Status of the Kelp Beds in 2018:

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

Aerial imaging surveys of the giant kelp beds off Ventura, Los Angeles, Orange, and San Diego counties were conducted for the Central Region Kelp Survey Consortium and the Region Nine Kelp Survey Consortium by MBC Aquatic Sciences on March 28, July 2, September 12, and December 30, 2018. The maximum surface canopy observed during 2018 was quantified from color infrared photos of each kelp bed.

The total kelp canopy in the Central Region covered approximately eight square kilometers in 2018, a 61 percent increase compared to 2017. This canopy coverage was the highest amount recorded in 50 years, slightly exceeding the peak level observed in 1967. All but one kelp bed increased in size. Three kelp beds reappeared in 2018, while none disappeared. The largest beds were three of the Palos Verdes kelp beds (PV-I, PV-2, and PV-3), which accounted for half of the total canopy coverage. There is no indication that wastewater treatment plant ocean discharges are impacting the health of kelp beds in the Central Region.

The total kelp canopy in Region Nine covered approximately 11 square kilometers in 2018, a 237 percent increase compared to 2017. Although canopy coverage was higher than the levels recorded for the past two years, it remained well below those attained in 2013 through 2015. Approximately three-fourths of the kelp beds increased in size. One kelp bed disappeared in 2018, while none reappeared. The largest beds were the La Jolla and Point Loma kelp beds, which accounted for 86 percent of the total canopy coverage.

Vessel surveys of all Region Nine kelp beds were scheduled for late 2018, but were not actually conducted until January 4 and 28, 2019. Visual observations indicated that the amounts of surface canopy and subsurface kelp in the northern area (North and South Laguna) and southern area (La Jolla and Point Loma) were similar to levels observed during the previous year’s surveys (December 2017 and January 2018). However, surface canopy at the other kelp beds in the region generally was less in January 2019 than during the prior survey and very little subsurface kelp was observed. More detailed in-water surveys were conducted by biologist-divers at the Horno Canyon and Encina Power Plant kelp beds. Very few kelp plants were observed on the bottom at either of these two locations.

Sea surface water temperatures were warmer than average the second half of the year in both the Central Region and Region Nine, but cooler than normal temperatures were recorded in March, April, and May. These cooler temperatures, along with stronger upwelling in the first half of 2018 than in 2017 may have accounted for the considerable increases in size of most kelp beds in both regions during 2018, all of which reached their maximum extent during the March or July quarterly surveys. These gains occurred despite little change in Nutrient Quotient values from 2017 to 2018.

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 three beds that have been missing or greatly reduced since the first half of the 20th century, namely Sunset, Horseshoe and Huntington Flats (MBC 2004a–2012a). 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 POLA-POLB. 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 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 in Orange County to the U.S./Mexico Border to the south and recognizes 24 existing or historic kelp beds (Figure 2). As in the Central Region, 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, namely La Jolla, and Point Loma kelp beds. There are eight ocean outfalls located within the geographical range of the RNKSC, including three that are shared by two different agencies (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, with population dynamics 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.

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

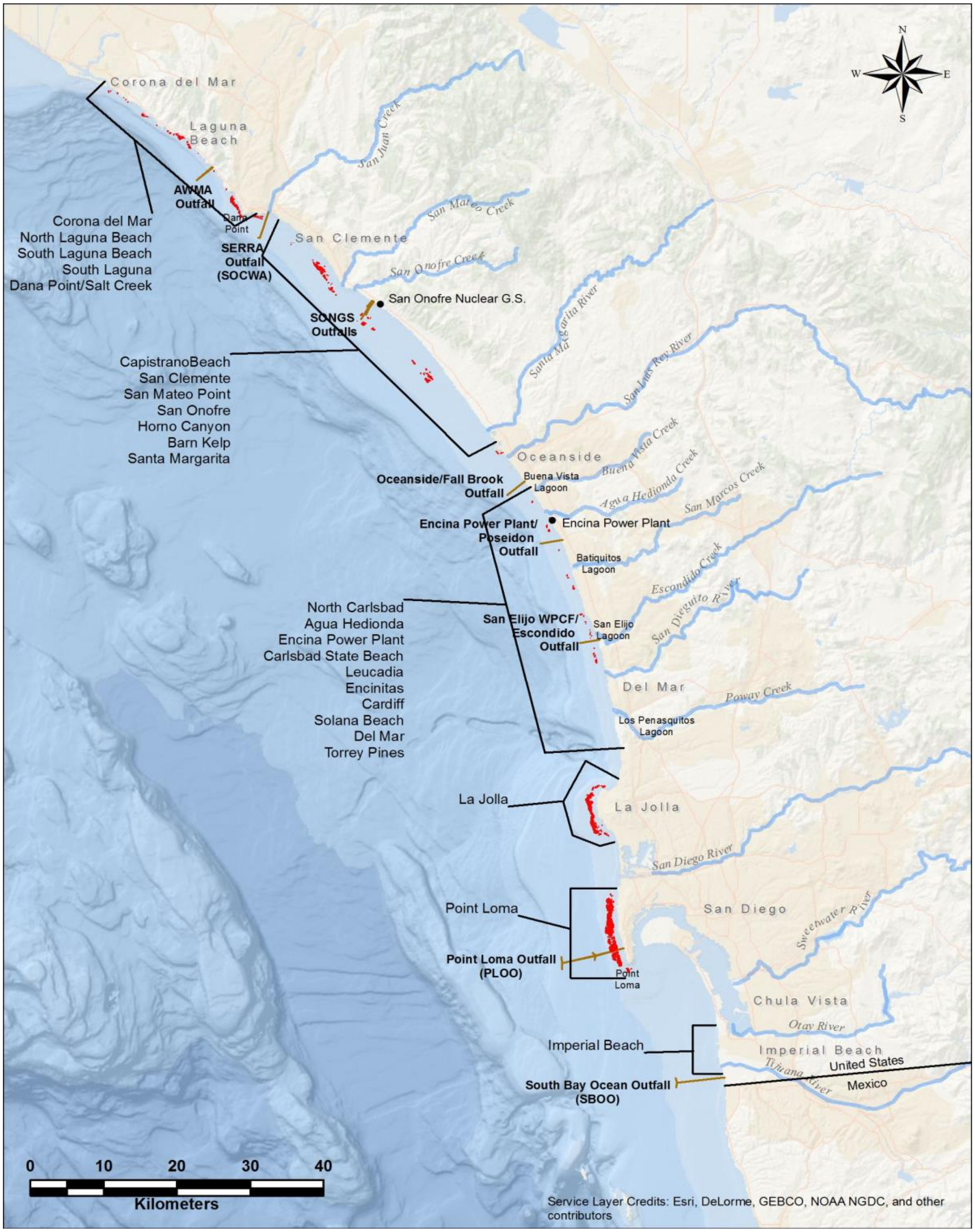


Figure 2. Ocean discharges and kelp beds located within Region Nine kelp survey area.

