Cove	ND	p	p	ND	ND	0.162	0.258	0.035	0.036	0.100
Escondido Wash	ND	p	p	ND	ND	0.214	0.250	0.078	-	0.339
Latigo Canyon	ND	p	p	ND	ND	0.125	0.161	0.032	0.007	0.186
Puerco/Amarillo	ND	p	p	ND	ND	0.074	0.051	0.039	0.055	0.095
Malibu Pt.	ND	p	p	ND	ND	0.011	0.013	0.008	0.008	0.016
Total F&W 16	ND	0.220	0.033	ND	ND	0.598	0.762	0.220	0.158	0.801
La Costa	ND	p	p	ND	ND	0.001	0.002	—	—	—
Las Flores	ND	p	p	ND	ND	0.009	0.023	0.004	—	0.005
Big Rock	ND	p	p	ND	ND	0.005	0.014	0.002	0.001	0.004
Las Tunas	ND	p	p	ND	ND	0.003	0.018	0.004	—	0.008
Topanga	ND	p	p	ND	ND	0.0002	0.002	0.0001	—	—
Sunset	ND	p	p	ND	ND	—	—	—	—	—
Total F&W 15	ND	0.045	0.000	ND	ND	0.017	0.059	0.010	0.001	0.017
Malaga Cove-PV Pt. (IV)	0.655	p	p	p	1.400	0.196	0.245	0.204	0.859	1.151
PV Pt-PT. Vic (III)	0.692	p	p	p	0.028	0.045	0.040	0.056	0.135	0.074
Total F&W 14	1.347	3.312	0.737	0.648	1.429	0.241	0.285	0.260	0.993	1.225
Pt Vic to Pt Insp (II)	0.171	p	p	p	0.039	0.059	0.023	0.034	0.082	0.034
Pt Insp to Cabr (I)	1.342	p	p	p	1.208	1.063	0.211	0.702	0.951	0.703
Cabrillo	ND	0.0001	0.0001	ND	ND	0.062	0.070	0.102	0.161	0.100
Total F&W 13	1.513	1.248	0.530	0.582	1.247	1.184	0.304	0.838	1.194	0.837
Total PV	2.860	4.560d	1.267	1.230	2.676d	1.425	0.589	1.098	2.187	2.062
POLA-POLB Harbor	ND	ND	ND	ND	ND	ND	ND	0.147	0.494	0.118
Horseshoe	ND	tr	0.0001	tr	0.0001	—	—	—	—	—
Huntington Flats	-	tr	—	—	-	—	—	—	—	—
Newport-Irvine Coast	0.008	0.010	—	—	tr	0.002	0.002	0.000	0.023	0.054
Total F&W 10	0.008	0.010	0.0001	—	0.000	0.002	0.002	0.147	0.517	0.172
TOTAL	2.893b	5.748	1.829	1.230	2.676c	3.105	2.698	2.075	3.161	4.076

Appendix B.3 (Cont.).

Kelp Bed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Deer Creek	0.074	0.105	0.062	0.055	0.041	0.104	0.103	0.124	0.087	0.105
Leo Carillo	0.207	0.255	0.232	0.226	0.337	0.366	0.261	0.408	0.326	0.426
Nicolas Canyon	0.268	0.433	0.291	0.130	0.240	0.369	0.288	0.347	0.279	0.179
El Pesc/La Piedra	0.173	0.238	0.164	0.136	0.173	0.236	0.244	0.246	0.160	0.157
Lechuza	0.075	0.105	0.096	0.096	0.066	0.154	0.137	0.119	0.063	0.086
Total F&W 17	0.797	1.136	0.844	0.642	0.857	1.229	1.034	1.244	0.914	0.953
Pt. Dume	0.070	0.104	0.094	0.078	0.154	0.113	0.092	0.169	0.042	0.050
Paradise Cove	0.223	0.244	0.259	0.109	0.346	0.244	0.223	0.086	0.127	0.024
Escondido Wash	0.278	0.321	0.267	0.104	0.248	0.243	0.281	0.095	0.084	0.059
Latigo Canyon	0.124	0.195	0.142	0.070	0.202	0.133	0.212	0.052	0.057	0.044
Puerco/Amarillo	0.064	0.115	0.126	0.069	0.153	0.105	0.130	0.034	0.027	0.002
Malibu Pt.	0.011	0.012	0.066	0.074	0.084	0.060	0.039	—	0.035	0.001
Total F&W 16	0.769	0.991	0.954	0.504	1.189	0.897	0.976	0.436	0.372	0.180
La Costa	—	0.001	0.001	—	0.003	0.003	0.001	—	—	—
Las Flores	0.001	0.005	0.005	0.008	0.025	0.022	0.016	—	—	—
Big Rock	0.002	0.005	0.006	0.007	0.018	0.017	0.011	0.004	0.001	0.000
Las Tunas	0.005	0.019	0.015	0.007	0.030	0.029	0.012	0.004	—	0.001
Topanga	0.001	0.002	0.052	0.041	0.048	0.044	0.016	0.005	—	—
Sunset	—	0.004	0.008	0.007	0.008	0.010	0.010	0.010	0.015	0.003
Total F&W 15	0.009	0.035	0.087	0.069	0.131	0.123	0.064	0.022	0.017	0.004
Malaga Cove—PV Pt. (IV)	1.839	2.122	1.136	1.139	1.337	0.974	0.264	1.410	1.420	1.048
PV Pt—PT. Vic (III)	0.300	0.570	0.624	0.452	0.488	0.502	0.468	0.750	0.430	0.576
Total F&W 14	2.140	2.692	1.760	1.591	1.825	1.476	0.732	2.160	1.850	1.624
Pt Vic to Pt Insp (II)	0.108	0.163	0.222	0.238	0.295	0.279	0.224	0.379	0.366	0.294
Pt Insp to Cabr (I)	0.608	0.980	0.389	0.465	0.384	0.672	0.533	0.478	0.610	0.935
Cabrillo	0.060	0.163	0.124	0.103	0.095	0.174	0.158	0.133	0.235	0.329
Total F&W 13	0.776	1.306	0.734	0.805	0.774	1.124	0.915	0.990	1.210	1.557
Total PV	2.916	3.998	2.494	2.396	2.599	2.600	1.647	3.149	3.060	3.181
POLA—POLB Harbor	0.213	0.151	0.277	0.397	0.495	0.337	0.196	0.359	0.359	0.531
Horseshoe	—	—	—	—	—	—	—	—	—	—
Huntington Flats	—	—	—	—	—	—	—	—	—	—
Newport—Irvine Coast	0.089	0.095	0.161	0.419	0.395	0.428	0.366	0.045	0.036	0.033
Total F&W 10	0.302	0.246	0.438	0.816	0.890	0.765	0.561	0.404	0.395	0.563
TOTAL	4.793	6.406	4.817	4.427	5.665	5.614	4.283	5.255	4.757	4.881

Appendix B.4 Historical canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 1911 through 2017. Values represent an estimate of coverage utilizing varying methods over the years.

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

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

red = warm year El Nino; **blue** = cold year La Nina; **black** = neutral year

Sources: 1934, 1941 from SWQCB (1964); 1955, 1959, 1963 from Neushul (1981); MBC (2007b-2012b, 2013-2017).

Appendix B.4 (Cont.).

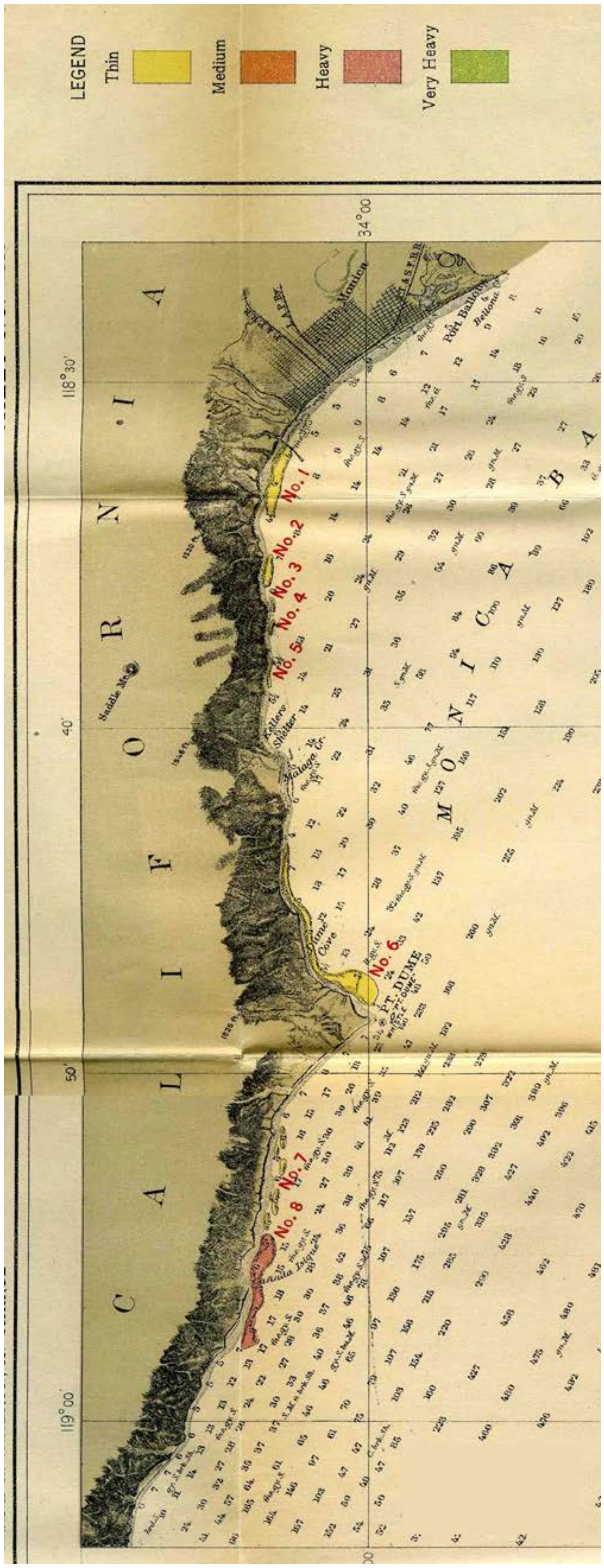
Kelp Bed	Canopy Area (km²)											
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
North Laguna Beach	0.028	0.022	0.028	0.042	0.055	0.034	0.029	—	—	—	—	0.001
South Laguna Beach	0.077	0.041	0.087	0.145	0.264	0.243	0.093	0.056	0.028	—	—	—
South Laguna	—	—	—	0.023	0.041	0.023	0.030	0.009	0.006	0.005	—	—
Dana Point-Salt Creek	0.036	0.031	0.174	0.568	0.878	0.329	0.480	0.184	0.234	0.116	0.076	0.061
Capistrano Beach	—	—	—	0.032	0.233	0.110	0.134	0.148	0.022	—	—	—
Total F&W 9	0.141	0.094	0.289	0.810	1.471	0.739	0.766	0.397	0.290	0.121	0.076	0.062
San Clemente	—	—	0.017	0.124	0.444	0.304	0.243	0.044	0.051	0.010	0.010	0.047
San Mateo Point	0.152	0.077	0.200	0.432	0.870	0.472	0.120	0.103	0.220	0.080	0.010	0.073
San Onofre	0.042	0.053	0.045	0.348	0.638	0.763	0.170	0.053	0.163	0.201	0.096	0.196
Total F&W 8	0.194	0.130	0.262	0.904	1.952	1.539	0.533	0.200	0.434	0.291	0.116	0.316
Horno Canyon	—	—	—	0.006	0.033	0.010	0.018	0.040	—	—	—	—
Barn Kelp	—	—	—	0.008	0.116	0.382	0.262	0.124	0.002	0.010	0.172	0.204
Santa Margarita	—	—	—	—	—	—	0.049	0.009	—	—	—	—
Total F&W 7	—	—	—	0.014	0.149	0.392	0.329	0.173	0.002	0.010	0.172	0.204
North Carlsbad	—	—	0.031	0.049	0.096	0.119	0.044	0.004	0.018	0.020	0.008	—
Agua Hedionda	0.011	0.018	0.021	0.032	0.047	0.046	0.016	0.004	0.012	0.004	0.008	0.009
Encina Power Plant	0.024	0.045	0.120	0.161	0.251	0.179	0.083	0.025	0.022	0.011	0.058	0.032
Carlsbad State Beach	0.027	0.018	0.077	0.032	0.049	0.081	0.035	0.008	0.002	0.011	0.025	0.013
Total F&W 6	0.062	0.081	0.249	0.274	0.443	0.425	0.178	0.041	0.054	0.046	0.099	0.054
Leucadia	0.104	0.074	0.426	0.197	0.291	0.341	0.163	0.084	0.035	0.010	0.189	0.087
Encinitas	0.083	0.032	0.177	0.153	0.209	0.241	0.080	0.036	0.037	0.016	0.061	0.023
Cardiff	0.176	0.120	0.340	0.229	0.575	0.468	0.072	0.054	0.034	0.080	0.092	0.026
Solana Beach	0.115	0.120	0.367	0.427	0.488	0.466	0.257	0.053	0.023	0.108	0.134	0.003
Del Mar	0.008	0.021	0.081	0.063	0.104	0.082	0.097	0.006	0.003	0.029	0.082	—
Torrey Pines	—	—	—	Tr	Tr	—	—	—	—	—	—	—
Total F&W 5	0.486	0.367	1.391	1.069	1.667	1.598	0.669	0.233	0.132	0.243	0.558	0.139
La Jolla F&W 4	0.720	0.930	2.369	2.200	4.755	3.632	3.230	1.301	0.681	1.119	0.824	0.371
Point Loma F&W 3&2	1.570	2.100	3.682	2.322	5.842	5.943	4.310	1.153	1.917	3.589	1.134	1.187
Imperial Beach F&W 1	0.058	0.150	0.727	0.067	0.579	0.651	0.370	0.111	0.025	0.108	0.053	0.008
TOTAL	3.173	3.702	8.242	7.593	16.279	14.268	10.015	3.498	3.510	5.419	3.032	2.341

Appendix B.4 (Cont.).

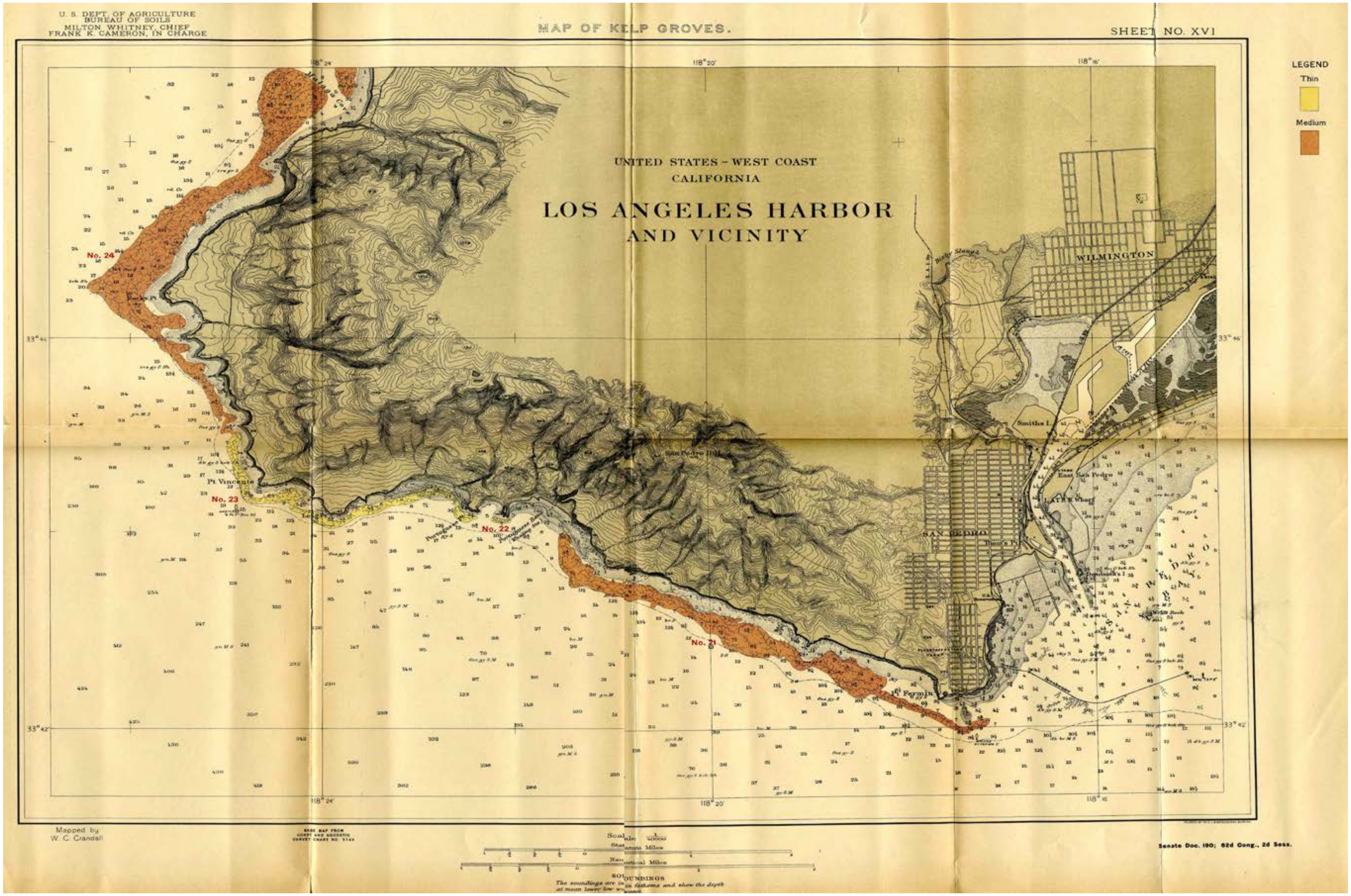
Kelp Bed	Canopy Area (km²)										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
North Laguna Beach	—	—	—	—	—	—	0.0004	—	—	—	—
South Laguna Beach	—	—	—	—	—	0.005	0.0002	0.008	—	—	0.001
South Laguna	—	—	—	0.003	0.002	<0.001	0.004	0.009	0.003	—	0.004
Dana Point-Salt Creek	0.034	0.005	0.080	0.170	0.314	0.432	0.303	0.278	0.123	—	0.302
Capistrano Beach	—	—	<0.001	<0.001	0.044	0.118	0.069	0.008	—	0.011	0.002
Total F&W 9	0.034	0.005	0.080	0.173	0.359	0.555	0.376	0.303	0.126	0.011	0.309
San Clemente	—	—	0.006	0.005	0.124	0.316	0.352	0.182	0.178	0.014	0.016
San Mateo Point	0.098	—	0.051	0.050	0.090	0.155	0.242	0.123	0.258	0.016	0.201
San Onofre	0.108	<0.001	0.005	0.020	0.041	0.030	0.162	0.109	0.065	—	0.320
Total F&W 8	0.206	—	0.062	0.075	0.255	0.501	0.755	0.414	0.501	0.030	0.536
Horno Canyon	—	—	—	0.002	0.034	—	0.001	—	—	—	0.015
Barn Kelp	0.178	—	0.310	0.375	0.547	0.667	0.492	0.075	0.064	—	0.466
Santa Margarita	—	—	—	—	—	—	—	—	—	—	—
Total F&W 7	0.178	—	0.310	0.377	0.581	0.667	0.494	0.075	0.064	—	0.481
North Carlsbad	—	0.003	—	—	0.017	0.053	0.017	0.003	0.013	—	0.026
Agua Hedionda	—	—	—	—	—	<0.001	0.002	0.001	0.008	—	0.016
Encina Power Plant	0.013	—	—	0.002	0.029	0.097	0.178	0.067	0.001	—	0.081
Carlsbad State Beach	—	—	—	0.003	0.023	0.047	0.002	0.0001	—	—	0.064
Total F&W 6	0.013	0.003	—	0.005	0.069	0.197	0.199	0.070	0.023	—	0.187
Leucadia	0.062	—	0.015	0.090	0.209	0.334	0.185	0.048	0.001	0.016	0.233
Encinitas	0.048	—	0.029	0.040	0.131	0.153	0.050	0.016	—	0.002	0.205
Cardiff	0.031	0.016	0.063	0.150	0.309	0.405	0.202	0.045	—	0.004	0.286
Solana Beach	0.073	0.009	0.091	0.200	0.407	0.488	0.245	0.022	0.093	0.0003	0.457
Del Mar	Tr	0.004	—	0.006	0.015	0.035	0.030	—	—	—	0.037
Torrey Pines	—	—	—	—	—	—	—	—	—	0.010	—
Total F&W 5	0.214	0.029	0.198	0.486	1.071	1.415	0.712	0.131	0.094	0.032	1.218
La Jolla F&W 4	0.478	0.215	1.146	1.250	2.555	3.366	3.444	1.029	0.873	0.117	2.750
Point Loma F&W 3&2	2.235	0.295	1.725	3.290	6.574	3.799	4.509	1.924	2.152	1.767	3.616
Imperial Beach F&W 1	0.027	—	0.019	0.020	0.078	0.210	0.083	0.191	0.400	0.400	1.493
TOTAL	3.385	0.547	3.540	5.676	11.542	10.710	10.572	4.136	4.233	2.358	10.591

Appendix B.4 (Cont.).