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 2018, 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,
- Sun angle greater than 20 degrees from vertical.

Aerial surveys were flown on March 28, July 2, September 12, and December 30, 2018 (Table 1). During the July overflight, fog obscured the coastline from Ventura to Point Mugu and along the northern portion of the Palos Verdes Peninsula; no images of the kelp beds were recorded in these areas. 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

A vessel survey is conducted once per year to observe all RNKSC kelp beds. The vessel survey for the 2018 survey year was conducted on January 4, 2019 from Santa Margarita to Imperial Beach, and on January 28, 2019 from North Laguna Beach to Barn Kelp. During each vessel survey, biologists visually located the main surface canopies present or in the absence of surface kelp, relied upon latitude and longitude coordinates for canopy present during prior years.

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,
- Composition of fronds: young, mature, or senile.

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

Table 1. Kelp bed overflights in 2018.

Quarter	Target Date	Actual Date	Comments
1st Quarter	**January to March 2018**	March 28, 2018	Excellent conditions.
2nd Quarter	**April to June 2018**	July 2, 2018	Very good conditions Fog from Ventura to Point Mugu and north side of Palos Verdes.
3rd Quarter	**July to September 2018**	September 12, 2018	Excellent conditions.
4th Quarter	**October to December 2018**	December 30, 2018	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 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, so data from one or two surveys usually are used to make the mosaics 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.

II.3 – WATER QUALITY DATA

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

- Water temperature data from automated shore stations at Newport Pier and Scripps Pier. At these locations, automated samplers measure conductivity, temperature, and fluorometry at a frequency of one to four minutes. Samplers are mounted at a depth of 2 meters Mean Lower Low Water (MLLW) at Newport Piers, and at 5 meters 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 meters, with sensors at the surface and depths of 2 meters and 11 meters MLLW.
- Water temperature data also were provided by the City of San Diego's Ocean Monitoring Program from a thermistor string approximately 3.8 kilometers west-northwest of Point Loma in 60 meters of water (City of San Diego 2017). Sensors were placed at four-meter intervals from near the sea surface to a depth of 54 meters 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 the outfall in 60 meters of water (Orange County Sanitation District, 2007).

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 1 through June 30 for a given time span (i.e., the 2018 NQ Indices shown on Figures 22 and 23 correspond to the period from July 1, 2018 to June 30, 2019). 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 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.

Table 2. Rankings assigned to kelp beds from aerial photographs from 2018 Central Region surveys between Ventura Harbor and Newport / Irvine Coast.

	2018 Surveys			
Kelp Beds	**28 March**	**2 July**	**12 September**	**30 December**
Ventura Harbor *	3.5	NI	—	—
Channel Islands *	2.5	1.5	1.0	—
Port Hueneme *	3.0	3.0	0.5	—
Deer Creek	3.5	4.0	0.5	1.0
Leo Carrillo	3.5	3.0	0.5	0.5
Nicolas Canyon	3.5	3.5	0.5	0.5
El Pescador/La Piedra	3.5	3.5	0.5	1.0
Lechuza Kelp	3.5	3.0	—	1.0
Point Dume	3.5	3.5	—	1.0
Paradise Cove	3.5	3.0	—	1.5
Escondido Wash	3.5	2.0	—	2.0
Latigo Canyon	3.5	1.5	—	0.5
Puerco/Amarillo	4.0	4.0	—	1.0
Malibu Pt.	4.0	0.5	—	—
La Costa	0.5	—	—	—
Las Flores	2.0	1.5	—	—
Big Rock	0.5	0.5	—	—
Las Tunas	1.0	0.5	—	—
Topanga	1.0	NI	—	—
Sunset	1.5	1.0	0.5	—
Marina Del Rey *	1.5	—	—	—
Hyperion Pipeline *	1.0	—	—	—
Redondo Breakwater *	1.5	0.5	—	—
Malaga Cove - PV Point (IV)	4.0	NI		0.5
PV Point - Point Vicente (III)	4.0	2.5	3.0	1.5
Point Vicente - Inspiration Point (II)	4.0	3.5	0.5	2.0
Inspiration Point - Point Fermin (I)	4.0	4.0	0.5	0.5
Cabrillo	4.0	3.5	0.5	0.5
LB/LA Harbor and Breakwaters	1.5	2.0	—	—
Horseshoe Kelp	—	—	—	—
Huntington Flats	—	—	—	—
Newport Harbor *	1.0	0.5	—	—
Corona Del Mar	3.0	2.5	—	—
North Laguna Beach	4.0	3.5	—	—

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
NI = No Image
"-" = no kelp present
Red highlight = survey utilized to quantify surface canopy area

Table 3. Rankings assigned to kelp beds from aerial photographs from 2018 Region Nine surveys between Newport / Irvine Coast and Imperial Beach.

	2018 Surveys			
Kelp Beds	**28 March**	**2 July**	**12 September**	**30 December**
Newport Harbor *	1.0	0.5	—	—
Corona del Mar	3.0	2.5	—	—
No. Laguna Beach	4.0	3.5	—	—
So. Laguna Beach	3.0	2.5	—	0.5
South Laguna	0.5	—	—	—
Salt Creek-Dana Point	3.0	1.5	—	—
Dana Marina *	1.0	1.0	—	—
Capistrano Beach	1.0	0.5	—	0.5
San Clemente	3.5	4.0	—	0.5
San Mateo Point	1.0	1.0	—	—
San Onofre	2.5	3.5	—	—
Pendleton Reefs *	—	—	—	—
Horno Canyon	1.5	0.5	—	—
Barn Kelp	2.5	3.0	—	—
Santa Margarita	—	—	—	—
Oceanside Harbor *	0.5	—	—	—
North Carlsbad	1.0	—	—	—
Agua Hedionda	—	—	—	—
Encina Power Plant	2.5	2.0	—	—
Carlsbad State Beach	—	—	—	—
North Leucadia	—	0.5	—	—
Central Leucadia	0.5	3.0	—	—
South Leucadia	—	0.5	—	—
Encinitas	3.0	3.5	—	—
Cardiff	0.5	1.5	—	—
Solana Beach	1.5	2.0	—	—
Del Mar	—	—	—	—
Torrey Pines Park	—	—	—	—
La Jolla Upper	2.5	3.5	0.5	1.5
La Jolla Lower	2.5	3.5	0.5	1.5
Point Loma Upper	2.5	4.0	—	3.0
Point Loma Lower	2.5	4.0	—	3.0
Imperial Beach	—	—	—	—

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
NI = No Image
“-“ = no kelp present
Red highlight = survey utilized to quantify surface canopy area

III - RESULTS

III.1 - 2018 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 7.868 km^2 in 2018,
    - Region Nine - maximum total kelp canopy covered 11.037 km^2 in 2018.
2. What is the variability of the coastal kelp bed canopy over time?
    - Central Region:
        - maximum total kelp canopy increased in size in 2018 by 61% (from 4.881 km^2 to 7.868 km^2),
        - 23 kelp beds increased in size, including La Costa, Las Flores, and Topanga, which reappeared in 2018,
        - one kelp bed decreased in size,
    - Region Nine:
        - maximum total kelp canopy increased in size in 2018 by 237% (from 3.277 km^2 to 11.037 km^2),
        - 15 kelp beds increased in size,
        - four kelp beds decreased in size, including Carlsbad State Beach which disappeared in 2018.
3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
    - Central Region
        - no beds disappeared in 2018 that had been visible in 2017,
        - Horseshoe and Huntington Flats, which historically have been absent, were not visible in 2018,
    - Region Nine
        - Carlsbad State Beach disappeared in 2018,
        - Five beds continued not to be visible in 2018, including Santa Margarita and Torrey Pines which disappeared in 2014, Agua Hedionda and Del Mar which disappeared in 2016, and Imperial Beach which disappeared in 2017.
4. Are new kelp beds forming?
    - Central Region
        - La Costa, Las Flores and Topanga reappeared in 2018, the first two having been absent since 2015 and the last since 2016,
    - Region 9
        - no new beds reappeared in 2018.

III.1.B - CENTRAL REGION RESULTS

Maps showing the areal extent of CRKSC canopy coverage in 2018 are provided in Appendix A. Tables displaying the historical canopy coverage for the Central Region from 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 2018 are included in Appendix E.

Most kelp beds in the CRKSC region attained maximum surface canopy area for the year during the March survey, although a few kelp beds were at their maximum during the July survey (Table 2). In 2018, 24 kelp beds displayed surface canopy, compared to 21 kelp beds with surface canopy in 2017. Of these 24 kelp beds, 23 increased in size, while only 1 decreased in size. The total amount of kelp canopy in the CRKSC region increased by 61%, from 4.9 km^2 in 2017 to 7.9 km^2 in 2018. 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 1.8 km^2 (Figure 3, Panel A). The Palos Verdes I, II, III, and IV kelp beds and the Cabrillo kelp bed accounted for 61% (4.8 km^2) of the total CRKSC kelp coverage. The largest percentage increase in size in 2018 was observed at the Malibu Point kelp bed, which increased by 6,800% (Figure 3, Panel C). The largest increase in actual size was observed at the Palos Verdes IV kelp bed, from Malaga Cove to Palos Verdes Point, which increased in size from 1.0 km^2 to 1.8 km^2 (68%). The greatest decline in size was observed at the Cabrillo kelp bed, which decreased by 5%, from 0.329 km^2 to 0.312 km^2. Four kelp beds, Leo Carrillo, Lechuza, Palos Verdes III, and Los Angeles/Long Beach Harbor, reached their maximum size recorded since CRKSC surveys began in 2003. In 2018, 18 kelp beds were at or above 40% of their historic maximum size, including 12 that were at or above 80% of their historic maximum, while only two kelp beds were at less than 20% of their historic maximum size (Figure 3, Panel B).

III.1.C - REGION NINE RESULTS

Maps showing the areal extent of RNKSC canopy coverage in 2018 are provided in Appendix A. Tables displaying the historical canopy coverage for Region Nine from 1983 through 2017 are included in Appendix B.4. Delineation of each kelp bed area is shown in Appendix D. Aerial photographs taken during the four quarterly overflights in 2018 are included in Appendix E.

All kelp beds in the RNKSC region attained maximum surface canopy area for the year during either the March or July surveys (Table 3). In 2018, 18 kelp beds displayed surface canopy, compared to 19 kelp beds with surface canopy in 2017. Of these 18 kelp beds, 15 increased in size, while three decreased in size. The Carlsbad State Beach kelp bed was not visible in 2018. The total amount of kelp canopy in the RNKSC region increased by 237%, from 3.3 km^2 in 2017 to 11.0 km^2 in 2018. The largest beds in the RNKSC region are the La Jolla and Point Loma kelp beds, with Point Loma being the largest at 7.9 km^2 (Figure 3, Panel A). These two large kelp beds accounted for 86% (9.5 km^2) of the total RNKSC kelp coverage in 2018. The largest percentage increase in size was observed at the Capistrano Beach kelp bed (+4,400%) (Figure 3, Panel B). The largest increase in actual size was observed at the Point Loma kelp bed, which increased from 1.8 km^2 to 7.9 km^2 (343%). The greatest percentage decline was observed at the Horno Canyon kelp bed (-27%), while the greatest decline in actual size was observed at the Solano Beach kelp bed, which decreased from 0.029 km^2 to 0.024 km^2 (Figure 3, Panel C). Two kelp beds, namely South Laguna and Point Loma, reached their maximum size recorded since RNKSC surveys began in 1983 (Figure 3, Panel B). Only three kelp beds were above 40% of their historic maximum size, while 11 kelp beds were at less than 20% of their historic maximum size (Figure 3, Panel B).

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 2018 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 2017 and 2018 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. There was a small amount of kelp growing along the breakwaters of Ventura Harbor (0.008 km^2), Channel Islands Harbor (0.010 km^2), and Port Hueneme (0.017 km^2) in 2018 (Appendices A.1, A.4, and A.5). The amount of kelp at Ventura Harbor and Port Hueneme increased in 2018, while it was approximately the same at Channel Islands Harbor in 2017 and 2018. 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

All five kelp beds increased in size in 2018 (38% to 107% larger than in 2017).

Deer Creek. This kelp bed increased in size by 38%, from 0.105 km^2 in 2017 to 0.145 km^2 in 2018 (Table 4). The canopy area in 2018 was the maximum recorded since the CRKSC surveys began in 2003 (Appendix B.3; Figure 3).