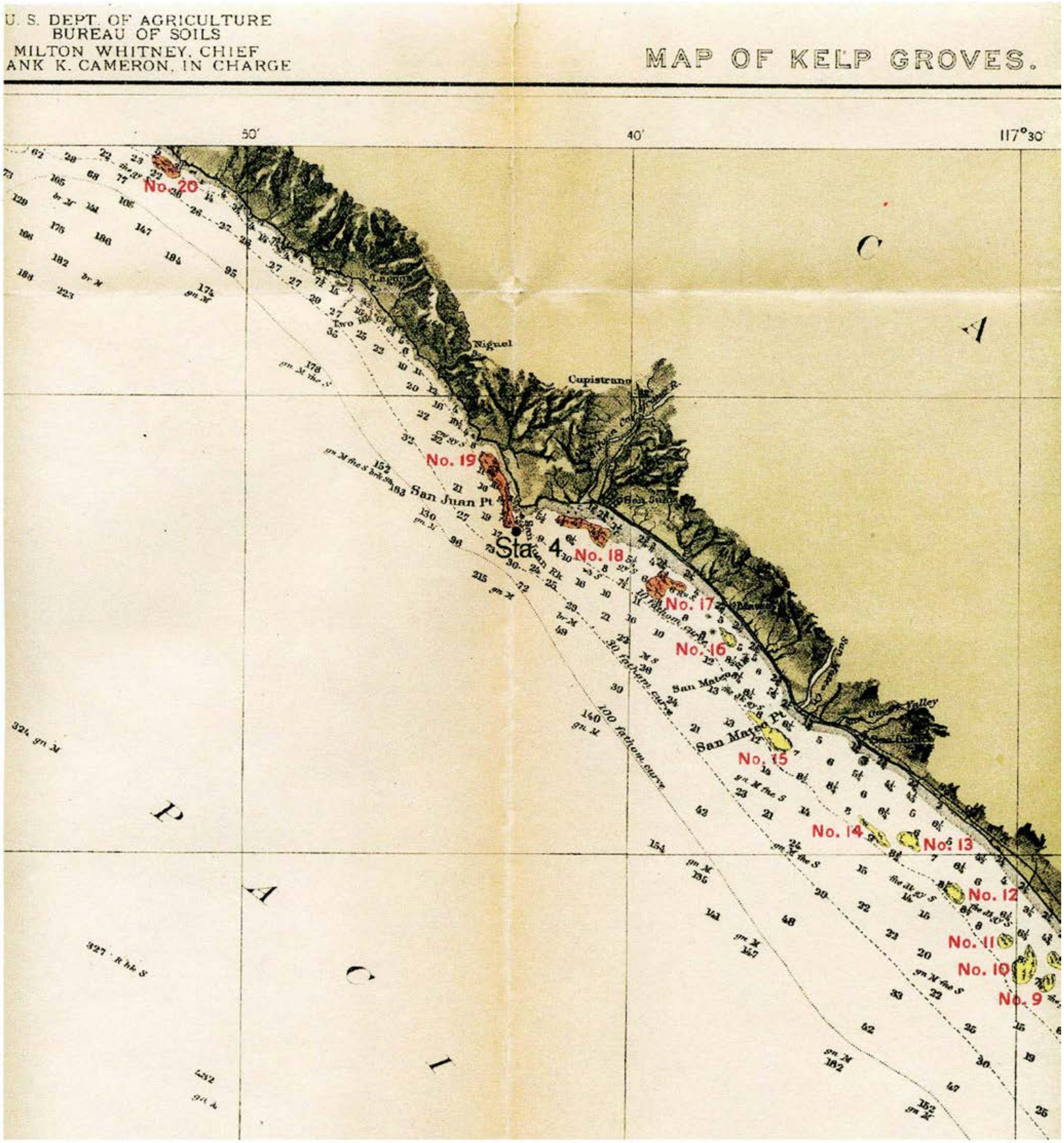
Kelp Bed	Canopy Area (km²)									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
North Laguna Beach	0.002	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096
South Laguna Beach	0.025	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032
South Laguna	0.023	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003
Dana Point-Salt Creek	1.068	0.892	0.839	0.442	0.607	0.835	0.528	0.137	0.110	0.133
Capistrano Beach	0.071	0.071	0.124	0.010	0.056	0.099	0.034	0.007	0.012	0.0004
Total F&W 9	1.189	1.043	1.178	0.838	1.086	1.385	0.879	0.287	0.237	0.264
San Clemente	0.203	0.210	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229
San Mateo Point	0.487	0.545	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033
San Onofre	0.476	0.419	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087
Total F&W 8	1.166	1.174	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349
Horno Canyon	0.083	0.018	0.081	—	0.008	0.125	0.055	0.019	0.010	0.011
Barn Kelp	0.858	0.926	0.500	0.095	0.442	0.868	0.741	0.085	0.133	0.096
Santa Margarita	—	—	—	—	—	0.080	—	—	—	—
Total F&W 7	0.941	0.944	0.581	0.095	0.450	1.073	0.795	0.104	0.143	0.107
North Carlsbad	0.108	0.135	0.078	0.017	0.052	0.125	0.086	0.047	—	0.004
Agua Hedionda	0.080	0.092	0.031	0.022	0.046	0.102	0.065	0.016	—	—
Encina Power Plant	0.306	0.215	0.176	0.084	0.216	0.352	0.221	0.159	0.009	0.025
Carlsbad State Beach	0.121	0.127	0.069	0.024	0.058	0.178	0.065	0.061	—	0.001
Total F&W 6	0.615	0.569	0.354	0.147	0.372	0.757	0.437	0.282	0.009	0.031
Leucadia	0.421	0.429	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010
Encinitas	0.346	0.205	0.128	0.124	0.260	0.231	0.112	0.113	0.009	0.003
Cardiff	0.484	0.520	0.213	0.395	0.459	0.590	0.299	0.318	0.024	0.003
Solana Beach	0.823	0.505	0.328	0.504	0.442	0.606	0.504	0.316	0.138	0.029
Del Mar	0.057	0.044	0.038	0.074	0.024	0.056	0.027	0.034	—	—
Torrey Pines	0.001	0.0004	0.003	0.031	0.034	0.081	—	—	—	—
Total F&W 5	2.133	1.703	0.925	1.247	1.452	2.106	1.221	1.195	0.204	0.045
La Jolla F&W 4	4.145	2.274	2.776	2.565	1.569	4.006	2.790	2.968	0.927	0.694
Point Loma F&W 3&2	6.623	4.909	3.977	4.212	5.340	5.127	5.121	5.806	3.037	1.787
Imperial Beach F&W 1	1.895	0.861	0.004	0.152	0.333	0.526	1.183	1.576	0.217	—
TOTAL	18.706	13.476	11.545	10.379	11.882	17.064	14.053	12.667	5.134	3.277



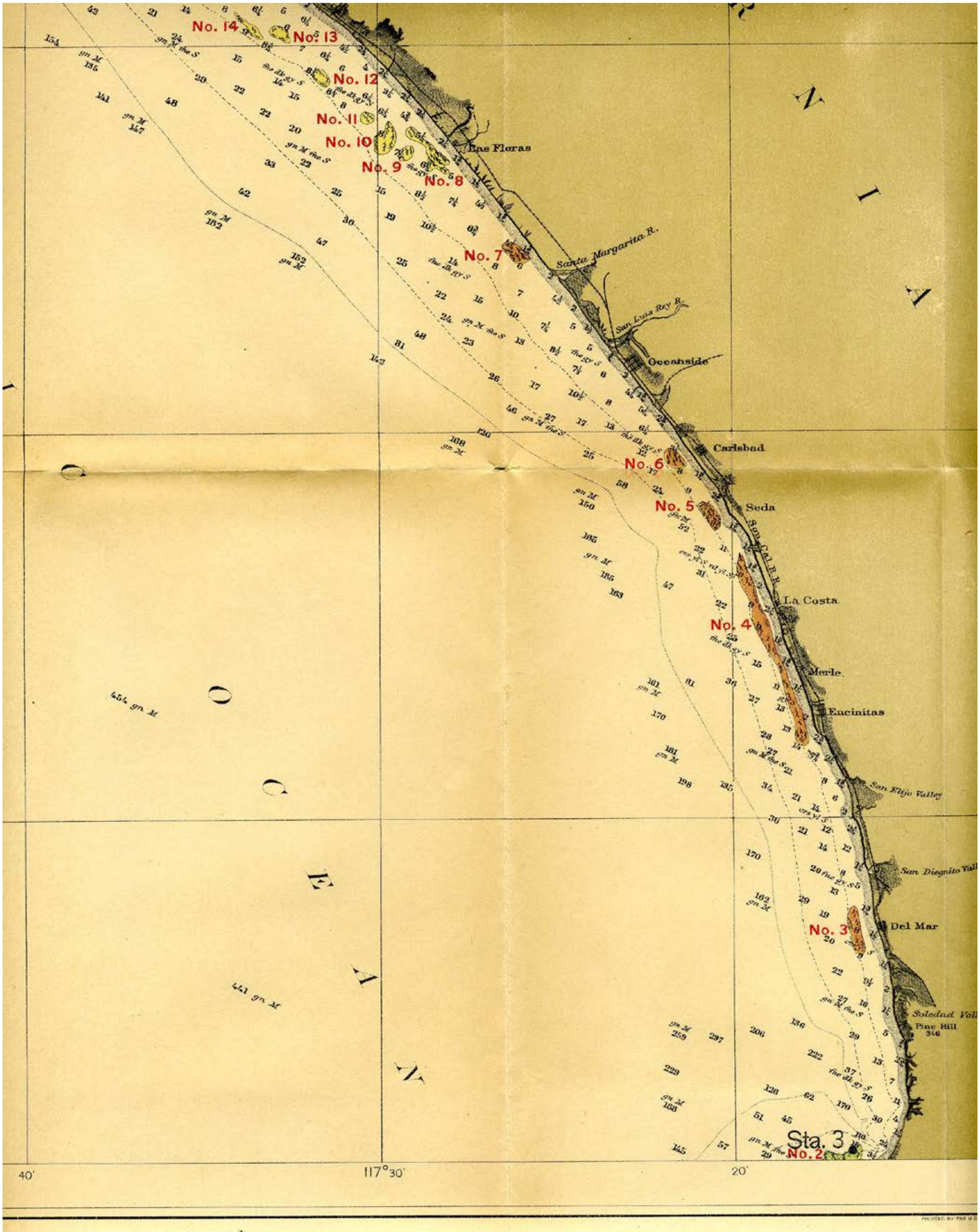
Appendix B.5 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.



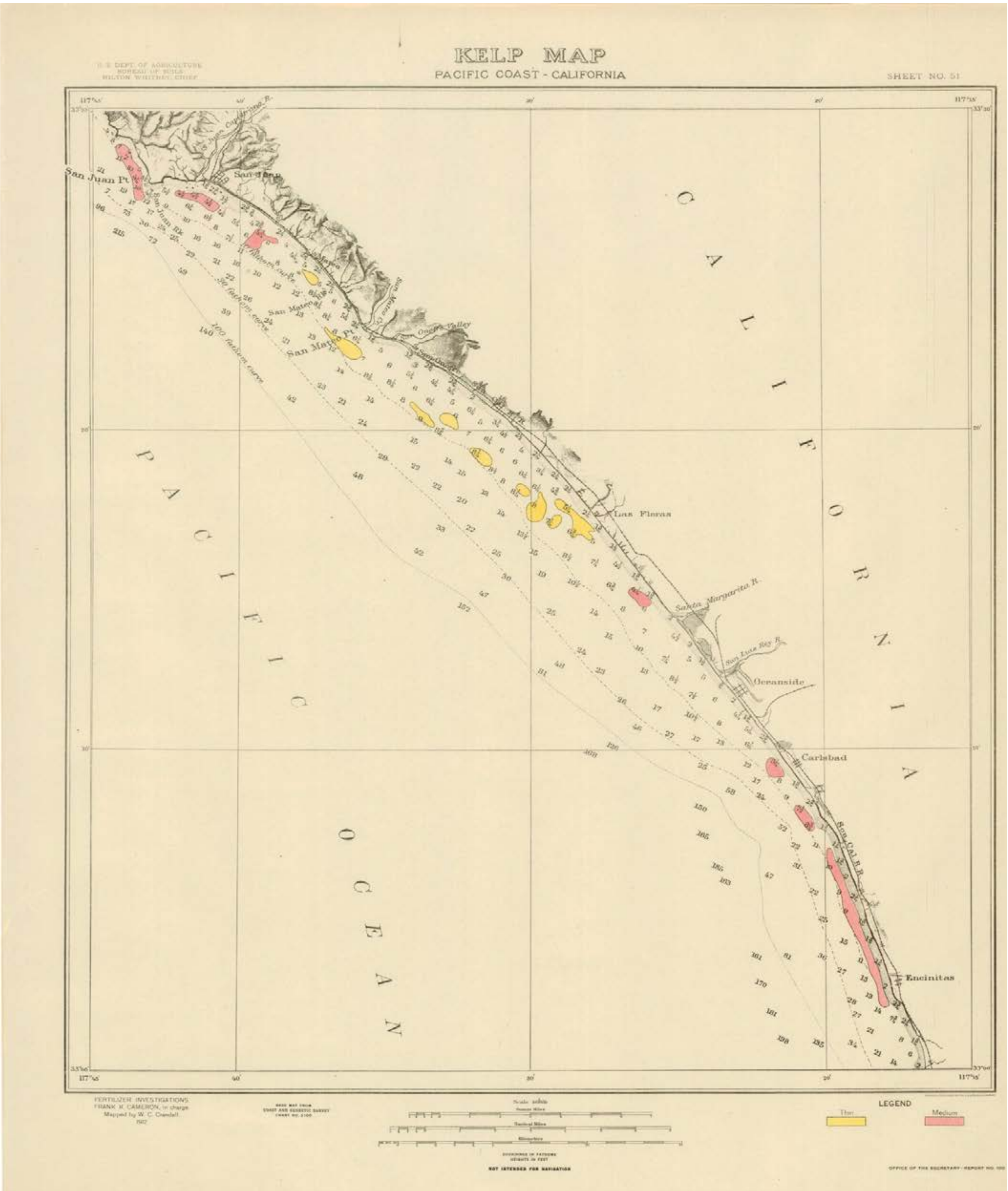
Appendix B.6 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.



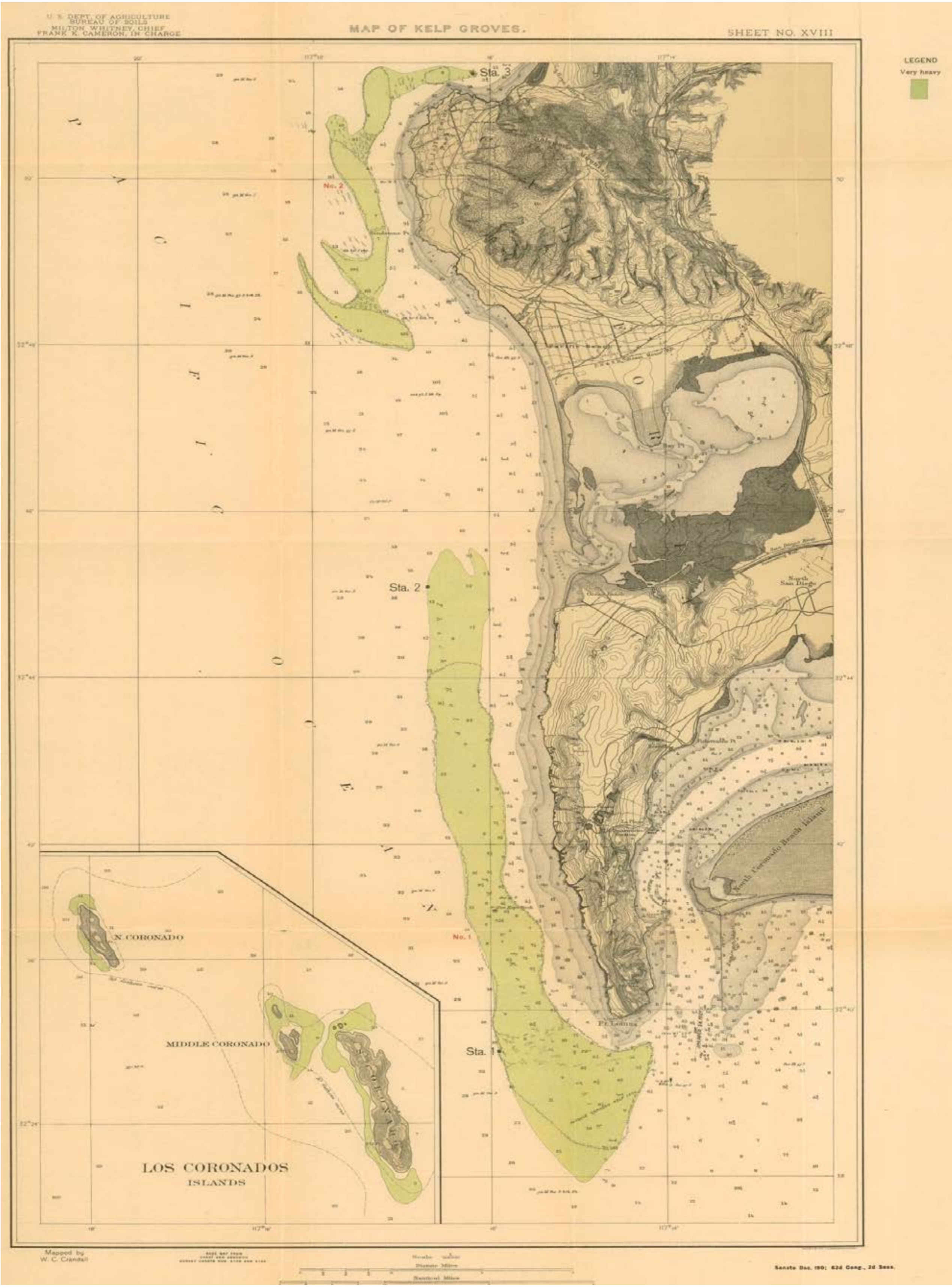
Appendix B.7 Crandall's 1911 kelp bed survey Newport to San Onofre.



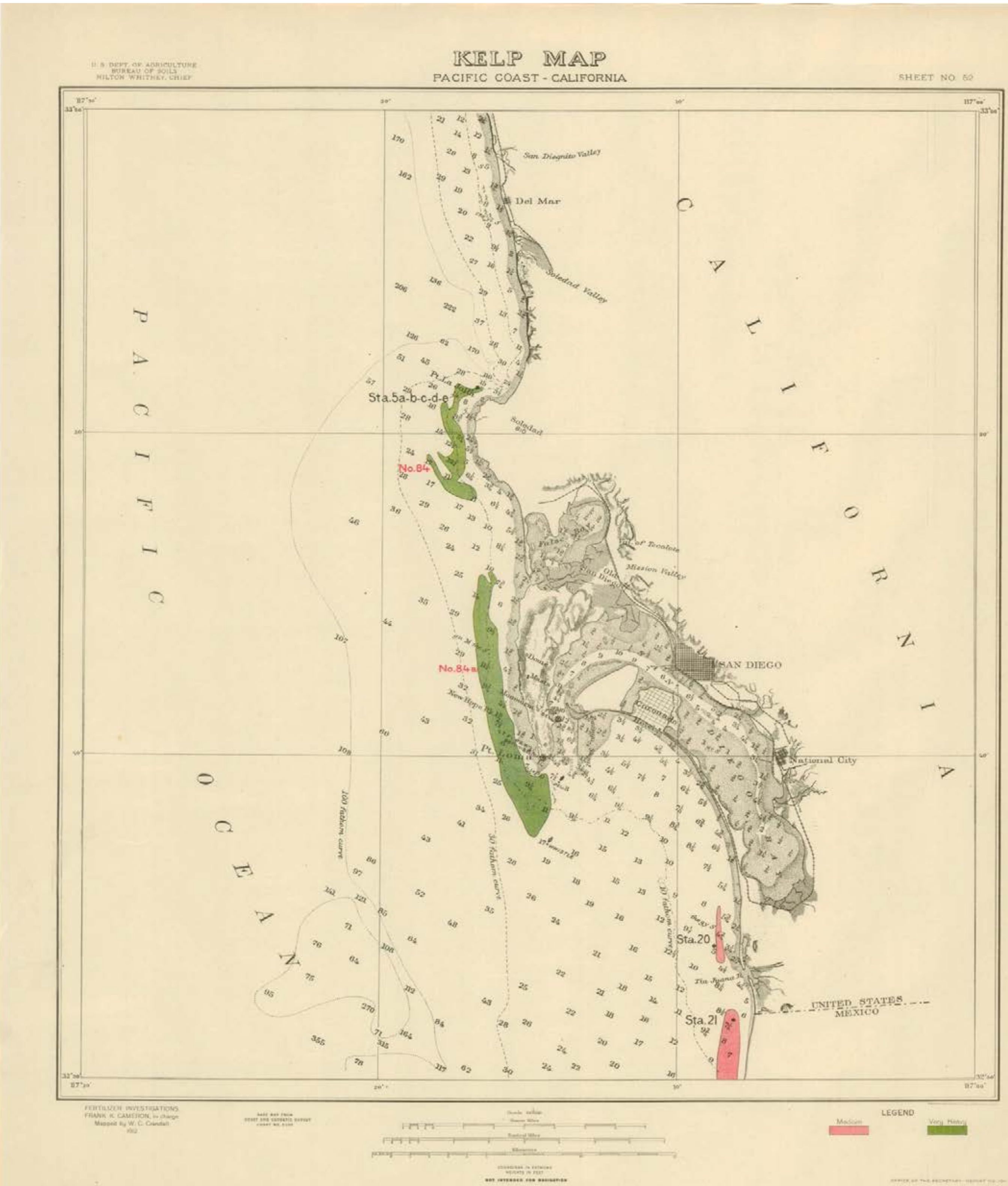
Appendix B.8 Crandall's 1911 kelp bed survey San Onofre to Del Mar.