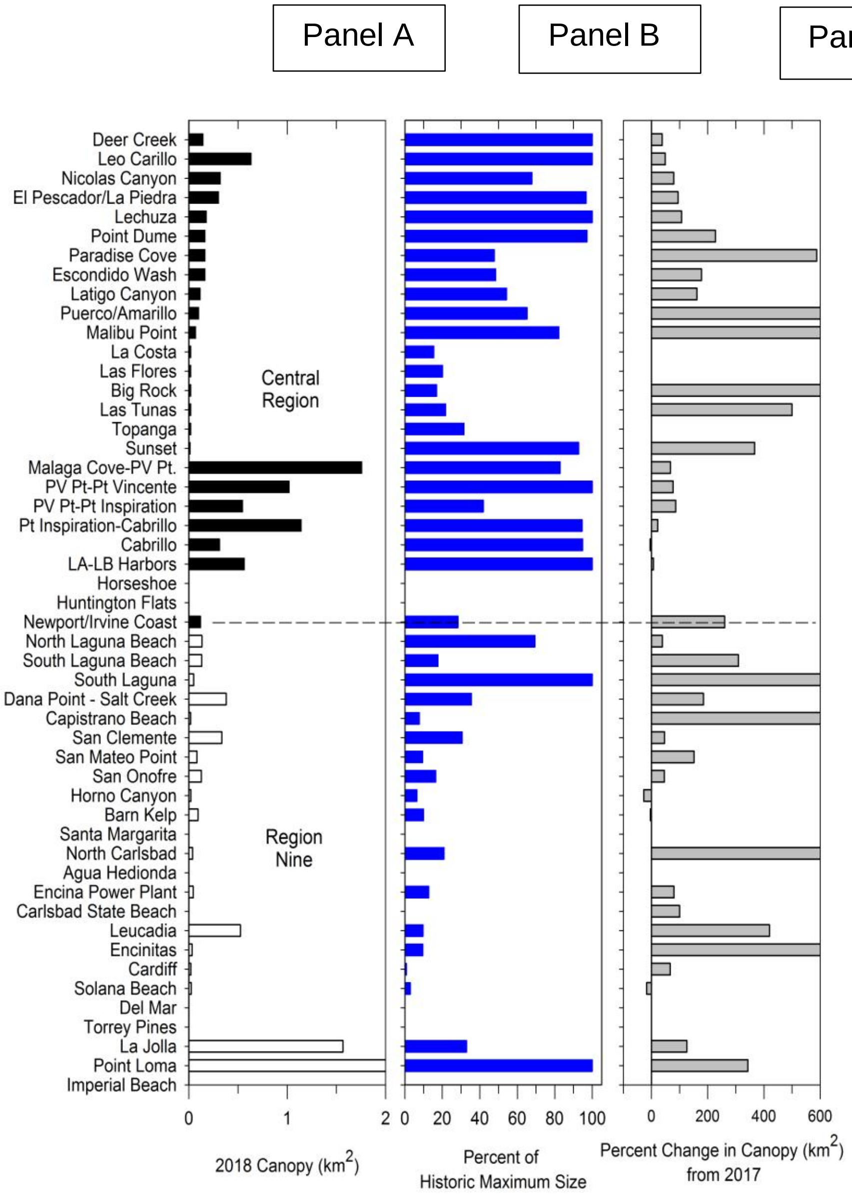
The Deer Creek kelp canopy (Appendix A.10) was compared to the ABAPY of the northern and central portions of the Central Region (average of the 17 kelp beds located in Fish and Wildlife kelp harvest lease areas 15, 16, and 17) to determine whether it was responding synoptically with other beds (Figure 4). The Deer Creek kelp bed increased in size in 2018 by less than the ABAPY (38% versus 112%). After declining to a low level in 2012, this kelp bed increased to a new maximum by 2015, then declined again in 2016, followed by increased in 2017 and 2018, when it reached a new peak level (Table 7; Figure 4, blue line). Deer Creek was the smallest kelp bed in the area from Point Mugu to Point Dume.

Leo Carrillo. This kelp bed increased in size by 49%, from 0.426 km^2 in 2017 to 0.633 km^2 in 2018 (Table 4). The canopy area in 2018 was the maximum recorded since the CRKSC surveys began in 2003 (Appendix B.3; Figure 3).

The Leo Carrillo kelp bed (Appendix A.11) increased in size in 2018 by less than the ABAPY (49% versus 112%). Leo Carrillo was the largest kelp bed in the northern and central Los Angeles County (Table 7; Figure 4, green line).

Nicolas Canyon. This kelp bed increased in size by 79%, from 0.179 km^2 in 2017 to 0.321 km^2 in 2018 (Table 4). The canopy area in 2018 was 68% of the maximum recorded in 2007 (Appendix B.3; Figure 3).

The Nicolas Canyon kelp bed (Appendix A.12) also increased in size in 2018 by less than the ABAPY (79% versus 112%). Despite this increase, this bed remained below the levels observed in 2013 and 2015 (Table 7; Figure 4, purple line).



Note: truncated scale in Panel A: Point Loma canopy area = 7.9 km^2

truncated scale in Panel C: Percent change in canopy for Puerco/Amarillo = 4,900%, for Malibu Pt. = 6,800%, for Big Rock = 2,900%, for South Laguna = 1,500%, for Capistrano Beach = 4,400%, for North Carlsbad = 850%, for Encinitas = 1,000%

Figure 3. Summary of Central Region and Region Nine kelp canopy coverage in 2018.

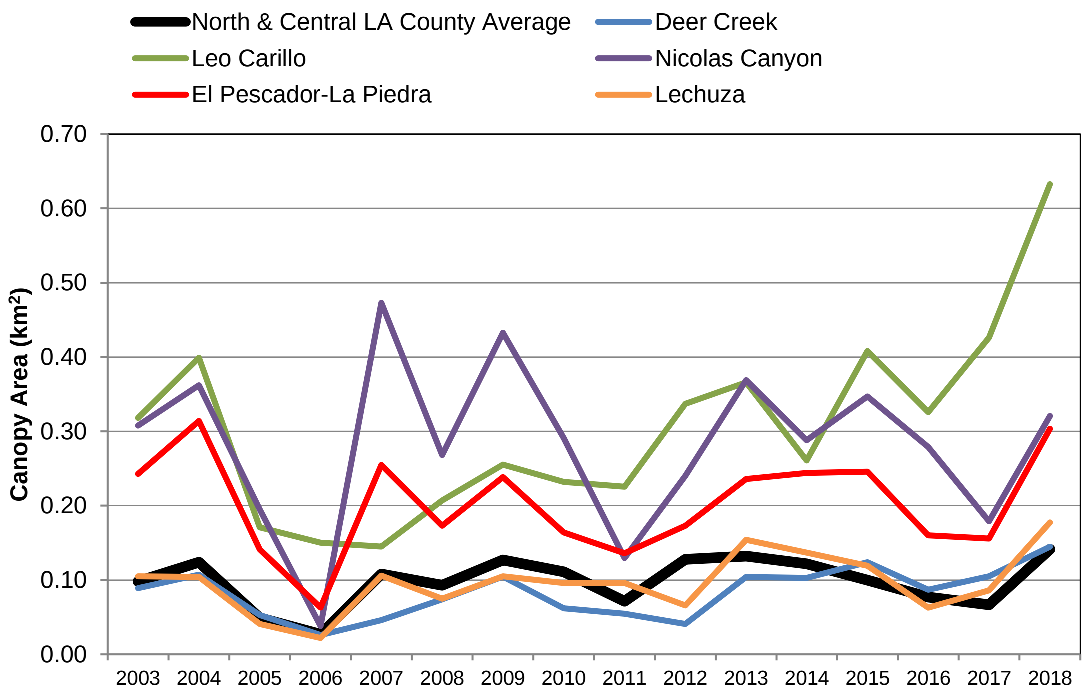


Figure 4. Comparisons between the average Northern and Central Los Angeles County ABAPY and canopy coverage from Point Mugu through Point Dume from 2003 through 2018.

El Pescador/La Piedra. This kelp bed increased in size by 95%, from 0.156 km^2 in 2017 to 0.304 km^2 in 2018 (Table 4). The canopy area in 2018 was 97% of the maximum recorded in 2004 (Appendix B.3; Figure 3).

The increase in size of the El Pescador/La Piedra kelp canopy (Appendix A.12 and A.13) was similar to the increase of the ABAPY (95% versus 112%). The canopy size in 2018 is the largest recorded since the peak in 2004 (Table 7; Figure 4, red line).

Lechuza. This kelp bed increased in size by 107%, from 0.086 km^2 in 2017 to 0.178 km^2 in 2018 (Table 4). The canopy area in 2018 was the maximum recorded since the CRKSC surveys began in 2003 (Appendix B.3; Figure 3).

The Lechuza kelp canopy increase in 2018 was similar to the increase of the ABAPY (107% versus 112%). In 2018, this kelp bed exceeded the previous peak recorded in 2013 (Table 7; Figure 4, orange line). Lechuza (Appendix A.13) was the second smallest of the five kelp beds located between Point Mugu and Point Dume.

Table 4. Canopy coverage of the Central Region kelp beds from Deer Creek to Newport/Irvine Coast (kelp beds listed north to south) during 2017 and 2018.

Kelp Bed	2017 (km^2)	2018 (km^2)	Percentage Difference
Deer Creek	**0.105**	**0.145**	**+38**
Leo Carrillo	**0.426**	**0.633**	**+49**
Nicolas Canyon	**0.179**	**0.321**	**+79**
El Pescador/La Piedra	**0.156**	**0.304**	**+95**
Lechuza	**0.086**	**0.178**	**+107**
Point Dume	**0.050**	**0.164**	**+228**
Paradise Cove	**0.024**	**0.165**	**+588**
Escondido Wash	**0.059**	**0.164**	**+178**
Latigo Canyon	**0.044**	**0.115**	**+161**
Puerco/Amarillo	**0.002**	**0.100**	**+4,900**
Malibu Point	**0.001**	**0.069**	**+6,800**
La Costa	–	**0.0004**	**reappeared**
Las Flores	–	**0.006**	**reappeared**
Big Rock	**0.0001**	**0.003**	**+2,900**
Las Tunas	**0.001**	**0.006**	**+500**
Topanga	–	**0.016**	**reappeared**
Sunset	**0.003**	**0.014**	**+367**

Table 4 (continued)

Kelp Bed	2017 (km^2)	2018 (km^2)	Percentage Difference
Malaga Cove to Palos Verdes Point (IV)	**1.048**	**1.758**	**+68**
Palos Verdes Point to Point Vicente (III)	**0.576**	**1.021**	**+77**
Point Vicente to Point Inspiration (II)	**0.294**	**0.547**	**+86**
Point Inspiration to Cabrillo (I)	**0.934**	**1.143**	**+22**
Cabrillo	**0.329**	**0.312**	**-5**
Port of Los Angeles/Port of Long Beach Harbor	**0.530**	**0.565**	**+7**
Horseshoe	–	–	**no change**
Huntington Flats	–	–	**no change**
Newport-Irvine Coast	**0.033**	**0.119**	**+261**
TOTAL	**4.881**	**7.868**	**+61**

III.2.C - POINT DUME TO MALIBU POINT

All six kelp beds increased in size in 2018 (161% to 6,800% larger than in 2017).

Point Dume. This kelp bed increased in size by 228%, from 0.050 km^2 in 2017 to 0.164 km^2 in 2018 (Table 4). The canopy area in 2018 was 97% of the maximum recorded in 2015 (Appendix B.3; Figure 3).

The Point Dume kelp canopy (Appendix A.14) increased by even more than the increase in the ABAPY (228% versus 112%). Due to the 2018 increase, the size of the Point Dume kelp bed nearly reached the peak level recorded in 2015 (Table 7; Figure 5, blue line).

Paradise Cove. This kelp bed increased in size by 588%, from 0.024 km^2 in 2017 to 0.165 km^2 in 2018 (Table 4). The canopy area in 2018 was 48% of the maximum recorded in 2012 (Appendix B.3; Figure 3).

The Paradise Cove kelp canopy (Appendix A.14) also increased by even more than the increase in the ABAPY (588% versus 112%). Despite this substantial increase in size, the

Paradise Cove kelp bed is less than half the size of the peak level observed in 2012, and smaller than the levels recorded in 2013 and 2014 (Figure 5, green line).

Escondido Wash. This kelp bed increased in size by 178%, from 0.059 km^2 in 2017 to 0.164 km^2 in 2018 (Table 4). The canopy area in 2018 was 48% of the maximum recorded in 2007 (Appendix B.3; Figure 3).

The Escondido Wash kelp canopy (Appendix A.15) increased more than the ABAPY in 2018 (178% versus 112%). Despite this substantial increase in size, the Escondido Wash kelp bed is still well below the levels observed from 2012 to 2014 (Figure 5, purple line).