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



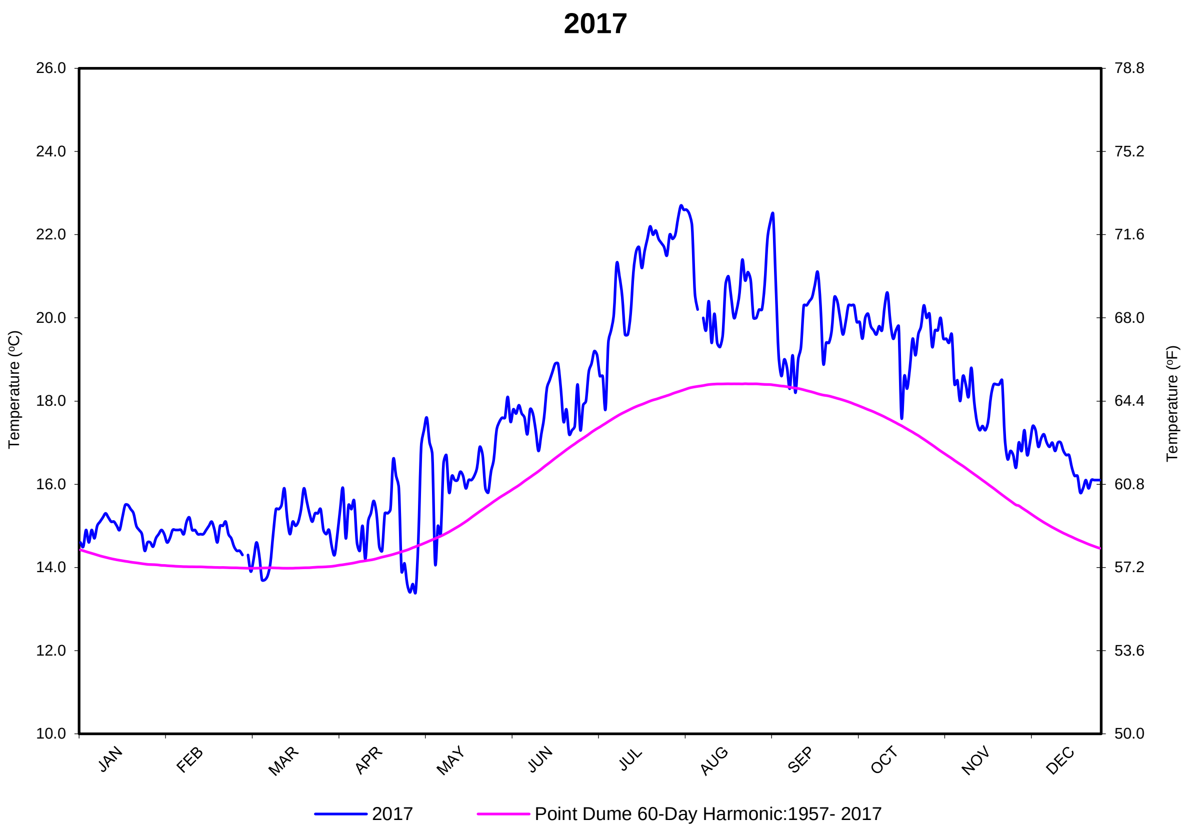
Appendix B.10 Crandall's 1911 kelp bed survey La Jolla to Point Loma.



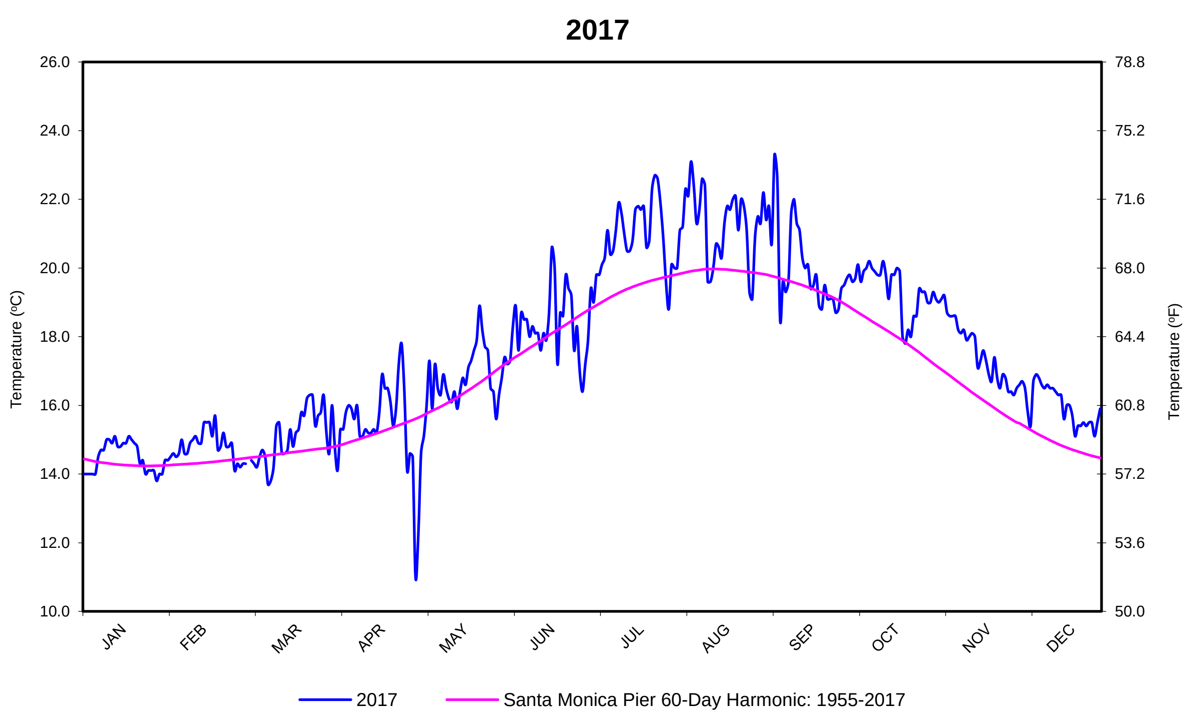
Appendix B.11 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

APPENDIX C

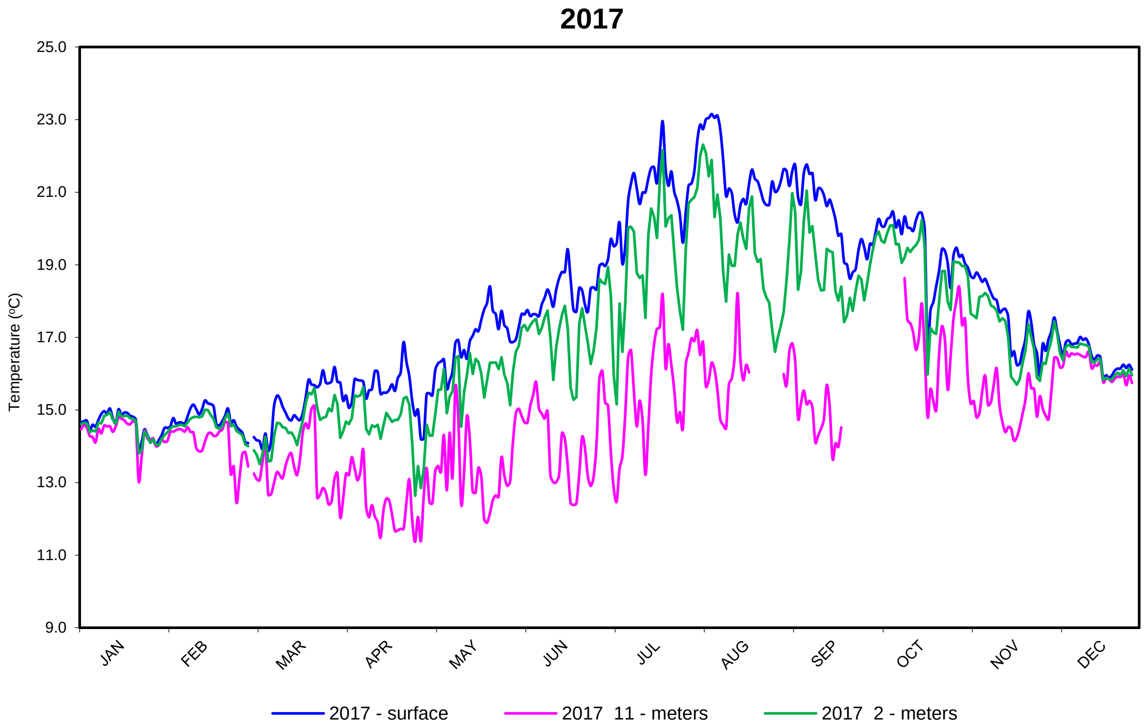
Sea Surface Temperatures



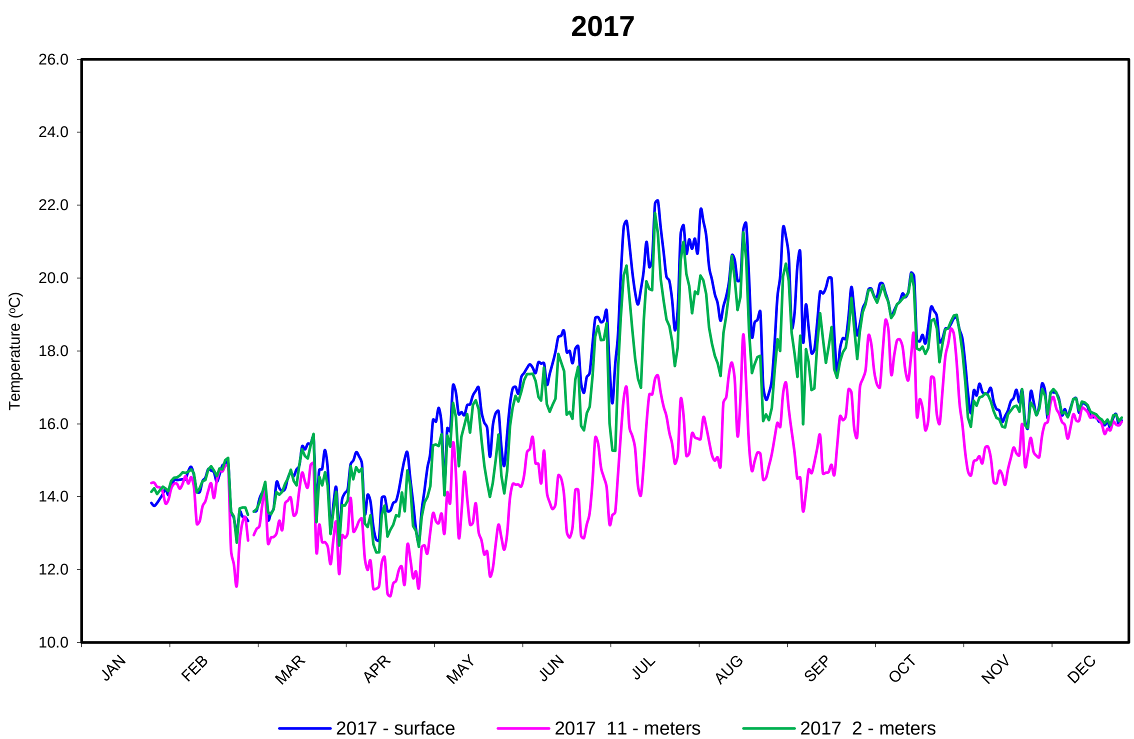
Appendix C.1 Daily sea surface temperatures (SST) at Point Dume for 2017.



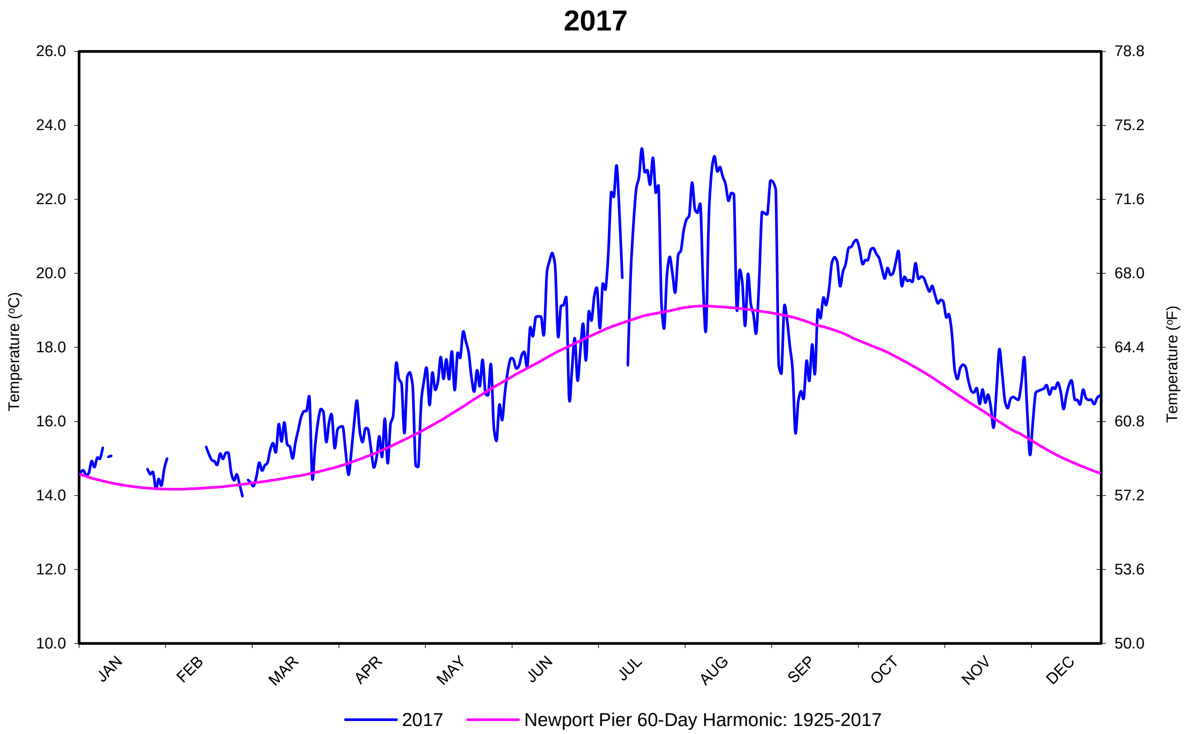
Appendix C.2 Daily sea surface temperatures (SST) at Santa Monica Station Buoy for 2017.



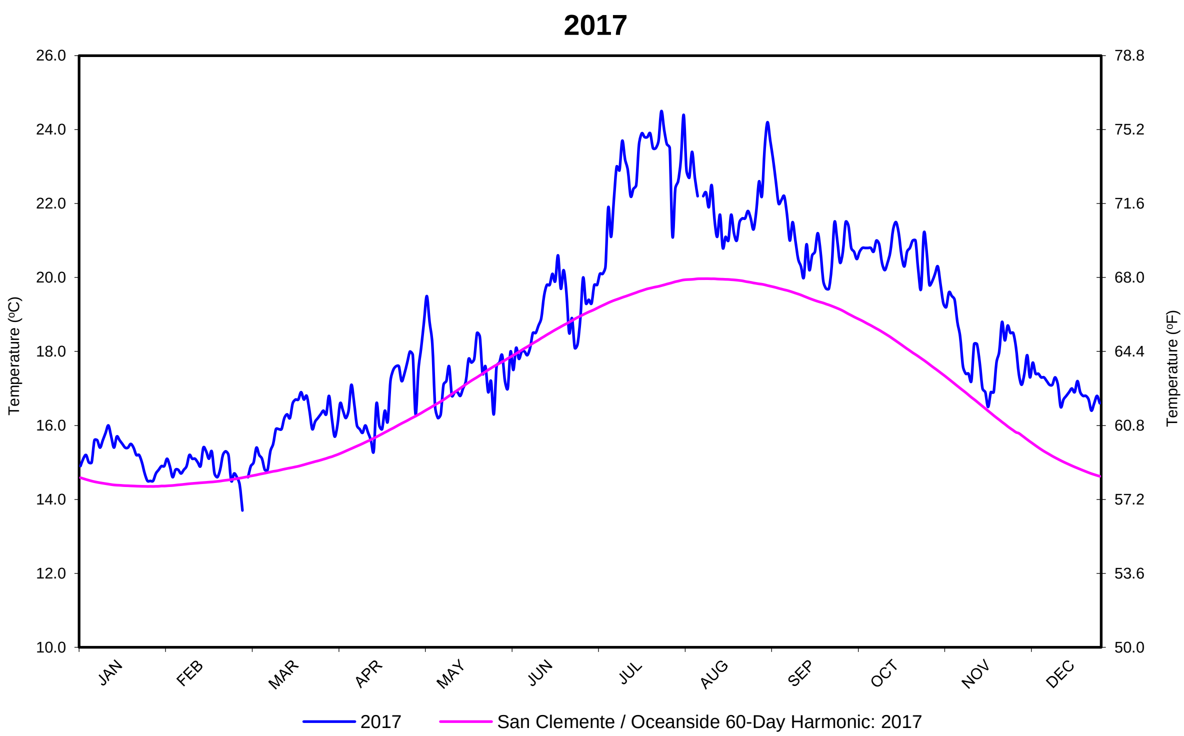
Appendix C.3 Daily sea surface temperatures (SST) at Station Palos Verdes North for 2017.



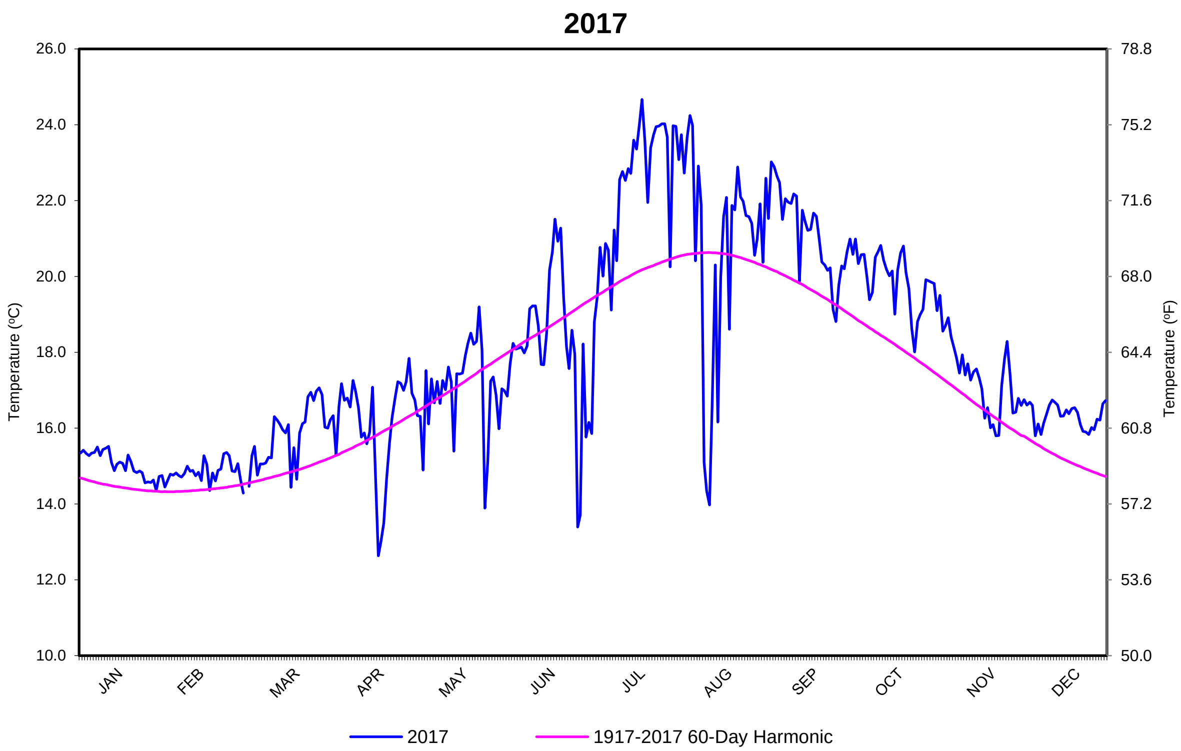
Appendix C.4 Daily sea surface temperatures (SST) at Station Palos Verdes South for 2017.



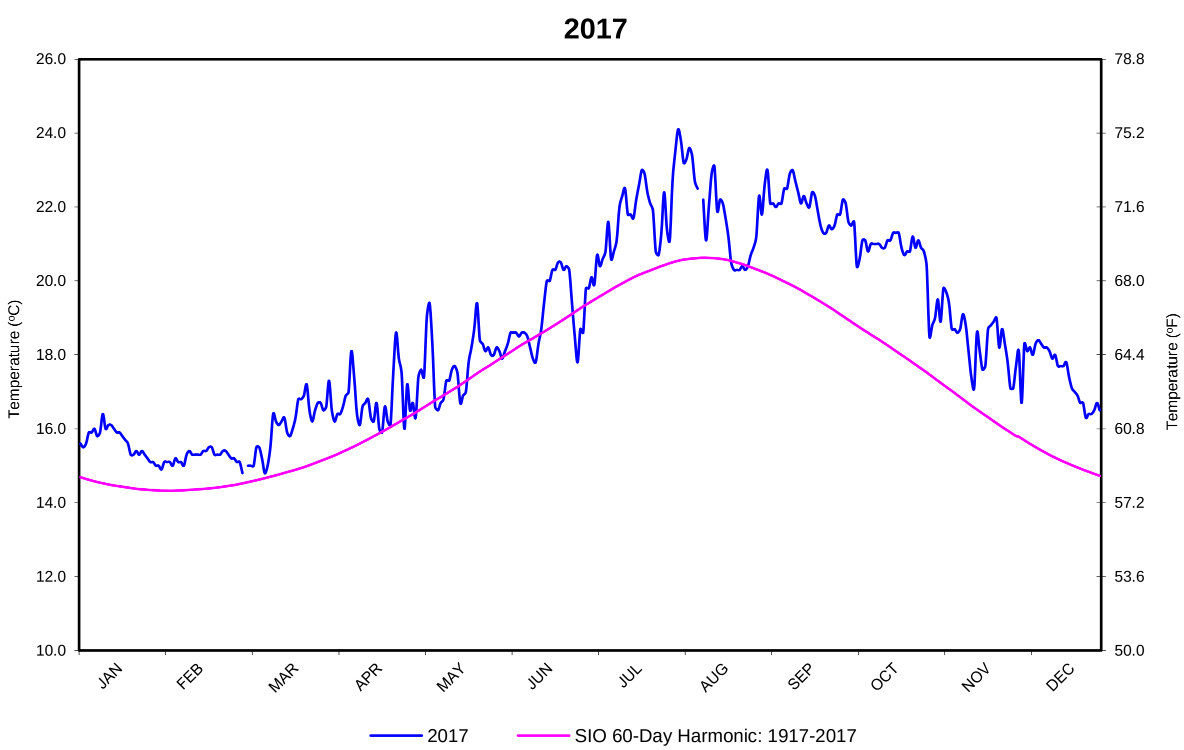
Appendix C.5 Daily sea surface temperatures (SST) at Newport Pier for 2017.



Appendix C.6 Daily sea surface temperatures (SST) at Oceanside for 2017.