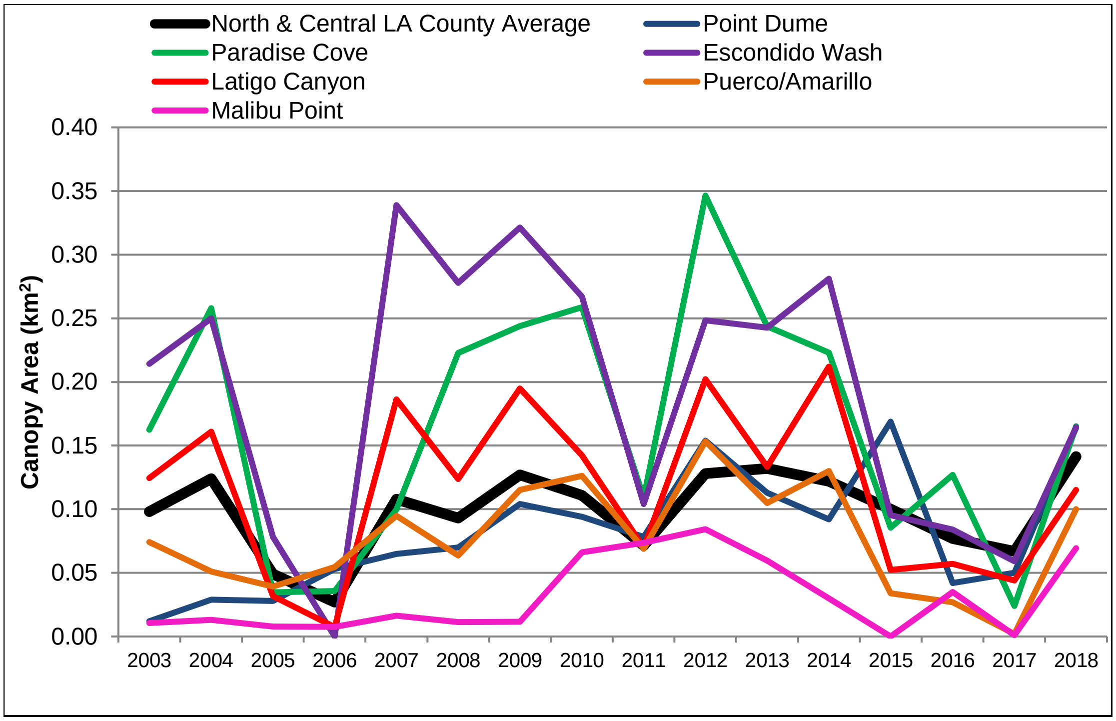


Figure 5. Comparisons between the average Northern and Central Los Angeles County ABAPY and canopy coverage from Point Dume to Malibu Point from 2003 through 2018.

Latigo Canyon. This kelp bed increased in size by 161%, from 0.044 km^2 in 2017 to 0.115 km^2 in 2018 (Table 4). The canopy area in 2018 was 54% of the maximum recorded in 2014 (Appendix B.3; Figure 3).

The Latigo Canyon kelp canopy (Appendix A.15) also increased more than the ABAPY in 2018 (161% versus 112%). Despite this increase, the kelp bed still is much smaller than the levels observed in 2012 and 2014 (Figure 5, red line).

Puerco/Amarillo. This kelp bed increased in size by 4,900%, from 0.002 km^2 in 2017 to 0.100 km^2 in 2018 (Table 4). The canopy area in 2018 was 65% of the maximum recorded in 2012 (Appendix B.3; Figure 3).

The Puerco/Amarillo kelp canopy (Appendix A.16) increased considerably more than the ABAPY (4,900% versus 112%). The Puerco/Amarillo kelp bed nearly disappeared in 2017, but this substantial increase brought it to the level observed in 2013, but still smaller than in 2012 and 2014 (Figure 5, orange line).

Malibu Point. This kelp bed increased in size by 6,800%, from 0.001 km^2 in 2017 to 0.069 km^2 in 2018 (Table 4). The canopy area in 2018 was 82% of the maximum recorded in 2012 (Appendix B.3; Figure 3).

The Malibu Point kelp canopy (Appendix A.17) increased more than the ABAPY as well (6,800% versus 112%) and was the largest percentage increase observed in the Central Region. This kelp bed was relatively small through 2009 but increased to a peak level in 2012. Subsequently, it declined until it disappeared in 2015, only to rebound in 2016, nearly disappeared again in 2017, but rebounded once more in 2018 (Figure 5, pink line).

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 and well below the average size for the region. All were visible in 2018, the first time that this has occurred since 2014.

La Costa. This kelp bed was not observed in 2017 but reappeared in 2018 at a size of 0.0004 km^2 (Table 4). The canopy area in 2018 was 15% of the maximum recorded in 2014 (Appendix B.3; Figure 3).

The La Costa kelp bed (Appendix A.18) has been visible in only half the years since 2003. After being absent since 2015, this kelp bed reappeared in 2018 but still is much smaller than peak levels observed several years ago (Appendix B.3; Figure 6, pink line).

Las Flores. This kelp bed was not observed in 2017, but reappeared in 2018 with a size of 0.006 km^2 (Table 4). The canopy area in 2018 was 20% of the maximum recorded in 2014 (Appendix B.3; Figure 3).

The Las Flores kelp bed reached its maximum size in 2012, but canopy size decreased until the kelp bed disappeared in 2015, reappearing once again in 2018 (Appendix A.18; Figure 6, blue line).

Big Rock. This kelp bed increased in size by 2,900%, from 0.0001 km^2 in 2017 to 0.003 km^2 in 2018 (Table 4). The canopy area in 2018 was 17% of the maximum recorded in 2012.

The Big Rock kelp bed increased substantially in size in 2018, after nearly disappearing in 2017. It is still well below the peak level observed in 2012 (Appendix B.3; Figure 6, green line).

Las Tunas. This kelp bed increased in size by 500%, from 0.001 km^2 in 2017 to 0.006 km^2 in 2018 (Table 4). The canopy area in 2018 was 22% of the maximum recorded in 2012 (Appendix B.3; Figure 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. Subsequent declines resulted in its disappearance in 2016, but it reappeared in 2017. Despite the increase in size in 2018, this bed still is much smaller than the levels observed from 2012 through 2014 (Appendix B.3; Figure 6, purple line).

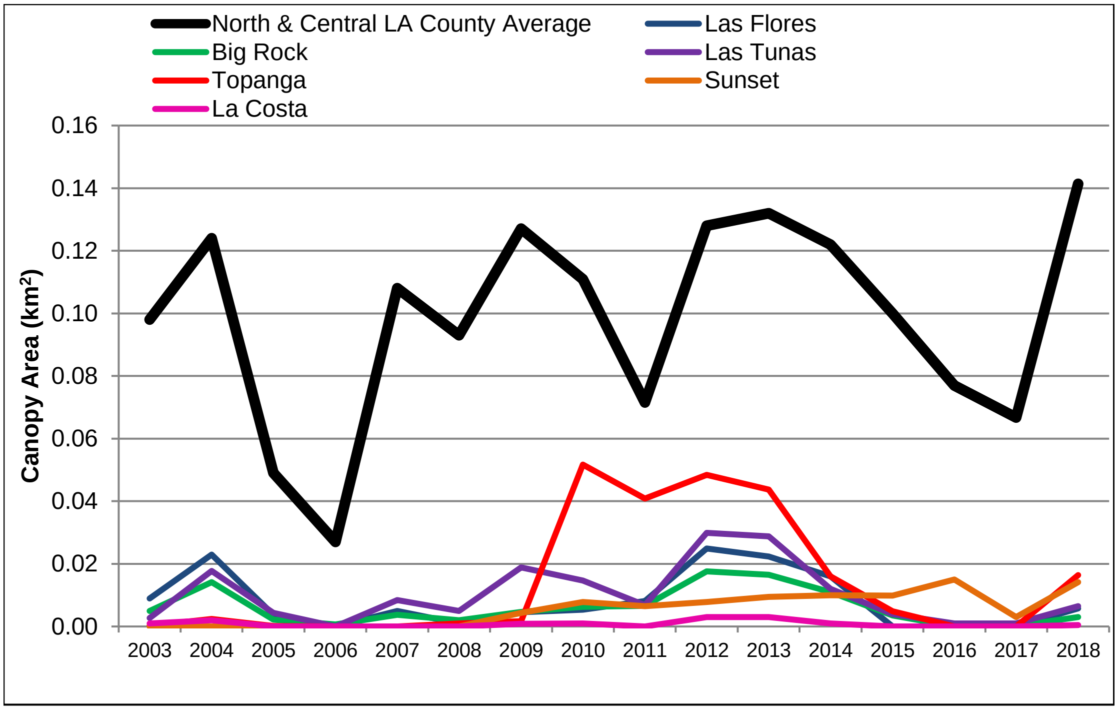


Figure 6. Comparisons between the average Northern and Central Los Angeles County ABAPY and the canopy coverage from Las Flores to Sunset from 2003 through 2018.

Topanga. This kelp bed was not visible in 2017 but reappeared in 2018 at a size of 0.016 km^2 (Table 4). The canopy area in 2018 was 32% of the maximum recorded in 2010 (Appendix B.3; Figure 3).

The Topanga kelp bed was relatively large (0.04 to 0.05 km^2) from 2010 through 2013 (Appendix B.3; Figure 6, red line). Although this kelp bed reappeared in 2018 following a two-year absence, it remains much smaller than the peak levels observed in the past.

Sunset. This kelp bed increased in size by 367%, from 0.003 km^2 in 2017 to 0.014 km^2 in 2018 (Table 4). The canopy area in 2018 was 93% of the maximum recorded in 2016 (Appendix B.3; Figure 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 it has been present every year since, reaching its maximum size of 0.015 km^2 in 2016. With the substantial increase in size in 2018, this kelp bed is near the peak level observed in 2016 (Appendix B.3; Figure 6, orange line).

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.

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), decreasing in size from 0.016 km^2 in 2017 to 0.011 km^2 in 2018.

Redondo Beach Breakwater to Malaga Cove, Torrance. Kelp was observed along the Redondo breakwater at King Harbor (Appendix A27) in 2018 (0.006 km^2), the same amount observed to 2017. No kelp was seen between King Harbor and Malaga Cove at the Palos Verdes Peninsula (Appendices A.27, A.28).

III.2.F - MALAGA COVE TO POINT FERMIN

Palos Verdes IV. This kelp bed increased in size by 68%, from 1.048 km^2 in 2017 to 1.7584 km^2 in 2018 (Table 4). The canopy area in 2018 was 83% of the maximum recorded in 2009 (Appendix B.3; Figure 3).

The Palos Verdes IV kelp bed includes the area from Malaga Cove to Palos Verdes Point (Appendix A.28). The PV-IV kelp bed increased in size more than the Palos Verdes-Cabrillo ABAPY (83% vs 50%). This kelp bed declined to a low level in 2014, then increased in size in 2015, declining once again in 2017, and increased substantially in 2018, reaching the second highest level observed since 2003 (Figure 7, blue line).

Palos Verdes III. This kelp bed increased in size by 77%, from 0.576 km^2 in 2017 to 1.021 km^2 in 2018 (Table 4). The canopy area in 2018 was the maximum size recorded since CRKSC surveys began in 2003 (Appendix B.3; Figure 3).

The Palos Verdes III kelp bed includes the area from Palos Verdes Point to Point Vicente (Appendix A.29). The PV-III kelp bed also increased in size more than the Palos Verdes-Cabrillo ABAPY (77% versus 50%). From a low point in 2016, this kelp bed reached the largest size observed since CRKSC surveys began, exceeding the previous peak in 2015 (Appendix B.3; Figure 7, green line).

Palos Verdes II. This kelp bed increased in size by 86%, from 0.294 km^2 in 2017 to 0.547 km^2 in 2018 (Table 4). The canopy area in 2018 was 42% of the maximum recorded in 2009 (Appendix B.3; Figure 3).

The Palos Verdes II kelp bed includes the kelp from Point Vicente to Inspiration Point (Appendix A.29). This kelp bed increased in size more than the Palos Verdes-Cabrillo ABAPY (86% vs 50%). The PV-II kelp bed attained its highest level since 2011, but remained well below the peak level of 2009 (Figure 7, purple line).

Palos Verdes I. This kelp bed increased in size by 22%, from 0.934 km^2 in 2017 to 1.143 km^2 in 2018 (Table 4). The canopy area in 2018 was 95% of the maximum recorded in 2002 (Appendix B.3; Figure 3).

The Palos Verdes I kelp bed includes the area from Inspiration Point to Point Fermin (Appendix A.30 and A.31). The PV-I kelp bed increase in size was less than the Palos Verdes-Cabrillo ABAPY (22% vs 50%). This kelp bed has increased in size every year since 2015, and in 2018 it nearly reached the peak level observed in 2002 (Figure 7, red line).