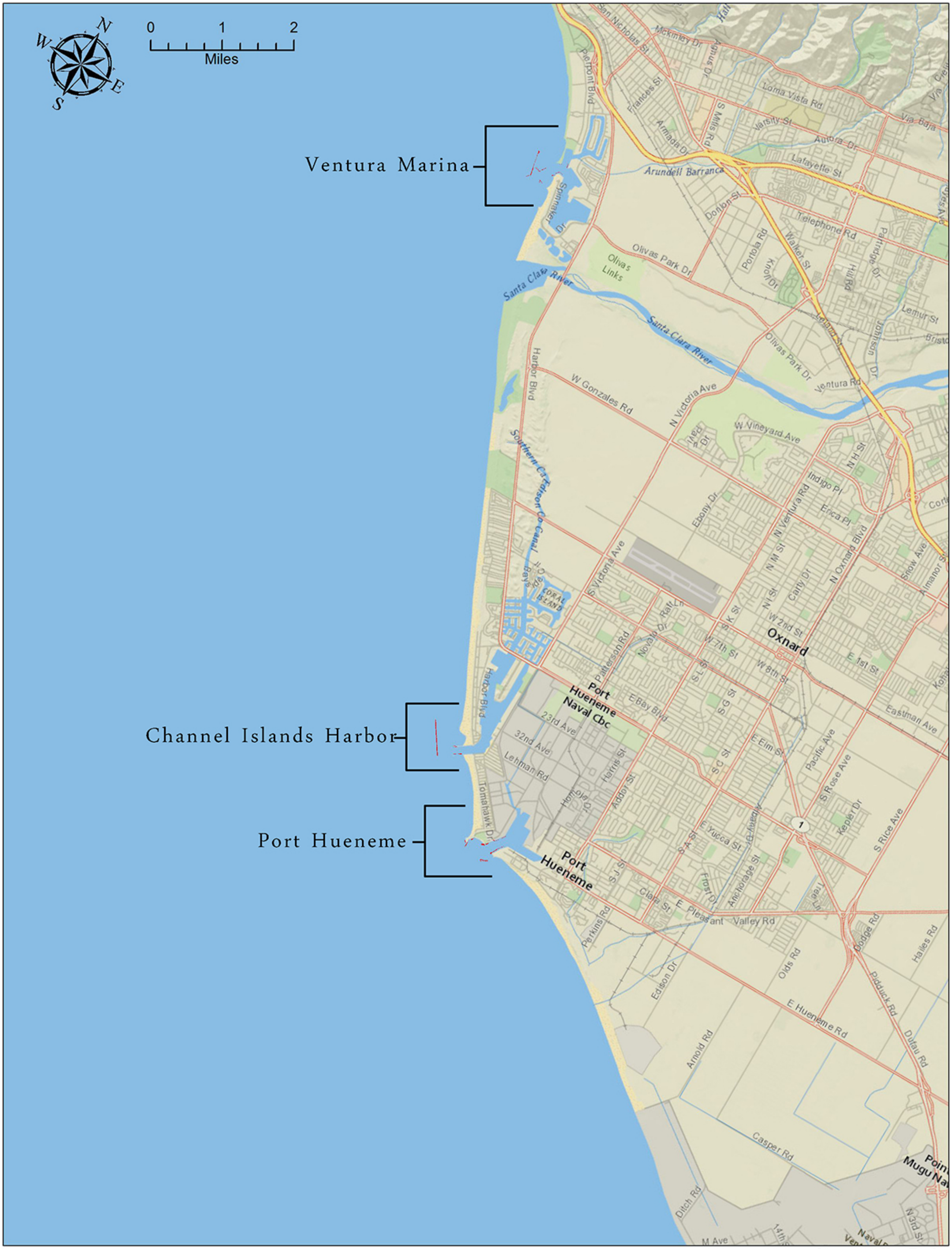
Appendix C.7 Daily sea surface temperatures (SST) at Scripps Pier for 2017.



Appendix C.8 Daily sea surface temperatures (SST) at Point Loma South for 2017.

APPENDIX D

Flight Path
Flight Data Reports
Field Data Sheets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Port Hueneme
Oxnard
Port Hueneme Naval Cbc
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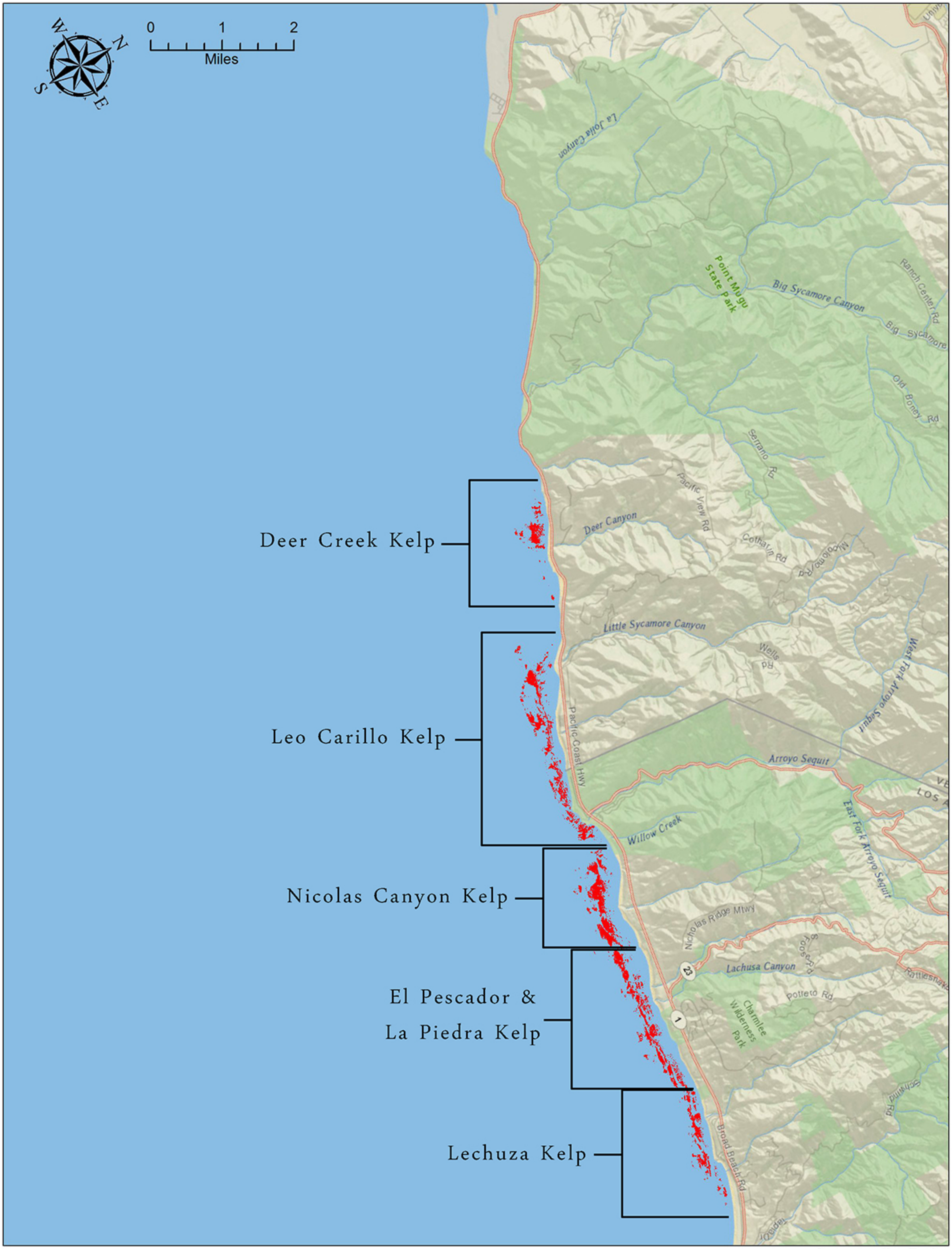
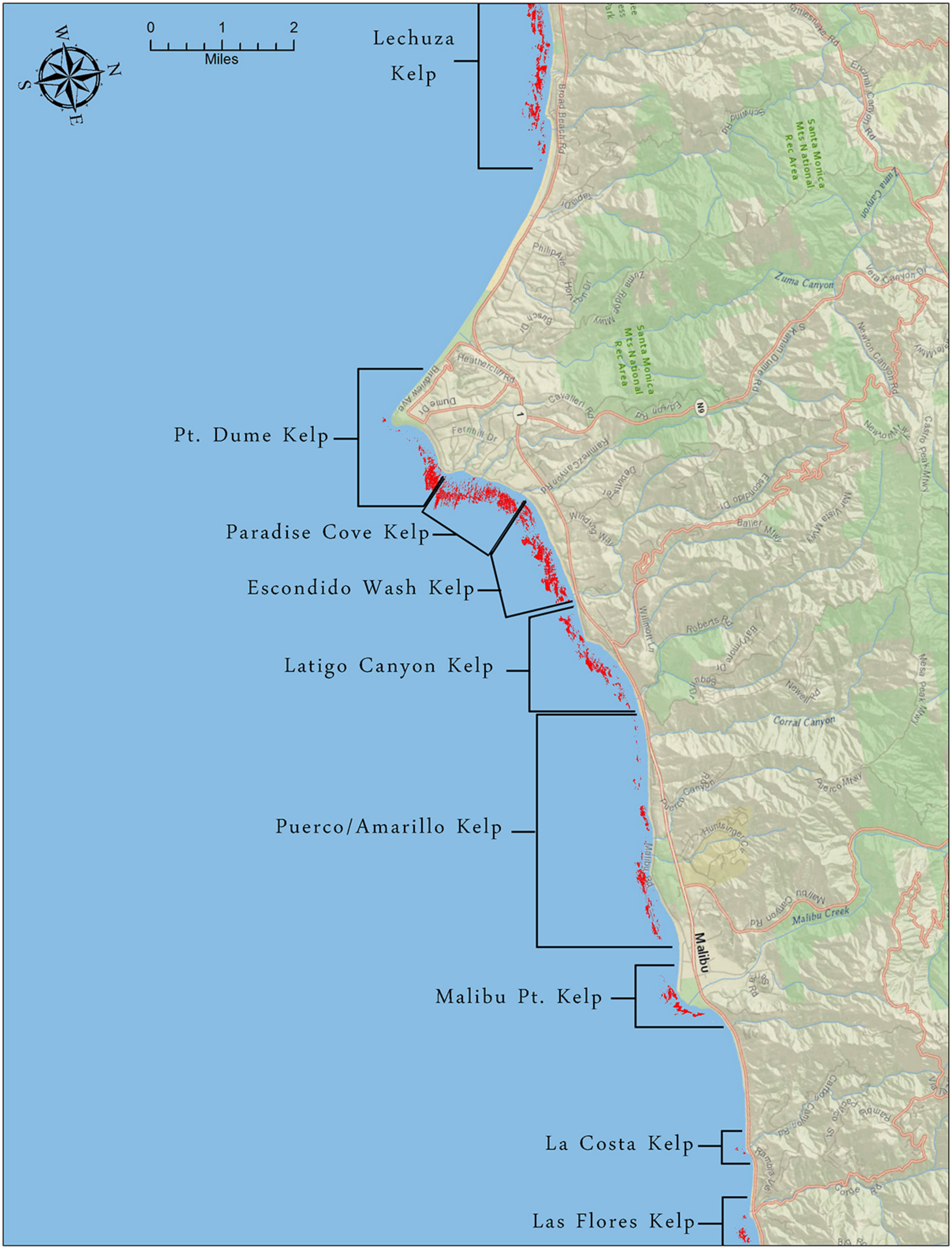
Santa Clara River
Santa Clara River
Arundell Barranca
Olivas Links
Southern Ca Edison Co Canal
Coral Island
Harbor Blvd
Harbor Blvd
Pierpont Blvd
Spinnaker Dr
Tomahawk Dr
W Gonzales Rd
N Victoria Ave
S Victoria Ave
Olivas Park Dr
Telephone Rd
Loma Vista Rd
Ventura Rd
W Vineyard Ave
E Hueneme Rd
E Pleasant Valley Rd
Casper Rd
Edison Dr
Arnold Rd
Ditch Rd
S Rose Ave
S Rice Ave
N Oxnard Blvd
Patterson Rd
E Bay Blvd
23rd Ave
32nd Ave
Lehman Rd
Perkins Rd
Olds Rd
Pidduck Rd
Dufau Rd
Hailes Rd
Eastman Ave
Telephone Rd
Lafayette St
Varsity St
Aurora Dr
Via Baja
Mckinley Dr
San Nicholas St
Frances St
Armada Dr
S Mills Rd
Donlon St
Portola Rd
Walker St
Johnson Dr
Lemur St
Ebony Dr
Indigo Pl
Erica Pl
Snow Ave
Almanor St
W 2nd St
W 7th St
W 8th St
E 1st St
E Elm St
E Yucca St
Clara St
Pacific Ave
Kepler Dr
Anchorage St
Frost Dr
Harris St
Addor St
Novato Dr
Ralf Ln
Dodge Rd
Casper Rd
M Ave
Point Mugu

Appendix D.1

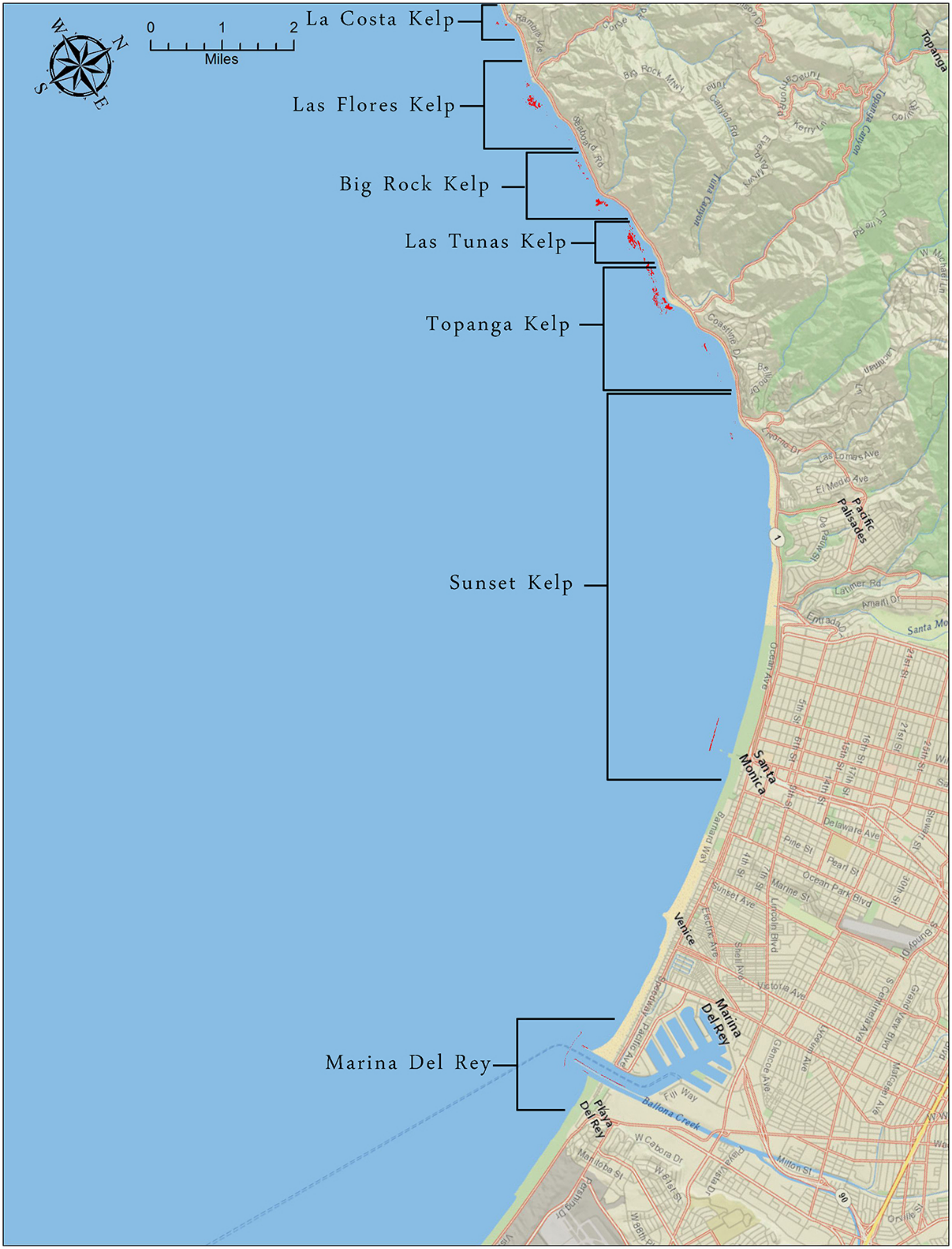


N
E
S
W
0
1
2
Miles
Deer Creek Kelp
Leo Carillo Kelp
Nicolas Canyon Kelp
El Pescador &
La Piedra Kelp
Lechuza Kelp
La Jolla Canyon
Point Mugu State Park
Big Sycamore Canyon
Ranch Center Rd
Big Sycamore
Old Boney Rd
Serrano Rd
Pacific View Rd
Deer Canyon
Cotharin Rd
Mulholland Rd
Little Sycamore Canyon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

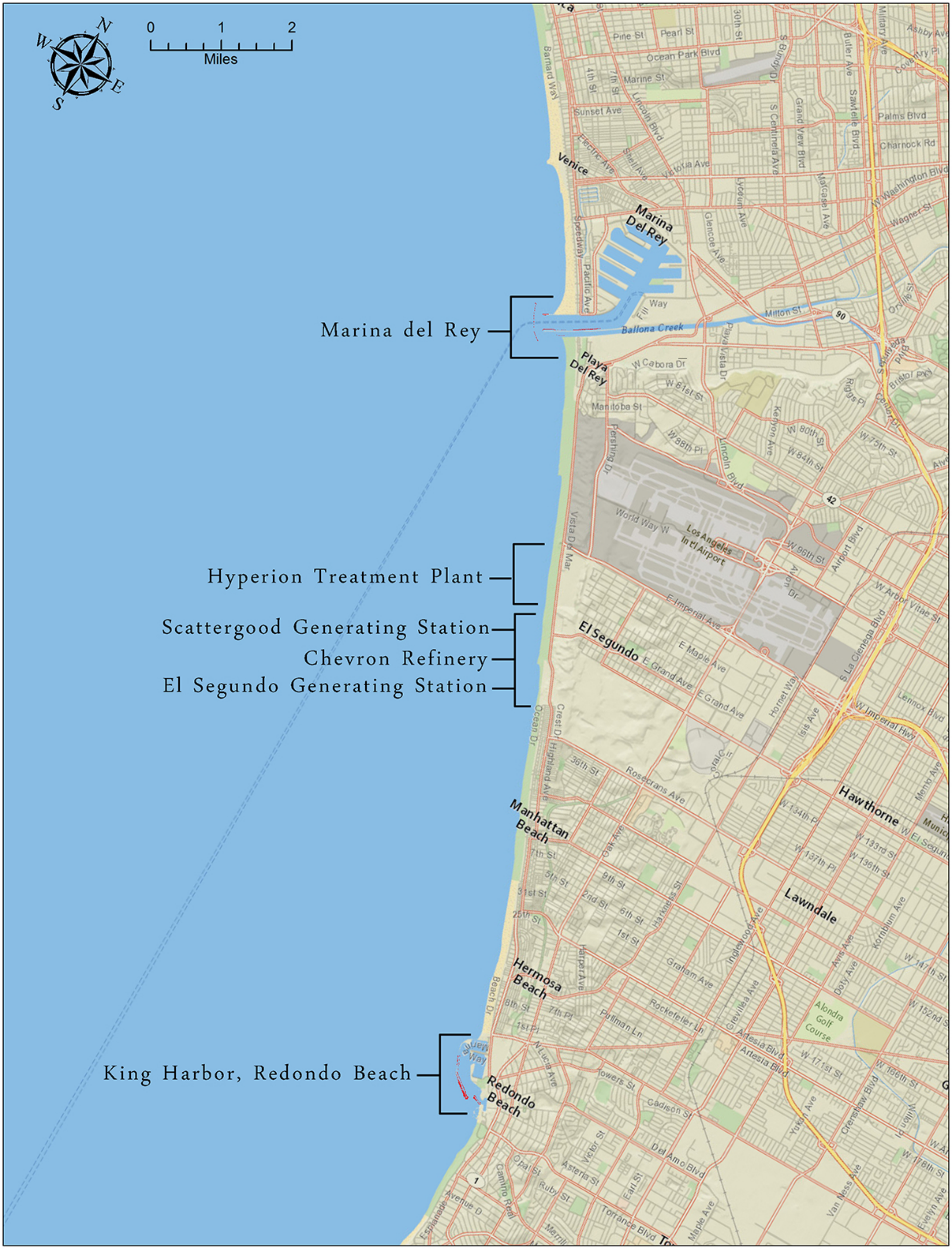
Appendix D.2


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

Appendix D.3



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


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

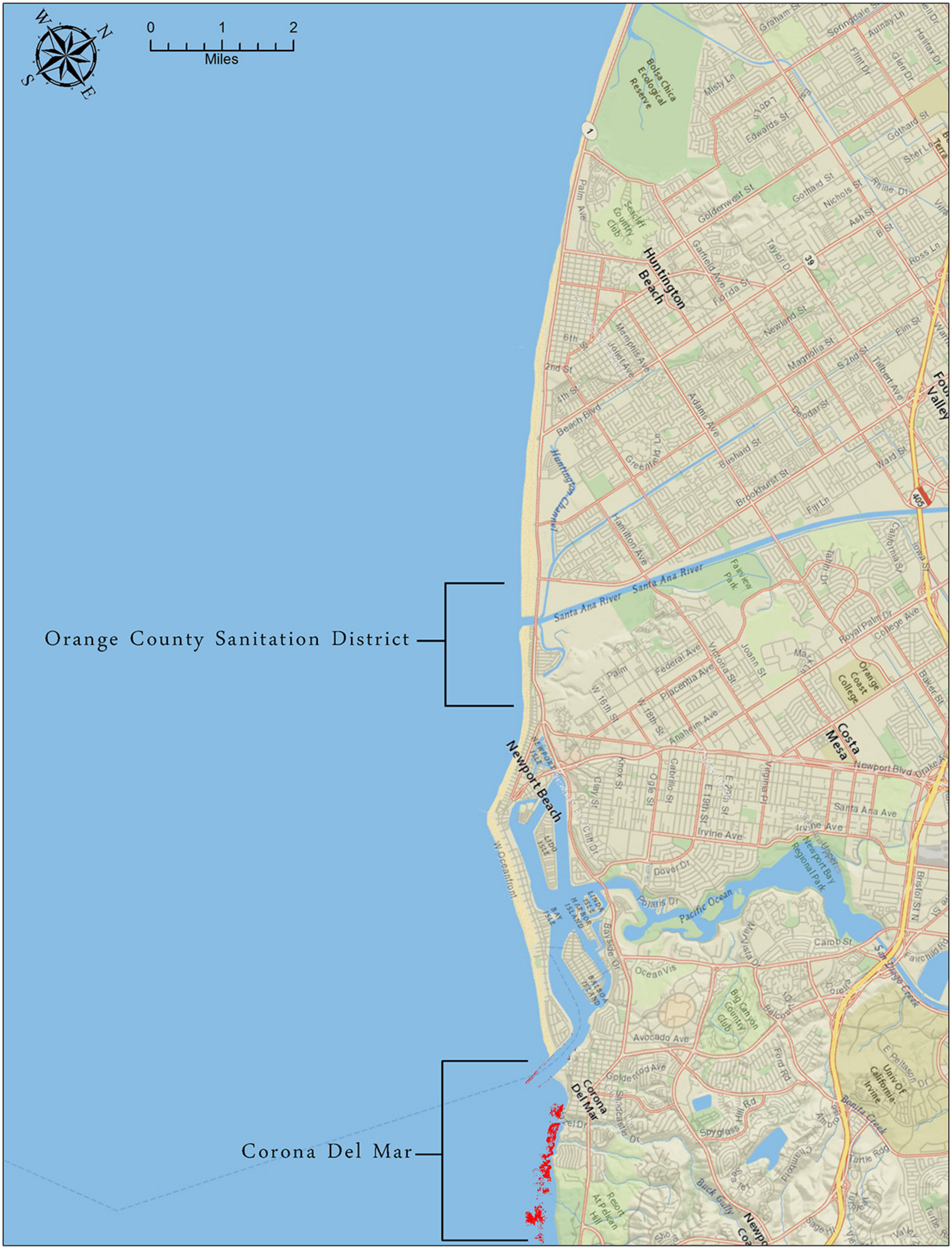
Appendix D.5


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

Appendix D.6

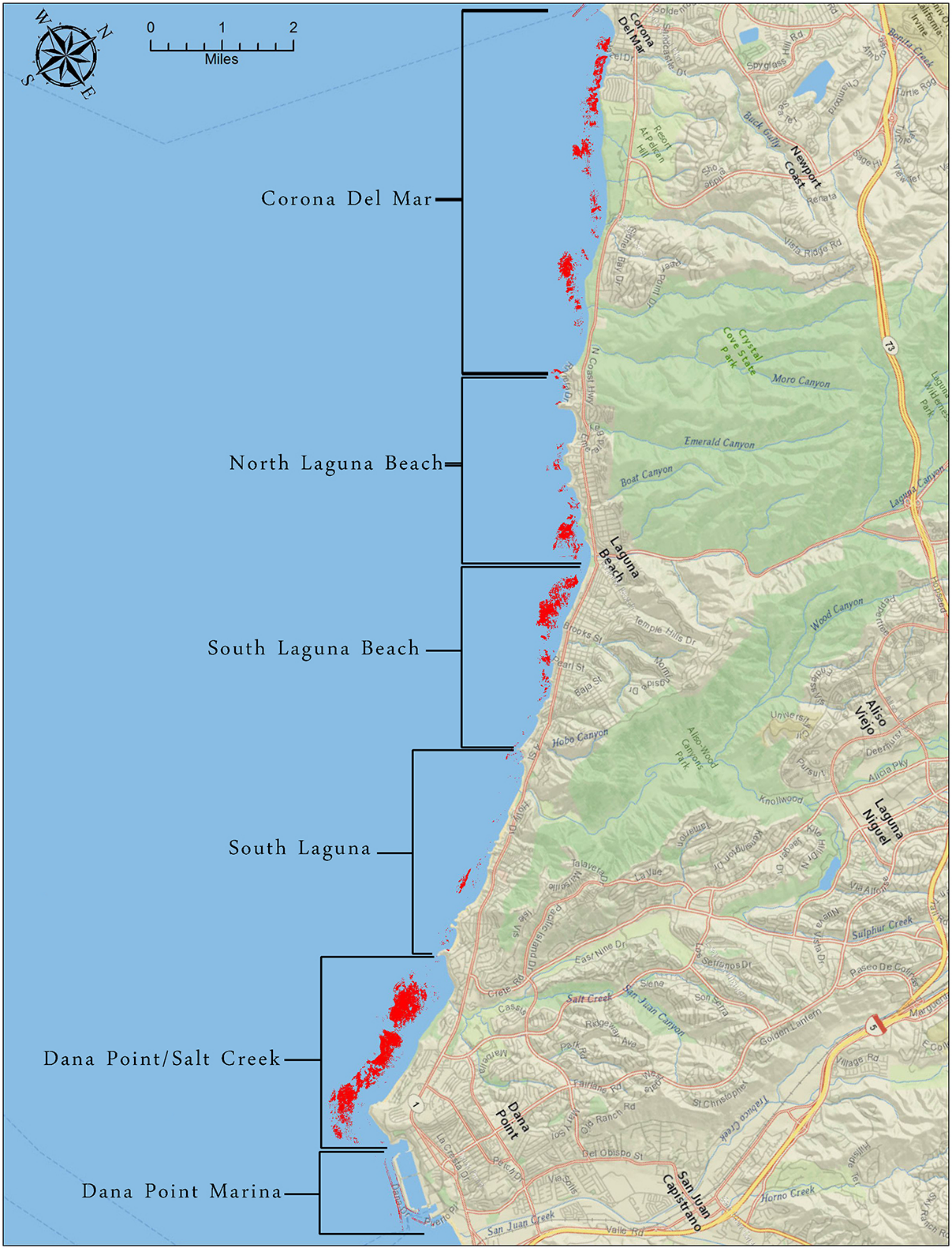

0
1
2
Miles
POLA/POLB
San Pedro
Wilmington
Los Angeles Harbor
Long Beach Harbor
Long Beach Harbor
Terminal Island
Pacific Ocean
Seal Beach
Surfside
Sunset Beach
Los Angeles River

Appendix D.7



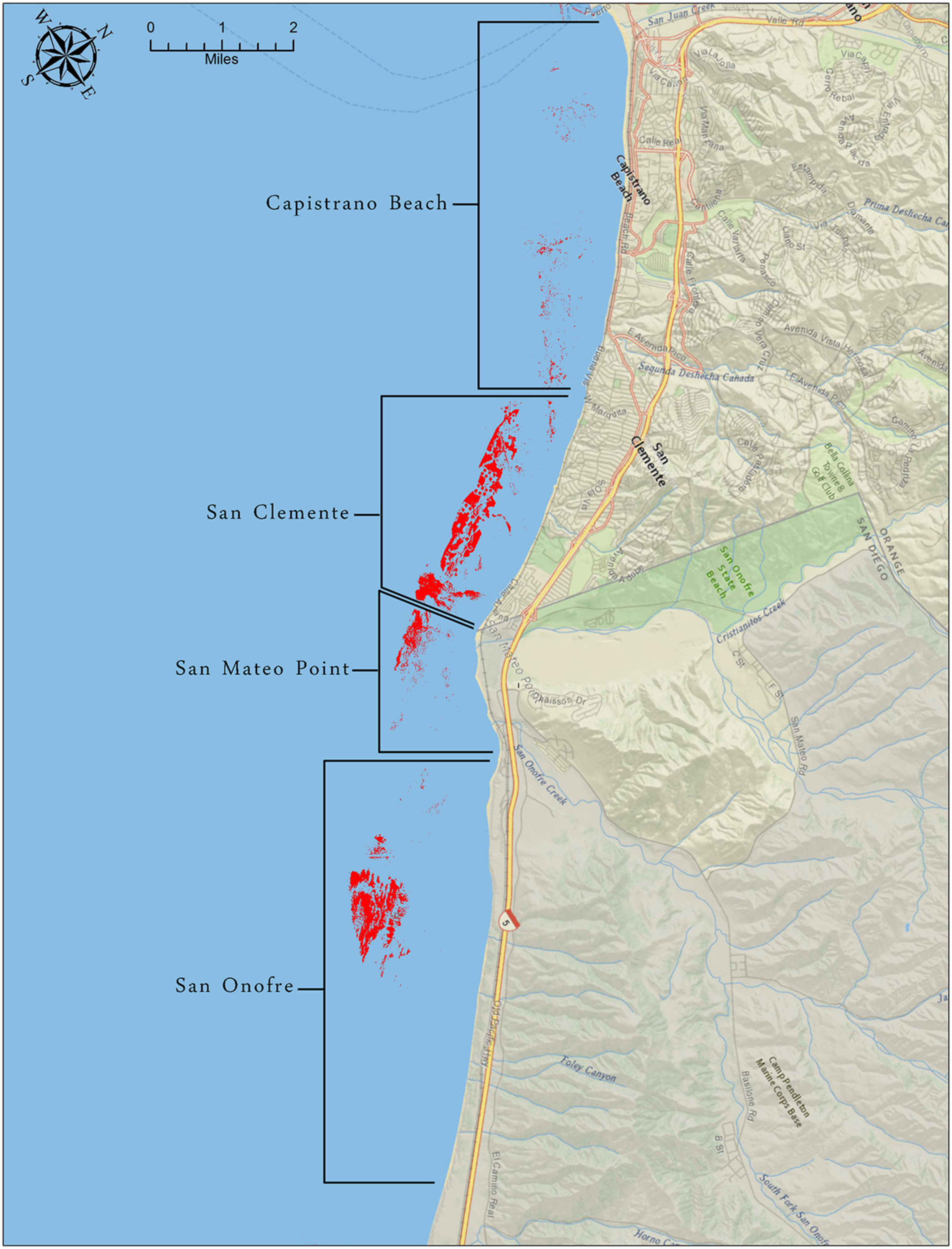
0
1
2
Miles
Orange County Sanitation District
Corona Del Mar
Huntington Beach
Newport Beach
Costa Mesa
Corona Del Mar
Bolsa Chica Ecological Reserve
Seacliff Country Club
Santa Ana River
Fairview Park
Orange Coast College
Pacific Ocean
Big Canyon Country Club
Resort At Pelican Hill

Appendix D.8

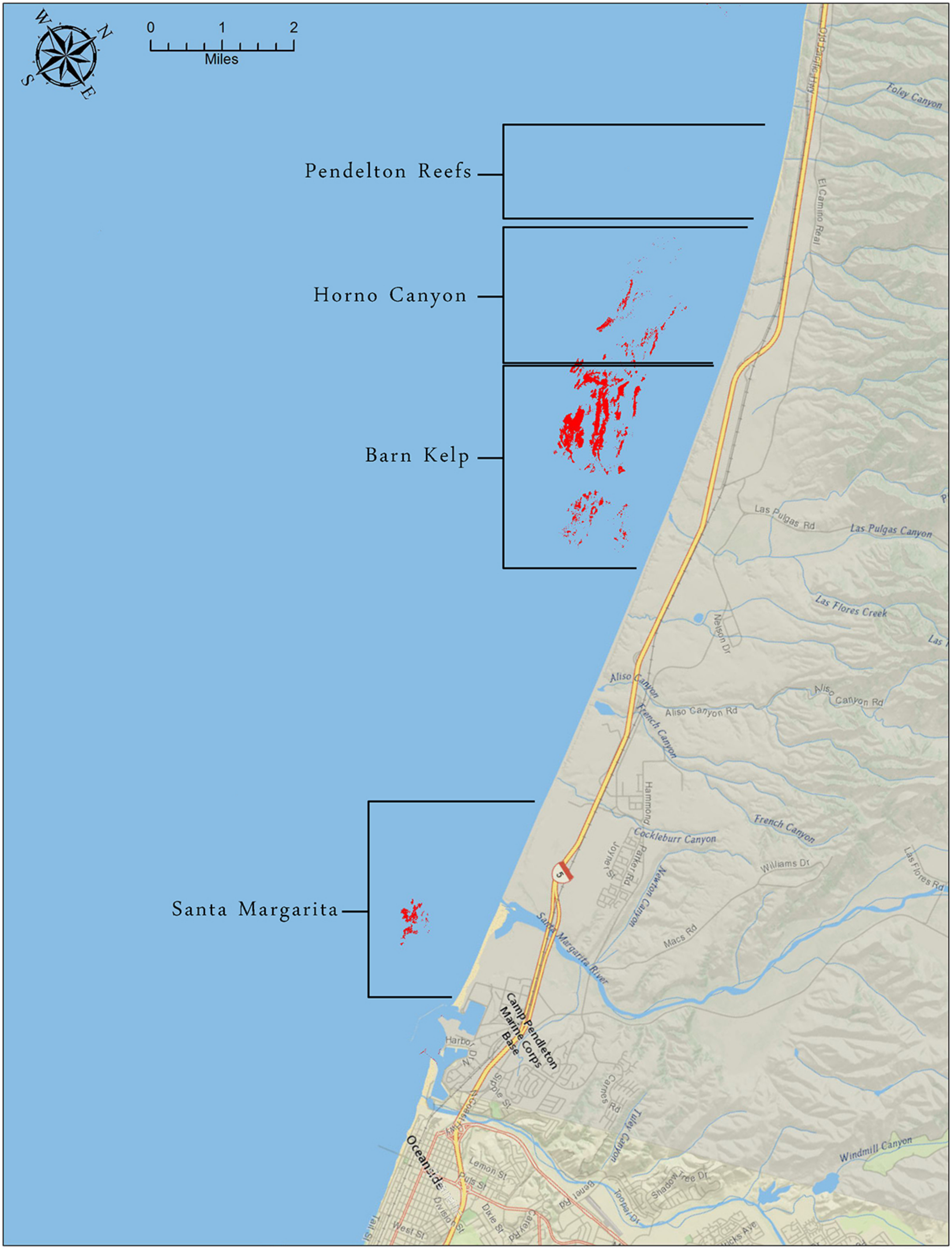


N
E
S
W
0
1
2
Miles
Corona Del Mar
North Laguna Beach
South Laguna Beach
South Laguna
Dana Point/Salt Creek
Dana Point Marina
Corona Del Mar
Newport Coast
Crystal Cove State Park
Moro Canyon
Emerald Canyon
Boat Canyon
Laguna Beach
Wood Canyon
Hobo Canyon
Aliso-Wood Canyons Park
Aliso Viejo
Laguna Niguel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

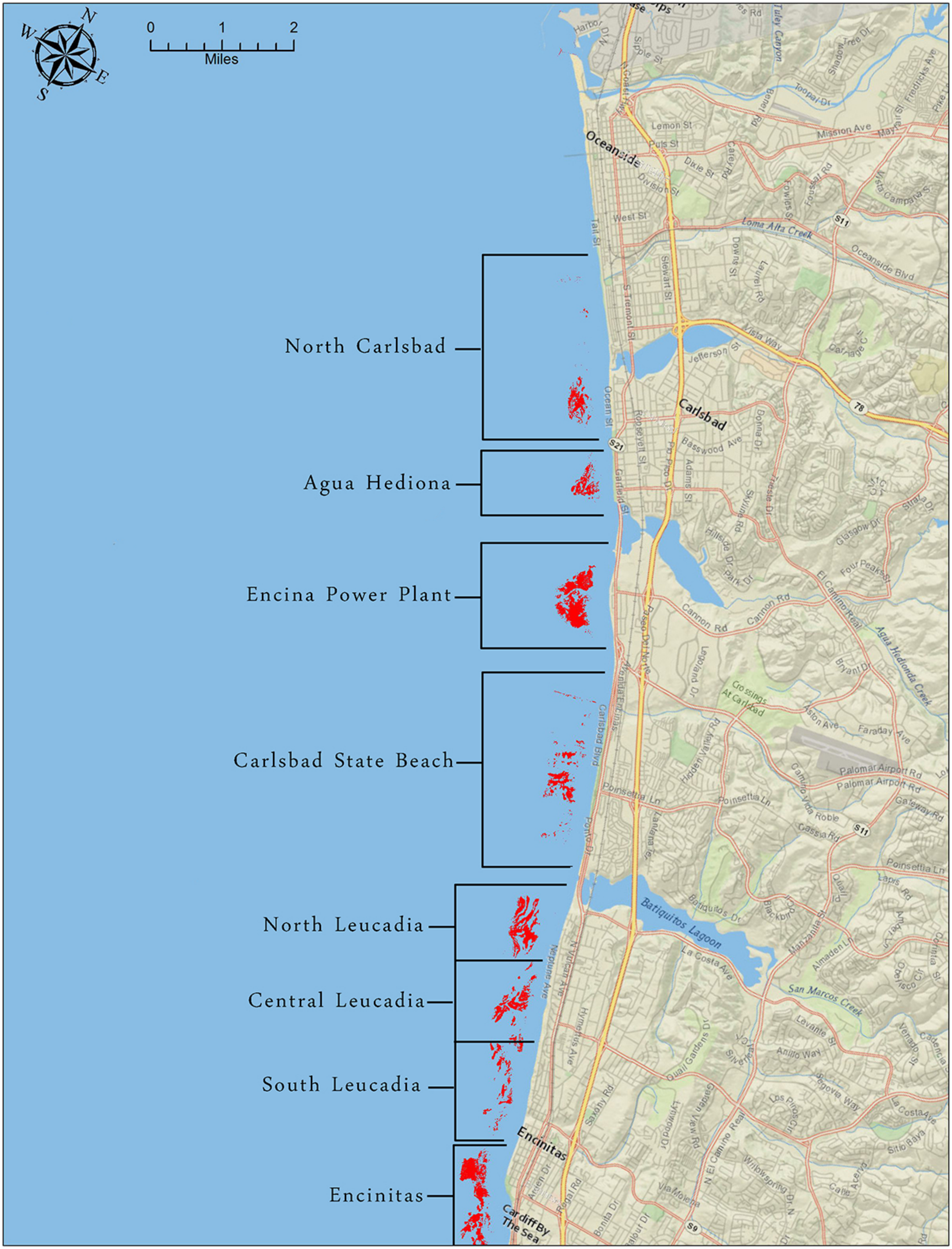
Appendix D.9



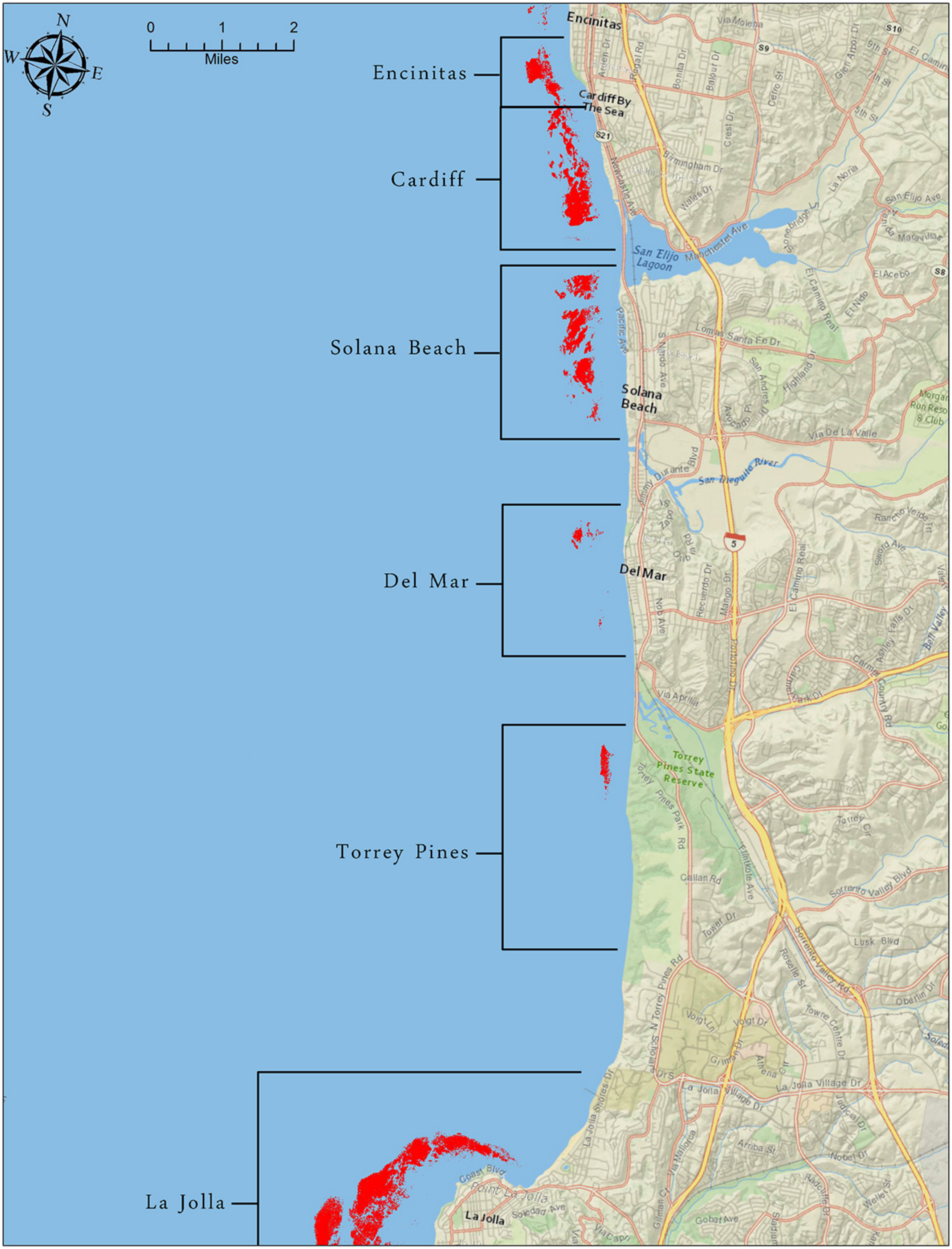
Appendix D.10

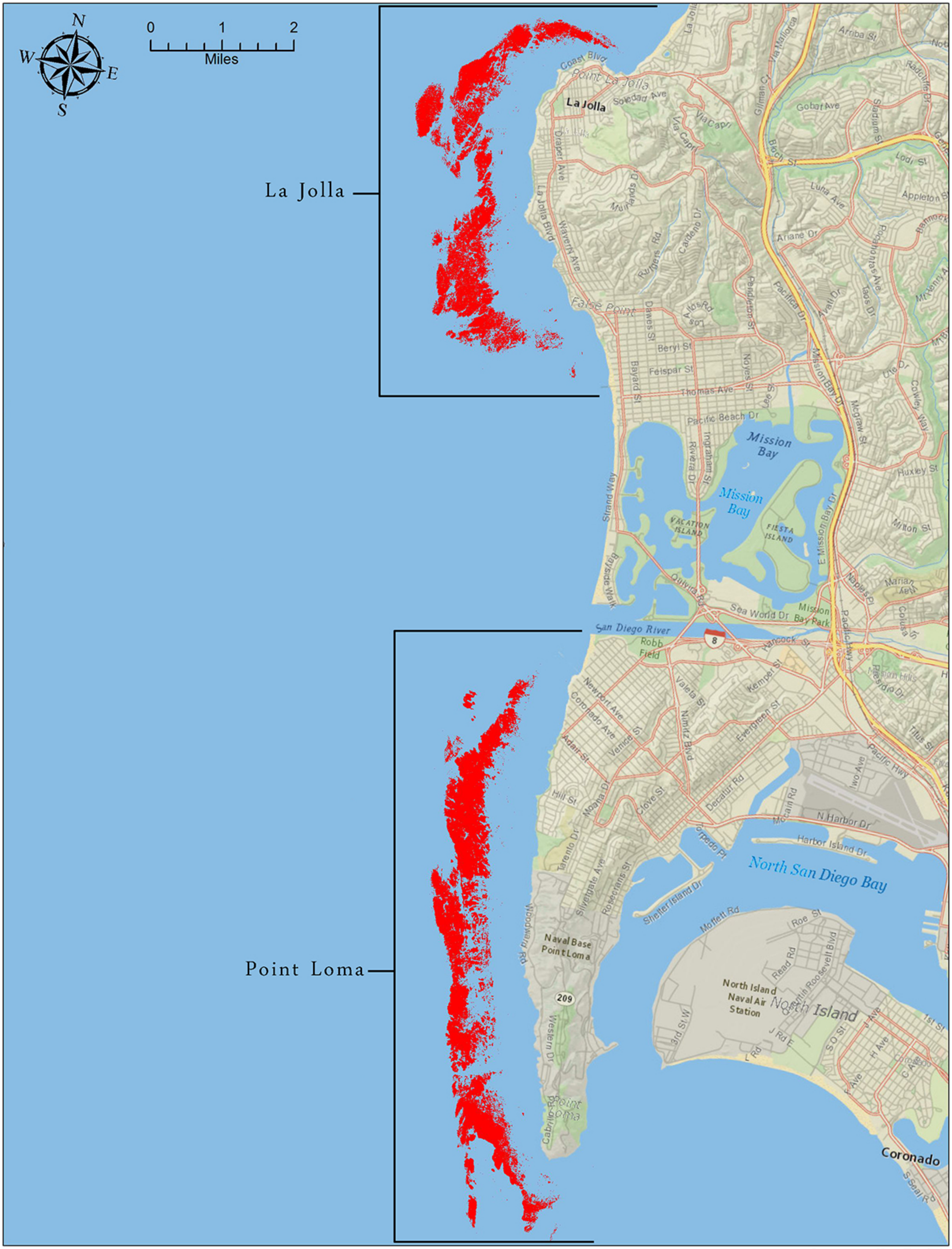


Appendix D.11

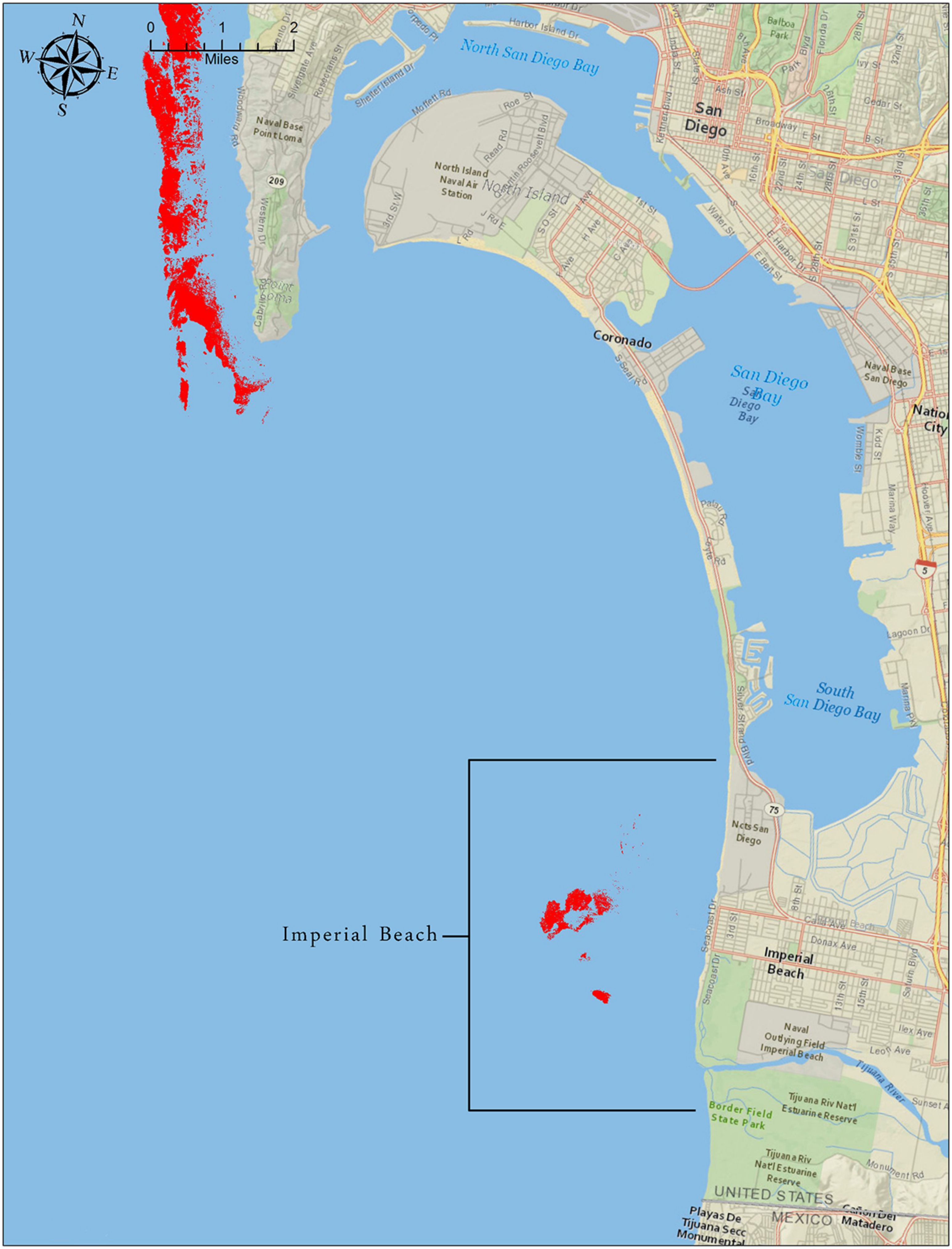


Appendix D.12


N
W
E
S
0
1
2
Miles
Encinitas
Cardiff
Solana Beach
Del Mar
Torrey Pines
La Jolla
Cardiff By The Sea
San Elijo Lagoon
San Dieguito River
Torrey Pines State Reserve
Point La Jolla
Coast Blvd
Via De La Valle
Lomas Santa Fe Dr
Manchester Ave
El Camino Real
Sorrento Valley Blvd
La Jolla Village Dr
N Torrey Pines Rd
Carmel Valley Rd



Appendix D.14



Appendix D.15

Appendix D.16A Flight record for March 29, 2017

Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Curtis, Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	3/17
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	3/29/17
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	4/17

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 3/29/17**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**March 29, 2017**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1358-1540
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.7' (+) to 0.2' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	The kelp canopies within the survey range were observed to have a significantly increased surface extent when compared with the December 2016 survey. A "red tide" was observed south of Del Mar to the Mexican Border and was easily distinguished from the kelp recorded on the imagery.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ____________________ Bob Van Wagenen, Director

Copy To:

Appendix D.16B Flight record for June 27, 2017

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:	Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	6/17
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	6/27/17
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	7/17

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 6/27/17**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**June 27, 2017**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1648-1759
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.7' (+) to 2.2' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Carlsbad. Coastal fog from Carlsbad to the Mexican border prevented imagery acquisition. The missing range will be surveyed when weather conditions permit.	
Target Resource Observations	Kelp Canopies	Many of the kelp canopies within the survey range were observed to have a significantly increased surface extent when compared with the March 2017 survey.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent mapping of the kelp resource. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ____________________ Bob Van Wagenen, Director

Copy To:

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:	Shane Beck	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	9/17
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	9/26/17
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	10/17

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 9/26/17**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach
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: September 26, 2017

Survey Type		Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	5-10 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1358-1530
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	4.4' (+) to 3.9' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Many of the kelp canopies within the survey range were observed to have a significantly reduced surface extent when compared with the June 2017 survey.
Imagery Quality/ Comments	Excellent	All surface kelp canopies were photographed within the above range. The image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent mapping of the kelp resource.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Appendix D.16D Flight record for December 27, 2017

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:	Shane Beck, Michael Lyons	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	12/17
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/27/17
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	1/18

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 12/27/17**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for: **December 27, 2017**

	Survey Type	Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 20 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	Less than 5 knots
	Videography	Lenses:	30mm (see note)	Sea/Swell:	2-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1348-1524
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.3' (+) to 3.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

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

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / DJ Schuessler
Lat/Long: 33° 35.228' 117° 52.164'

Date: 20 Dec 17
Location: Corona
Time: 1320
Wind/Direction: 8 k W
Current: Downcoast
Weather: Overcast
UW Visibility: 3-4 m
Swell Ht/Period: 2-3 w

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None all subsurface
Density:
Tissue color:
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks: 23'
Canopy shallow @ 20'
Subsurface: Lots present on outer south
North area scattered subsurface

UNDERWATER OBSERVATIONS

Midwater
Tissue Color:
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom
Tissue color:
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:
Sporophyllis:
Juvenile fronds:
Holdfasts:
Old holdfasts:
Recruitment:

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore / DJ Schuessler
Lat/Long: 33° 34.722' 117° 51.437'

Date: 20 Dec 17
Location: Whistlers Reef
Time: 1320
Wind/Direction: SW
Current: downcoast
Weather: Overcast
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 150m L x 50m
Density: Scattered
Tissue color:
% Frond comp.: 95% Senile 5% Mature ____ Young ____ Other
Disease: –
Encrustation: Heavy
Apical blades: No
Sediment on blades: No
Remarks: Surface plants senile/mature

Subsurface: Maturing subsurface - lots visible lots of new growth underwater

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

CONDITION OF MACROCYSTIS BED

Observer: R Moore / DJ Schuessler

Lat/Long: 33° 33.820 117° 50.360

Date: 20 Dec 17

Location: L30 S. Crystal Cove

Time: 1304

Wind/Direction:

Current:

Weather:

UW Visibility:

Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 200 m X 200 m

Density: Med

Tissue color:

% Frond comp. ______ Senile ______ Mature ______ Young ______ Other

Disease:

Encrustation:

Apical blades:

Sediment on blades:

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Bottom

Tissue color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Sporophyllis:

Juvenile fronds:

Holdfasts:

Old holdfasts:

Recruitment:

Community

Litter:

Turf algae:

Turf invert.:

Shrub algae:

Large Invert.:

Fishes:

Disease:

Sed. on rocks:

Urchin status:

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / DJ Schroeder
Lat/Long: ① 33°33.712' 117°44.773'
② 33°33.737' 117°49.881'
③ 735 50.036

Date: 20 Dec 17
Location: Crystal Cove / El Moro
Time: 1255
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

	①	②	③
Extent	None (1 plant)	30m x 30m	100m x 100m
Density		Scattered	Med / Med
Tissue color		Med Yell	
Disease		(all 2)	③
Encrustation		Med/Heavy	
Apical blades		No Yes	
Sediment on blades		No	

% Frond comp. ②③ 5% Senile 90 Mature 5% Young ____ Other

Remarks 33' depth

Subsurface All Subsurface

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / DJ Schuessler
Lat/Long: 33° 32.325' 117° 47.5801

Date: 20 Dec 17
Location: N. Laguna Beach
Time: 1115
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 100m L x 30m
Density: Medium
Tissue color: 80% dk Yel 20% Lt Yel
% Frond comp.: 5% Senile 10% Mature 85% Young ____ Other
Disease: No
Encrustation: mild to heavy Conold
Apical blades: Yes 5%
Sediment on blades: No
Remarks: Large are of canopy inshore of wash rock zone 45'

Subsurface

UNDERWATER OBSERVATIONS

Midwater

- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom

- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

Community

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

Bottom characteristics

REMARKS: Small canopy upcast near rocks

MA

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / DJ Schuessler
Lat/Long: 33° 31.762' 117° 46.864'

Date: 20 Dec 17
Location: S. Laguna Beach
Time: 1100
Wind/Direction: W
Current: Downcoast
Weather: 90 % overcast
UW Visibility: 5m vert
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 100m x 500m
Density: Thick
Tissue color: 60 % dk yel 40% med yell
% Frond comp.: 5% Senile 25% Mature 70% Young ______ Other
Disease: —
Encrustation: med (below surface)
Apical blades: Yes 30%
Sediment on blades: — No
Remarks: 3m frond 58' depth

Subsurface: Matured

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / DJ Schuessler
Lat/Long: 33° 29.579' 117° 44.580' 54'
28.846' 44.704' 37'

Date: 20 Dec 17
Location: S. Laguna
Time: 1048
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 10-20 m In/off @ 0.25 mi along
Density: Sparse
Tissue color: Med Yellow
% Frond comp.: 20 Senile 80 Mature 10 a Young ____ Other
Disease: Med/Heavy
Encrustation: Med Heav
Apical blades:
Sediment on blades:
Remarks: 54'

Subsurface: Metered sporadic along entire distance

UNDERWATER OBSERVATIONS

Midwater 33 29 579 117 44 880 sparse 50 m x 20 m
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore / DJ Schuessler
Lat/Long: 33° 27.944' 117° 43.392' E

Date: 20 Dec 17
Location: Salt Creek
Time: 0745
Wind/Direction: E
Current:
Weather:
UW Visibility: 4m Vert
Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS 33 ~~28.537~~ 28 752 117 ~~43.443~~' 44 014' (end of Bed W)

Kelp Canopy

Extent: 100x150m Inshore alongshore
Density: Sparse / Scattered
Tissue color: MED Yell
% Frond comp. ______ Senile ______ Mature 100 % Young ______ Other
Disease: —
Encrustation: No - mild
Apical blades: 50 %
Sediment on blades: No
Remarks: 1-2 m Frond Small areas w/ consistent canopy 59'

Subsurface: lots subsurface more deeper ~60'

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

CONDITION OF MACROCYSTIS BED

Observer: R Moore / DJ Schuessler

Lat/Long: 33°27.336' 117°41.876'

Date: 20 Dec 17

Location: Dana Point Marina

Time: 0730

Wind/Direction: E

Current:

Weather:

UW Visibility:

Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None

Density:

Tissue color:

% Frond comp. ______ Senile ______ Mature ______ Young ______ Other

Disease:

Encrustation:

Apical blades:

Sediment on blades:

Remarks

Subsurface None noticed

UNDERWATER OBSERVATIONS

Midwater

- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Community

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

Bottom

- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schaessler
Lat/Long: 33°26.6186'N 117°39.0066 W

Date: 15 JAN 18
K6 Location: Capistrano Beach
Time: 1250
Wind/Direction: 7-8 W
Current: Slight Dncoast
Weather: FOGGY (1/4 mi)
UW Visibility: 3m
Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 75m L x 75m W
Density: 5% canopy
Tissue color: Light → Med Yellow
% Frond comp.: 30 Senile 65 Mature 5 Young ____ Other
Disease: None
Encrustation: 75%
Apical blades: 5%
Sediment on blades: None
Remarks

Subsurface more subsurface than canopy

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schuessler
Lat/Long: 33° 24.183'N, 117 37.5800 W

Date: 15 JAN 18
Location: San Clemente
Time: 1238
Wind/Direction: 2-3 W
Current: Slight D. coast
Weather: Foggy (1/2 mi)
UW Visibility: 3m
Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: ~2 miles L x 150m W
Density: 70% Canopy
Tissue color: Med. Yellow
% Frond comp.: 5% Senile 90% Mature 5% Young ____ Other
Disease: None
Encrustation: 70%
Apical blades: Very few *
Sediment on blades: None
Remarks: 47 ft

Subsurface: * All apical blades subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: PJSchuessler

Lat/Long: 33°21.3994' N, 117° 36.8445' W

Date: 15 JAN 18

Location: San Mateo (RR8)

Time: 1230

Wind/Direction: 2-3 W

Current: slight D. coast

Weather: FOGGY (1/4 mi)

UW Visibility: 3 m

Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 200 m x 1+ km

Density: 50% canopy

Tissue color: Med. Yellow

% Frond comp.: 5% Senile 85% Mature 10% Young ____ Other

Disease: None

Encrustation: 10%

Apical blades: 15%

Sediment on blades: None

Remarks: 52 ft

Subsurface: Most apical blades subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Community

Litter:

Turf algae:

Turf invert.:

Shrub algae:

Large Invert.:

Fishes:

Disease:

Sed. on rocks:

Urchin status:

Bottom

Tissue color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Sporophyllis:

Juvenile fronds:

Holdfasts:

Old holdfasts:

Recruitment:

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJSchuessler
Lat/Long: 33°20.7071'N, 117°34.1285'W

Date: 15JAN18
R9 Location: San Onofre
Time: 1000
Wind/Direction: 2-3 W
Current: Slight D. Coast
Weather: Clear
UW Visibility: 3m
Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 150m L x 150m W
Density: 65% of surface
Tissue color: Med. Yellow
% Frond comp.: 10 Senile 70 Mature 20 Young ___ Other
Disease: None
Encrustation: 40% encrusted
Apical blades: 15%
Sediment on blades: None
Remarks: Depth: 53 ft

Subsurface: Most young blades subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schuessler
Lat/Long: 33° 19.464 N, 117° 31.645 W

Date 15 JAN 18
Location Pendleton Arts Reef
Time 1015
Wind/Direction 2-3 W
Current Slight D. coast
Weather Clear
UW Visibility 3m
Swell Ht/Period 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None
Density
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schuessler

Lat/Long: 33°19.130'N, 117°31.080'W

Date: 15JAN18

R9 K11 Location: Horno Canyon

Time: 1035

Wind/Direction: 2-3 W

Current: Slight D coast

Weather: Clear

UW Visibility: 3m

Swell Ht/Period: 1-2 W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None

Density

Tissue color

% Frond comp. ______ Senile ______ Mature ______ Young ______ Other

Disease

Encrustation

Apical blades

Sediment on blades

Remarks Depth 45 ft

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schuetzler
Lat/Long: 33° 17.107' N, 117° 29.568' W

Date 16 JAN 18
Location Barn Kelp
Time 1020
Wind/Direction 2W
Current Slight D, coast
Weather Clear
UW Visibility 3m
Swell Ht/Period 1-2w

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 200m LY 100m W
Density Scattered ; 50% of surface
Tissue color Med. Yellow
% Frond comp. 10 Senile 70 Mature 20 Young ____ Other
Disease None
Encrustation Slight to Med., ~40% of blades
Apical blades 10%
Sediment on blades None
Remarks Depth 50 ft

Subsurface Younger blades subsurface Apical

UNDERWATER OBSERVATIONS

Midwater
Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom
Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 33° 14.815' 117° 26.442'

Date: 19 Dec 17
Location: Santa Margarita R
Time: 1505
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks 31'

Subsurface Nothing Metered

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schaessler
Lat/Long: 33° 09.341' 117° 21.649'

Date: 19 Dec 17
Location: North Carlsbad
Time: 1430
Wind/Direction: W 2 kt
Current: None
Weather: Sunny
UW Visibility: 5 m
Swell Ht/Period: 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks:

Subsurface: Lots. Subsurface ~40% new growth, old growth ragged. Extended @ 0.25 m on fathometer

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom

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

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

1349 - 24m - 40'

Observer: R. Moore

Lat/Long: 33°08.684' 117° 21.134'

Date: 19 Dec 17

Location: Agua Hedionda

Time: 1342

Wind/Direction:

Current:

Weather:

UW Visibility:

Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None

Density:

Tissue color:

% Frond comp. ____ Senile ____ Mature ____ Young ____ Other

Disease:

Encrustation:

Apical blades:

Sediment on blades:

Remarks:

Subsurface

Adult 4+1+12+1 (20) Juv 1+3 1+3 (8) Rec. 4+3+4+2+5+9 (27)

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Bottom

Tissue color: Med Yellow

Encrustation: mild to heavy (on old growth)

Disease: –

Sediment on blades: No

Sinking fronds: –

Grazed tissues: Yes

Sporophyllis: Yes

Juvenile fronds: Yes

Holdfasts: Yes

Old holdfasts: No

Recruitment: Yes

Community

Litter: –

Turf algae: Turk Tow. red fil

Turf invert.:

Shrub algae:

Large Invert.: lobster

Fishes: Senorita KBass

Disease: –

Sed. on rocks: Yes

Urchin status: None

Bottom characteristics

flat stone reef - shale

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJ Schuessler
Lat/Long:

Date 12/19/17
Location Agua Hedionda
Time 1345
Wind/Direction
Current
Weather Sunny/Clear
UW Visibility
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent NONE
Density
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks

Subsurface

UNDERWATER OBSERVATIONS

Adults: 卌 卌 卌 卌 ||
Juv.: 卌 ||

Midwater

Tissue Color Yellow
Encrustation 60%
Disease None
Sediment on blades Minimal
Sinking fronds A few
Grazed tissues None

Bottom

Tissue color Dark yellow
Encrustation 20%
Disease None
Sediment on blades minimal
Sinking fronds None
Grazed tissues None
Sporophyllis Yes
Juvenile fronds Yes
Holdfasts Yes
Old holdfasts None
Recruitment Yes, many

Community

Litter None
Turf algae red
Turf invert. None; some gorgonians
Shrub algae Turkish towel, brown algae
Large Invert. C. fran. urchin
Fishes Kelp/Barred bass, Señorita
Disease None
Sed. on rocks None
Urchin status 1 urchin

Bottom characteristics Very flat shale bottom patches surrounded by sand

REMARKS Video of outgoing transect; pics also

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D Schuessler
Lat/Long: 33° 07.461' 117° 20.409'

Date: 19 Dec 17
Location: Encina Power Plant
Time: 1328
Wind/Direction: 2-3 W
Current:
Weather:
UW Visibility:
Swell Ht/Period: 1-2ft

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 400m x 70m ~0.25 mi long
Density: High
Tissue color: Dk Yellow (on new)
% Frond comp. ______ Senile 10% Mature 90% Young ______ Other
Disease: No
Encrustation: Mod on old
Apical blades: 15+%
Sediment on blades: No
Remarks 44'-47'

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore / D. Schuessler

Lat/Long: 1) 33° 05 349 117° 19.278'

2) 33° 05 932' 117° 19.639'

Date: 19 Dec 17

Location: Carlsbad State Park 1

Time: 1315

Wind/Direction:

Current:

Weather:

UW Visibility:

Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 1) None 2) None

Density:

Tissue color:

% Frond comp. ______ Senile ______ Mature ______ Young ______ Other

Disease:

Encrustation:

Apical blades:

Sediment on blades:

Remarks:

Subsurface 1) None metered 2) Metered subs. @ 10' below sfc. lots visible ~10% Young & 90% Mature/senile

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Community

Litter:

Turf algae:

Turf invert.:

Shrub algae:

Large Invert.:

Fishes:

Disease:

Sed. on rocks:

Urchin status:

Bottom

Tissue color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Sporophyllis:

Juvenile fronds:

Holdfasts:

Old holdfasts:

Recruitment:

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 33° 05.338' 117° 19.457'

Date: 19 Dec 17
Location: Leucadia North
Time: 1312
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks: 57'

Subsurface None Metered

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom

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

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 33º 04.370' 117º 19.064'

Date: 19 Dec 17
Location: Leucadia Central
Time: 1307
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: Below Surface
Density:
Tissue color:
% Frond comp.: Senile 80% Mature 20% Young Other
Disease: – med yellow dk yellow
Encrustation: med to heavy
Apical blades: –
Sediment on blades: –
Remarks: 50'

Subsurface Lots subsurface current pulling down; subsurface continue on water for 200+ m

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore D. Schuessler

Lat/Long: S- 33° 03.113' 117° 18.512' → 03.505 18.533'

Date: 19 Dec 17

Location: Leucadia South

Time: 1253 - 1300

Wind/Direction:

Current:

Weather:

UW Visibility:

Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy S. C. N

Extent: None - Sparse

Density: — Sparse

Tissue color:

% Frond comp. ____ Senile M-100% Mature ____ Young ____ Other

Disease: N - No — Mix of 10% 2nd lo

Encrustation: S - Heavy

Apical blades: N - No

Sediment on blades: - No

Remarks: S, 58' C

Subsurface: South - nothing on meter up count Several patches 10x100 m Central

UNDERWATER OBSERVATIONS

Midwater

Tissue Color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Bottom

Tissue color:

Encrustation:

Disease:

Sediment on blades:

Sinking fronds:

Grazed tissues:

Sporophyllis:

Juvenile fronds:

Holdfasts:

Old holdfasts:

Recruitment:

Community

Litter:

Turf algae:

Turf invert.:

Shrub algae:

Large Invert.:

Fishes:

Disease:

Sed. on rocks:

Urchin status:

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 33° 07.083' 117° 18.086'

Date: 19 Dec
Location: Encinitas
Time: 1248
Wind/Direction:
Current: None
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 100m x 50m
Density: Sparse / Scattered
Tissue color: Med Yellow 90%
% Frond comp.: 5% Senile 93% Mature 2% Young ____ Other
Disease: No
Encrustation: Heavy
Apical blades: 1%
Sediment on blades: No
Remarks: 1-3m fronds 42'

Subsurface: Med #'s subsurface

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS: Sporadic plants @ surface downcoast

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore / D. Schuessler
Lat/Long: 33° 00.772' 117° 17.301'

Date: 19 Dec 17
Location: Cardiff
Time: 1240
Wind/Direction: W 2-3 kn
Current: downcoast
Weather: Sunny
UW Visibility:
Swell Ht/Period: 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 50m x 100m
Density: med
Tissue color: 50% dk Yel 50% med Yel
% Frond comp.: 5% Senile 45% Mature 50% Young ____ Other
Disease: —
Encrustation: 1%
Apical blades: 5%
Sediment on blades: N
Remarks: Depth 42'

Subsurface: lots visible subsurface

UNDERWATER OBSERVATIONS

Midwater
Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom
Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

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

Bottom characteristics

REMARKS: long band shallow

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler

Lat/Long: 32° 59.154' 117°16.982'

Date: 19 Dec 17

Location: Solana Bch (s)

Time: 1230

Wind/Direction: W 3 kn

Current: Downcoast

Weather:

UW Visibility: 5m Vert

Swell Ht/Period: 1-2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 100 m x 100 m

Density: Med

Tissue color: Med Yel 90% dk Yel 10%

% Frond comp. ______ Senile 95% Mature 5% Young ______ Other

Disease:

Encrustation: 90% Med to Heavy

Apical blades: 2-4

Sediment on blades:

Remarks: 1-2m fronds 2 Kelp canopy patch 2x2 32°59.610' 117°17.210' w some surf 3x2 North edge @ ½ size others

Subsurface: lots of plants subsurf

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

1153 51' 23m

Observer:	RHM
Lat/Long:	32° 57.464' 117 16.559'
	32° 57.522' 117 16.689' 644 Dive
Date	19 Dec 17
Location	DEL MAR
Time	1150
Wind/Direction	
Current	
Weather	
UW Visibility	30+ ft
Swell Ht/Period	

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent	
Density	
Tissue color	
% Frond comp.	___ Senile ___ Mature ___ Young ___ Other
Disease	
Encrustation	
Apical blades	
Sediment on blades	
Remarks	

Video ?

Subsurface Metered S-Surface C10 fall

UNDERWATER OBSERVATIONS ≥40 cm (2) < 40cm (1)

Midwater

Tissue Color	
Encrustation	
Disease	
Sediment on blades	
Sinking fronds	
Grazed tissues	

Bottom

Tissue color	med Yellow
Encrustation	50%
Disease	No
Sediment on blades	No
Sinking fronds	—
Grazed tissues	Yes
Sporophyllis	No → 1 small
Juvenile fronds	Yes
Holdfasts	—
Old holdfasts	—
Recruitment	?

Community Turkish Towel

Litter	—
Turf algae	Laminaria / Red
Turf invert.	
Shrub algae	—
Large Invert.	1 Sorp. / 3 S.f / lobster
Fishes	Sheephead / Blk Bass / Garib
Disease	—
Sed. on rocks	X
Urchin status	low

Bottom characteristics

Scattered boulder / reef
Sand patches
Shale Rock

REMARKS Scattered Slate Stone exposed / covered w/ Sand
Laminariales recruits

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJSchwessler
Lat/Long: DEL MAR
Date 12/19/17
Location DEL MAR
Time 1145
Wind/Direction
Current
Weather Clear
UW Visibility 30 ft
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent NONE
Density
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks

Subsurface

UNDERWATER OBSERVATIONS

(1) Adult
(1) Juv.

Midwater

Tissue Color NONE
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color Yellow
Encrustation Yes / slight / 20%
Disease None
Sediment on blades slight
Sinking fronds —
Grazed tissues Yes
Sporophyllis None
Juvenile fronds None
Holdfasts None
Old holdfasts None
Recruitment possible? – see video

Community

Litter None
Turf algae None
Turf invert. —
Shrub algae Turkish Towel, laminariae
Large Invert. S. purp, C. fran
Fishes sheephead, bar/kelpbass, gari
Disease None
Sed. on rocks Yes
Urchin status Low abundance

Bottom characteristics

Shale bottom with scattered 2-3 ft boulders & 10x5 ft rocks sporadically jutting out of the substrate

REMARKS Video of return 50m transect & pic.s

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 32° 53.563 117° 15.343

Date: 19 Dec 17
Location: Torrey Pines
Time: 1105
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks No subsurface kelp material

Subsurface

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 32° 51.163' 117°17.065'
Date: 19 Dec 17
Location: La Jolla N
Time: 1050
Wind/Direction: E 2-3 kt
Current: Upcst
Weather: Sunny
UW Visibility:
Swell Ht/Period: 1-2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: ~ 180 m wide
Density: Sparse
Tissue color: Medium yellow
% Frond comp.: 5% Senile 85 Mature 10% Young ____ Other
Disease: No
Encrustation: Light - 90%
Apical blades: None
Sediment on blades: None
Remarks: 60' depth

Subsurface: Adult plants visible

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Community

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

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophyllis
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Bottom characteristics

REMARKS: La Jolla C nothing at L/L's 75' Canopy visible inshore
Subsurface kelp metered heading to LJN. Begin @ 65'

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer:	R. Moore / D Schuessler	Date	19 Dec 17
Lat/Long:	32 48.598' 117' 17.334'	Location	LA Jolla S
		Time	1030
		Wind/Direction	E / 1 kn
		Current	Lt
		Weather	Sunny
		UW Visibility	5+ m
		Swell Ht/Period	1-2

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent	~200+ m inshore Extensive alongshore up/down
Density	50%
Tissue color	Pale 70% 30 dark yellow %
% Frond comp.	10% Senile 50% Mature 40% Young ___ Other
Disease	No
Encrustation	Heavy on old growth
Apical blades	Yes - 1%
Sediment on blades	None
Remarks	~~1-4m visibility~~ 62°F Surface
Subsurface	Meter @65' ~~5m vis~~ 1-4m frond length Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color	
Encrustation	
Disease	
Sediment on blades	
Sinking fronds	
Grazed tissues	

Bottom

Tissue color	
Encrustation	
Disease	
Sediment on blades	
Sinking fronds	
Grazed tissues	
Sporophyllis	
Juvenile fronds	
Holdfasts	
Old holdfasts	
Recruitment	

Community

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

Bottom characteristics

REMARKS 48.327' 18.344'

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler
Lat/Long: 32°43.479' 117°16.253'

Date: 19 Dec 17
Location: Pt Loma North
Time: 1000
Wind/Direction: East
Current: None
Weather: Sunny
UW Visibility: 3-5m
Swell Ht/Period: 1-2w

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: Soft 100m inshore both up & down coast
Density: Solid
Tissue color: Dark Yellow 80% Lt yellow 20%
% Frond comp.: 2% Senile 8% Mature 90% Young ___ Other
Disease: None
Encrustation: 50%
Apical blades: Yes 2%
Sediment on blades: No
Remarks: 1-2m fronds

Subsurface: 68' on numbers all subsurface Canopy @ 55' + towards shore

UNDERWATER OBSERVATIONS

Midwater
- Tissue Color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophyllis
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

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

Bottom characteristics

REMARKS Continuous from PLS
32°43.400' 117°16.475'

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore / D. Schuessler

Lat/Long: 32° 39. 865' 117°15.359'

Date: 19 Dec 17

Location: Pt. Loma South

Time: 0937

Wind/Direction: East

Current: upcoast

Weather: Sunny

UW Visibility: 5m

Swell Ht/Period: 1-2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 150m inshore / ~0.5km upcoast

Density: Solid

Tissue color: Gold dark Yellow

% Frond comp.: Ø Senile 5% Mature 95% Young ____ Other

Disease: No

Encrustation: 10%

Apical blades: Yes @ 5%

Sediment on blades: No

Remarks: 1-2m long frond canopy 150m inshore & 0.5km upcst

Subsurface @55' start metering subsurface
Ø between 80' to 55'

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

REMARKS 32° 40.460' 117°15.835' @60' @64' depth to PLN scattered subsurface on meter

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore / D. Schuessler

Lat/Long: 32° 34.5601 117° 69.475'

Date 19 Dec

Location Imperial Beach

Time 0900

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None visible none metered

Density

Tissue color

% Frond comp. ____ Senile ____ Mature ____ Young ____ Other

Disease

Encrustation

Apical blades

Sediment on blades

Remarks Check lobster pot line

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

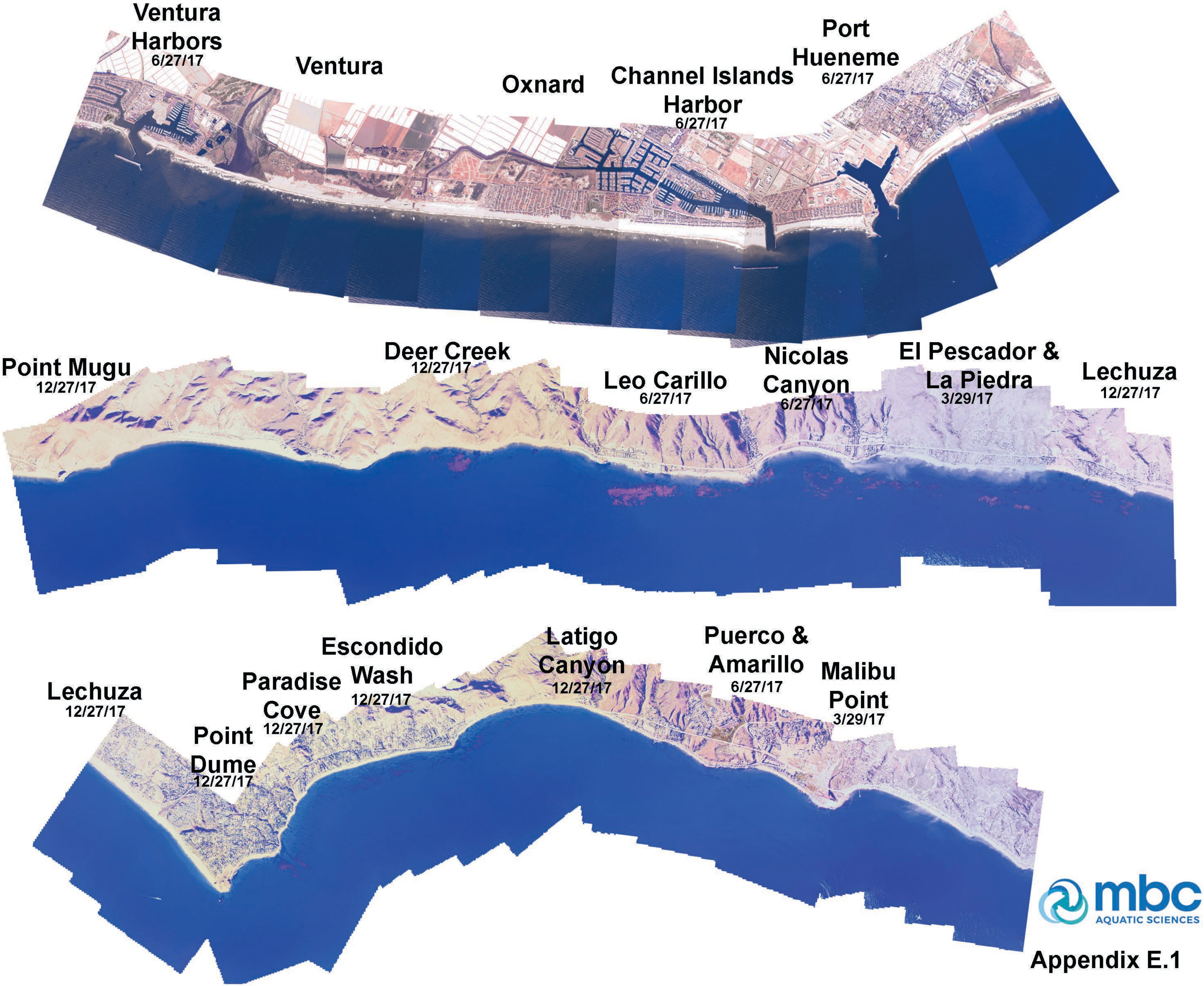
Urchin status

Bottom characteristics

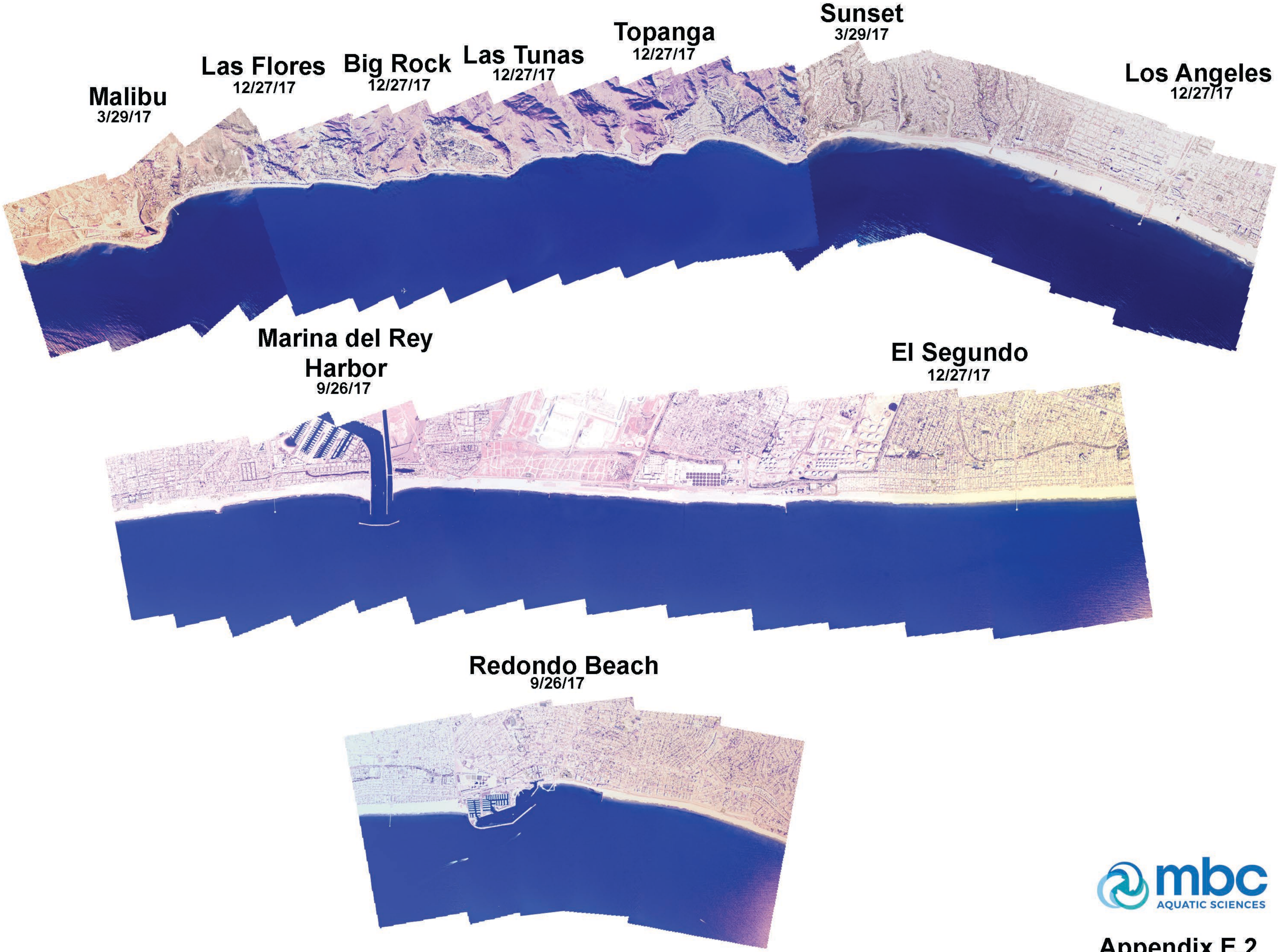
REMARKS

APPENDIX E

Kelp Canopy Aerial Photographs

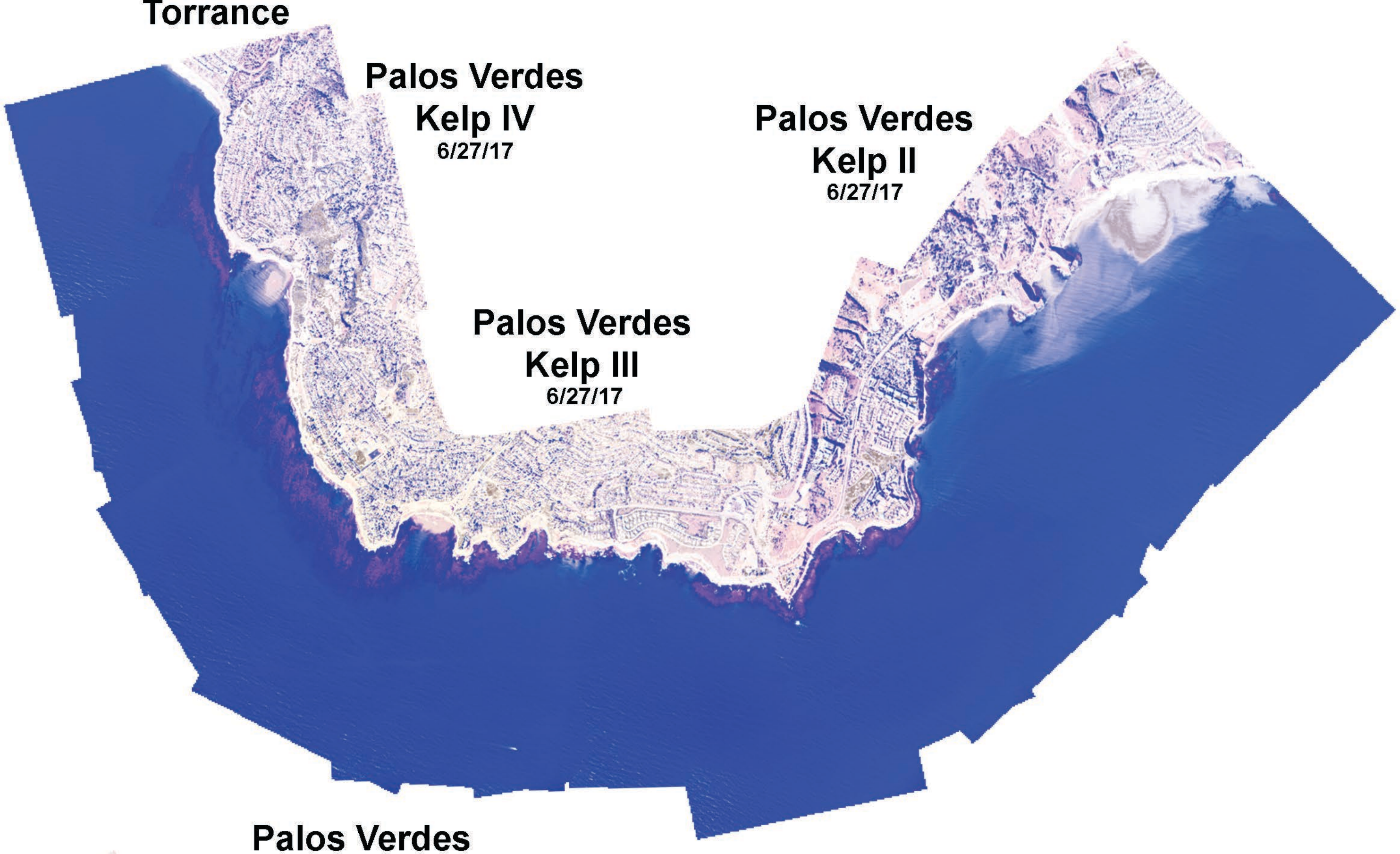

Ventura Harbors
6/27/17
Ventura
Oxnard
Channel Islands Harbor
6/27/17
Port Hueneme
6/27/17
Point Mugu
12/27/17
Deer Creek
12/27/17
Leo Carillo
6/27/17
Nicolas Canyon
6/27/17
El Pescador & La Piedra
3/29/17
Lechuza
12/27/17
Lechuza
12/27/17
Point Dume
12/27/17
Paradise Cove
12/27/17
Escondido Wash
12/27/17
Latigo Canyon
12/27/17
Puerco & Amarillo
6/27/17
Malibu Point
3/29/17
mbc
AQUATIC SCIENCES

Appendix E.1



mbc AQUATIC SCIENCES

Appendix E.2


Torrance
Palos Verdes Kelp IV 6/27/17
Palos Verdes Kelp II 6/27/17
Palos Verdes Kelp III 6/27/17

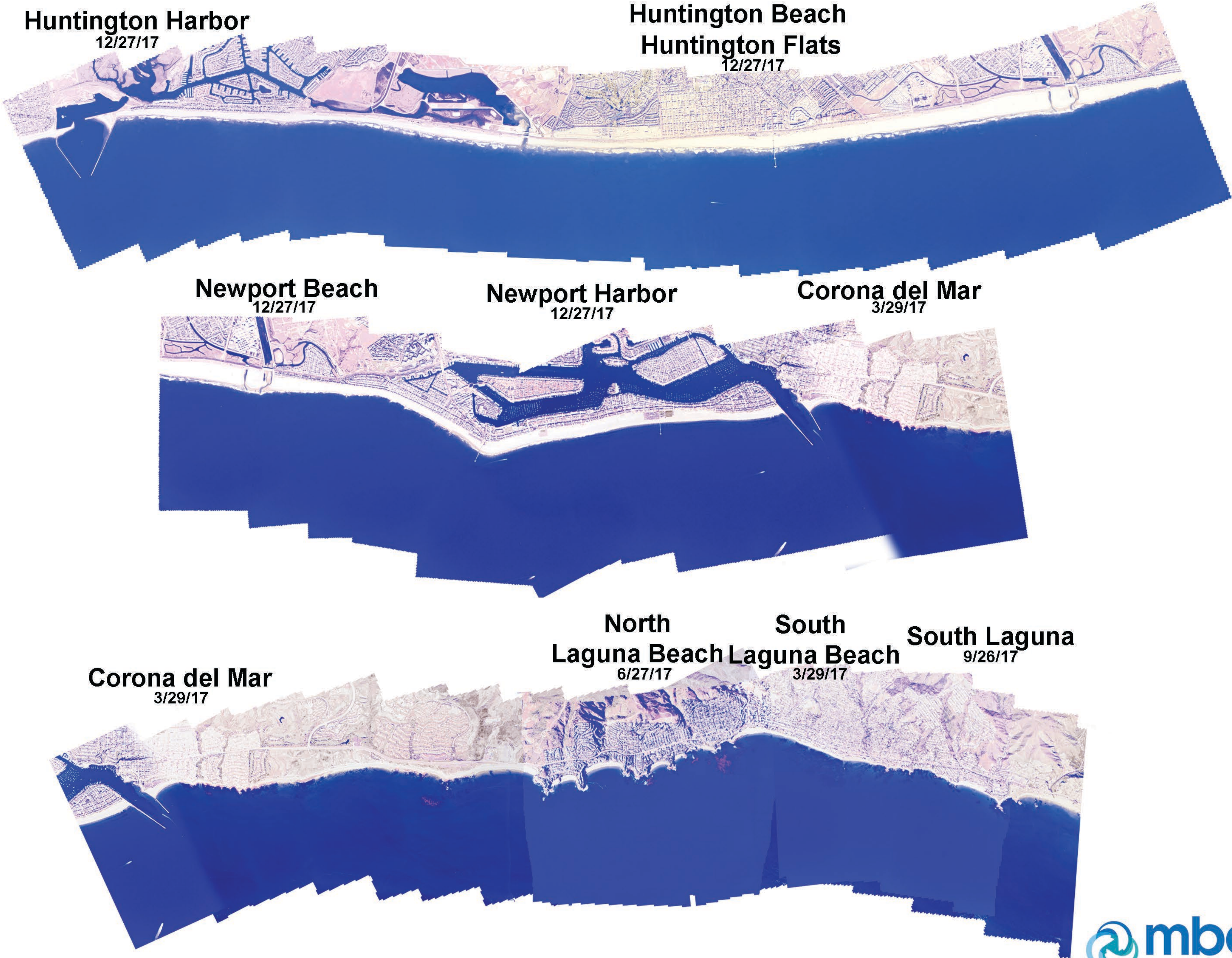

Palos Verdes Kelp I 12/27/17
Cabrillo 12/27/17

Appendix E.3

POLA/POLB Harbors

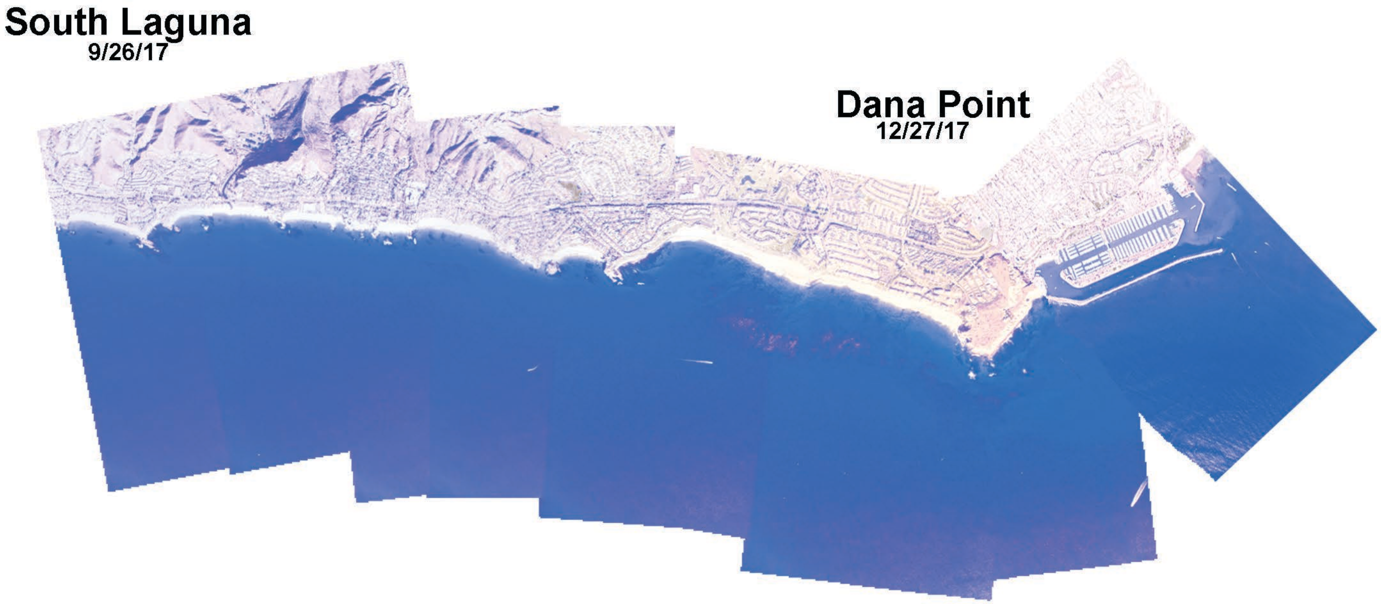
6/27/17

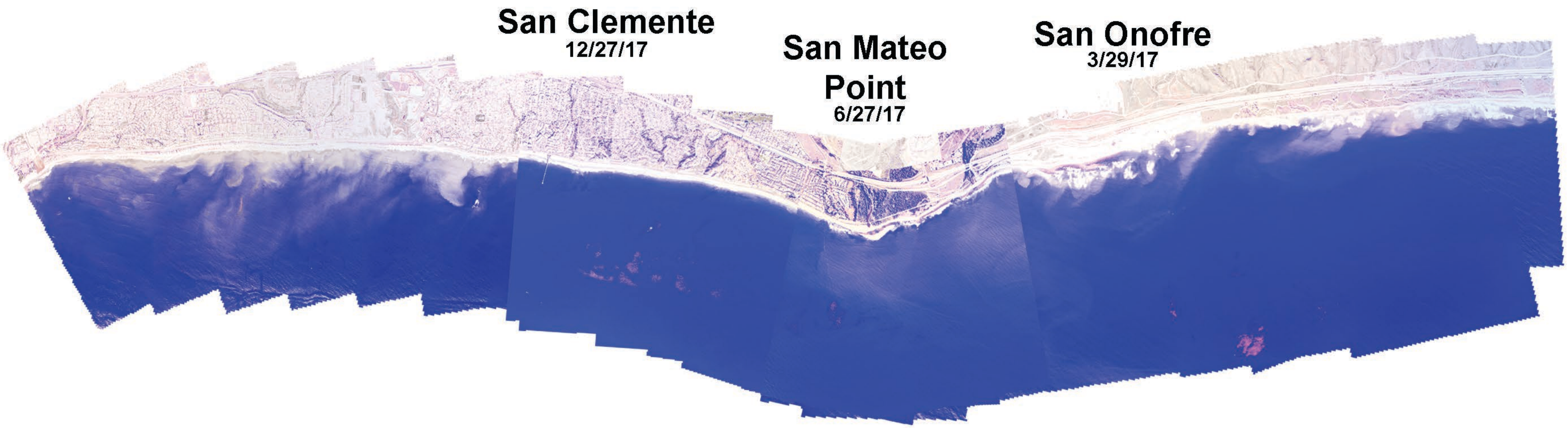
Appendix E.4



mbc AQUATIC SCIENCES

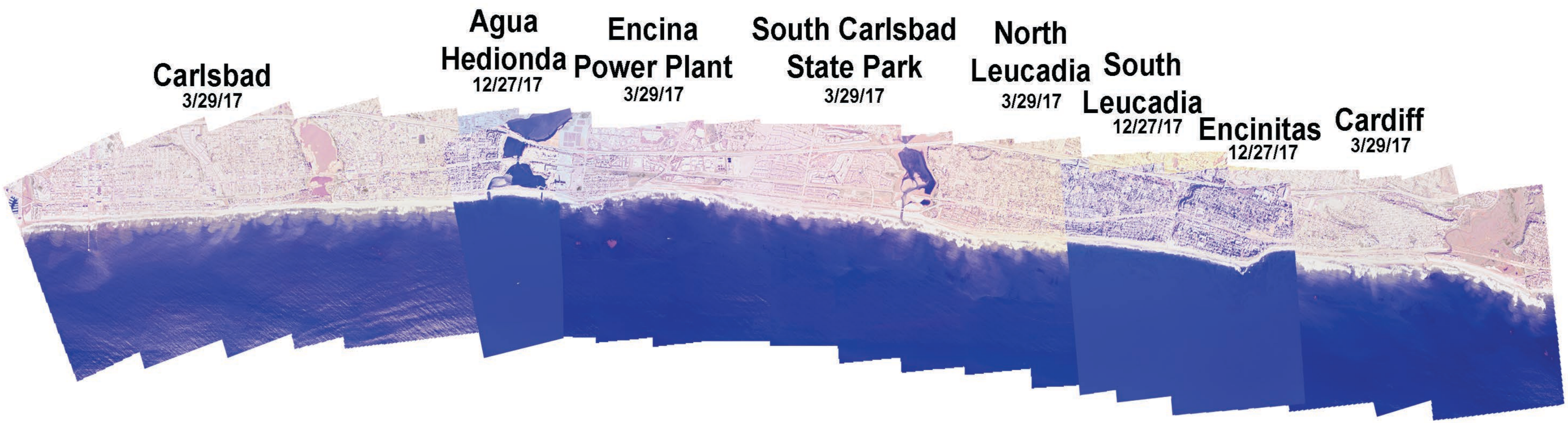
Appendix E.5





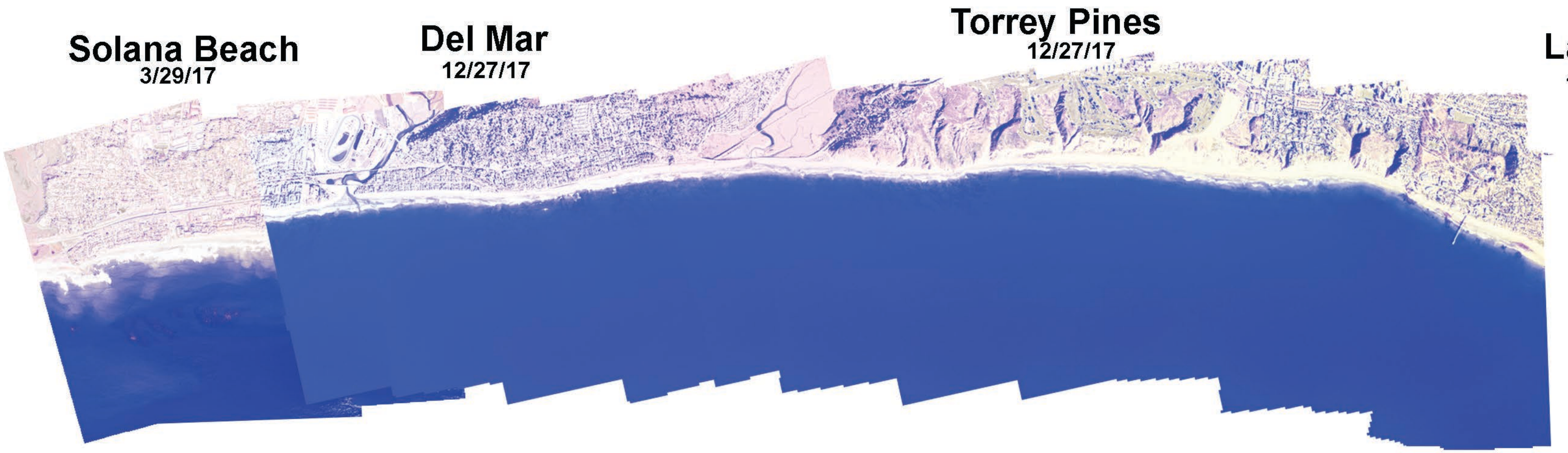
mbc AQUATIC SCIENCES

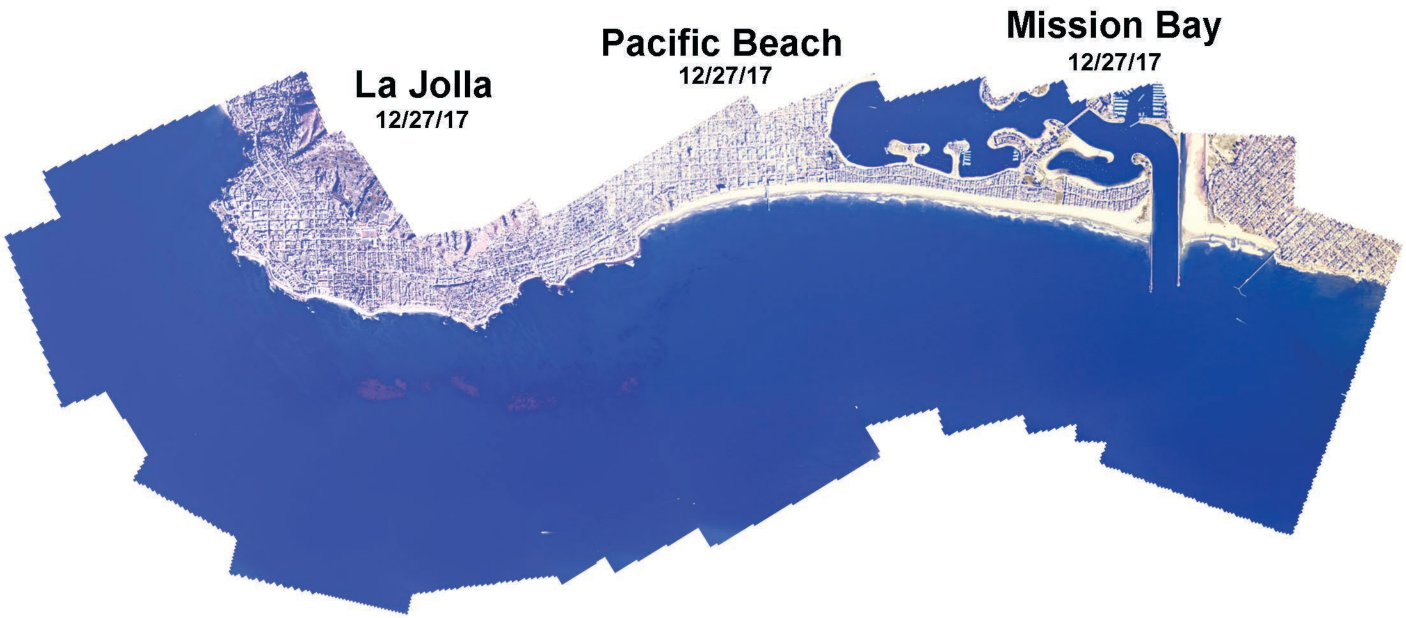
Appendix E.6



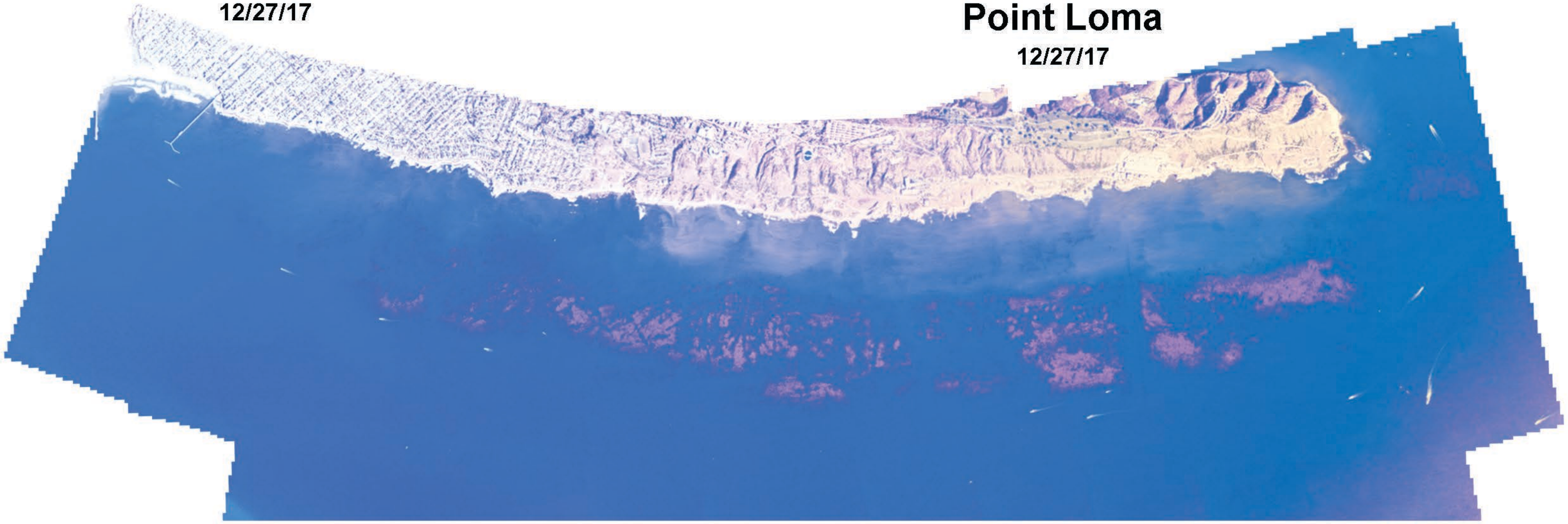
mbc AQUATIC SCIENCES

Appendix E.7


Solana Beach
3/29/17
Del Mar
12/27/17
Torrey Pines
12/27/17
La Jolla
12/27/17


La Jolla
12/27/17
Pacific Beach
12/27/17
Mission Bay
12/27/17

Appendix E.8


Ocean Beach
12/27/17
Point Loma
12/27/17


Silver Strand
12/27/17
Imperial Beach
12/27/17
Point Loma
12/27/17

Appendix E.9