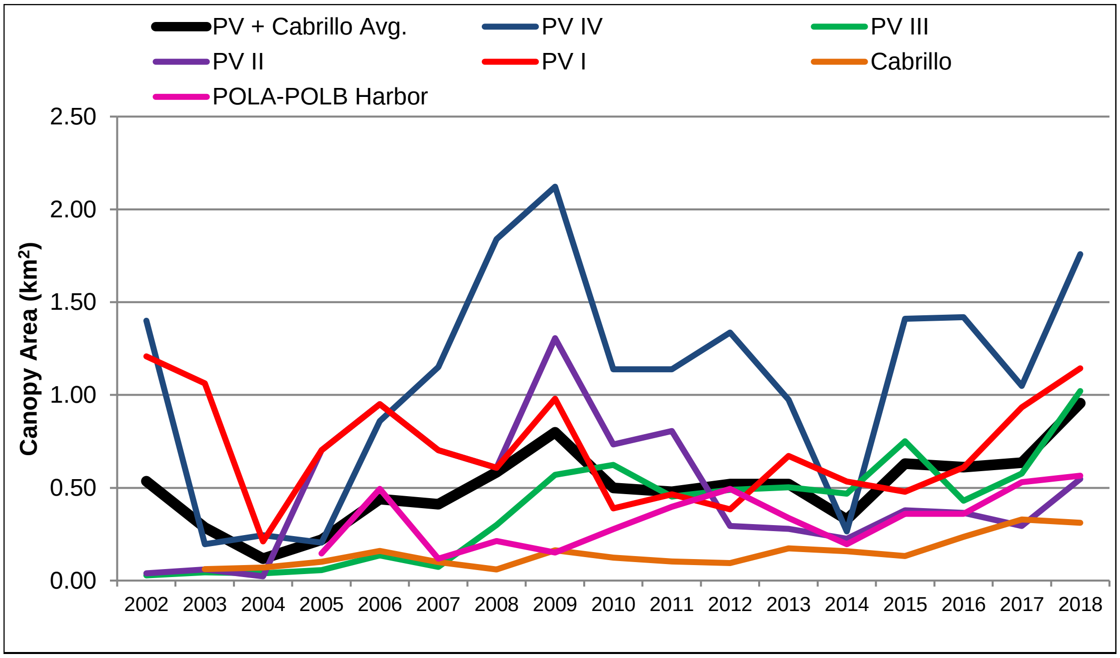


Figure 7. Comparisons between the average Palos Verdes and Cabrillo ABAPY and canopy coverage of the kelp beds off Palos Verdes and POLA/POLB Harbor from 2002 through 2018.

III.2.G - POINT FERMIN TO NEWPORT BEACH

Cabrillo. This kelp bed decreased in size by 5%, from 0.329 km^2 in 2017 to 0.312 km^2 in 2018 (Table 4). The canopy area in 2018 was the 95% of the maximum recorded in 2017 (Appendix B.3; Figure 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). Despite the 50% increase in the Palos Verdes-Cabrillo ABAPY in 2018, the Cabrillo kelp bed decreased slightly in size. However, this kelp bed remains close to the peak level observed in 2017 (Figure 7, orange line).

Los Angeles and Long Beach Harbors (POLA/POLB). Kelp coverage increased in size by 7%, from 0.504 km^2 in 2017 to 0.565 km^2 in 2018 (Table 4). The canopy area in 2018 was the maximum recorded since the CRKSC surveys began in 2005 in the POLA/POLB area (Appendix B.3; Figure 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 than 95% of the kelp coverage, with *Egregia menziesii* comprising less than 5% (MBC and Merkel 2016).

The POLA/POLB kelp canopy increased slightly in 2018, exceeding the peak level observed the previous year (Appendix B.3; Figure 7, pink line). The kelp canopy in 2018 also was larger than prior peaks observed in 2006 and 2012.

Horseshoe Kelp. This bed was not observed in 2018, nor was it visible in 2017 (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 2018, nor was it visible in 2017 (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 2018 (Appendices A.36 through A.40, D.8, and E.5). Narrow bands of kelp (0.113 km^2) were visible on the Newport Harbor jetties in 2018 (Appendix A.40). However, this area is not considered to be one of the 26 designated kelp beds within the CRKSC.

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

Newport/Irvine Coast. This kelp bed increased in size by 261%, from 0.033 km^2 in 2017 to 0.119 km^2 in 2018 (Table 4). The canopy area in 2018 was 28% of the maximum recorded in 2011 (Appendix B.3; Figure 3).

Downcoast from Newport Harbor, giant kelp grows in a number of small beds collectively called the Newport/Irvine Coast kelp bed, or sometimes referred to 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 (Appendices A.41 and A.42; Figure 8, red line). In 2018, the canopy area increased in size more than the Orange County ABAPY (261% versus 116%), but still was considerably smaller than the peak level observed in 2013.

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 2018 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 2017 and 2018 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 recorded in Table 6 are based on vessel surveys conducted in January 2019. Observations from diver surveys conducted at the Horno Canyon and Encina Power Plant kelp bed areas are also presented in Table 6.

III.3.A - ABALONE POINT TO CAPISTRANO BEACH

There are five kelp beds located between Abalone Point and Capistrano Beach. In 2018, all five beds increased in size (Table 5).

North Laguna Beach/South Laguna Beach. The North Laguna Beach kelp bed increased in size by 38%, from 0.096 km^2 in 2017 to 0.133 km^2 in 2018 (Table 5). The canopy area in 2018 was 69% of the maximum recorded in 2012. The South Laguna Beach kelp bed increased in size by 309%, from 0.032 km^2 in 2017 to 0.131 km^2 in 2018. The canopy area in 2018 was 18% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

The North and South 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. Although the two kelp beds increased from a combined total of 0.109 km^2 in 2016 to 0.264 km^2 in 2018 (Figure 8, green line), their combined size is considerably smaller than the peak level observed in 2012.

During the January 2019 vessel survey (Table 6), the North Laguna Beach surface canopy was medium in area and measured approximately 200 by 100 meters. Subsurface kelp was visible on the fathometer, extending over a larger area than the surface canopy. Tissue color was 50% dark yellow and 50% light to medium yellow, with 20% apical blades and the fronds had medium encrustation. The kelp bed was composed of approximately 10% senile, 50% mature, and 40% young fronds. The South Laguna Beach surface canopy also was medium in area and measured approximately 300 by 150 meters. Some 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 light encrustation. The kelp bed was composed of approximately 10% senile, 80% mature, and 10% young fronds.

South Laguna. This kelp bed increased in size by 1,500%, from 0.003 km^2 in 2017 to 0.048 km^2 in 2018 (Table 5). The canopy area in 2018 was the maximum recorded since RNKSC surveys began in 1983 (Appendix B.4; Figure 3).

After nearly disappearing in 2017, the South Laguna kelp bed increased substantially in size in 2018, reaching the highest level observed since RNKSC surveys began (Appendix B.4; Figure 8, purple line). This kelp bed increased in size much more than the Orange County ABAPY (1,500% vs 116%).

No surface or subsurface kelp was observed during the January 2019 vessel survey (Table 6).

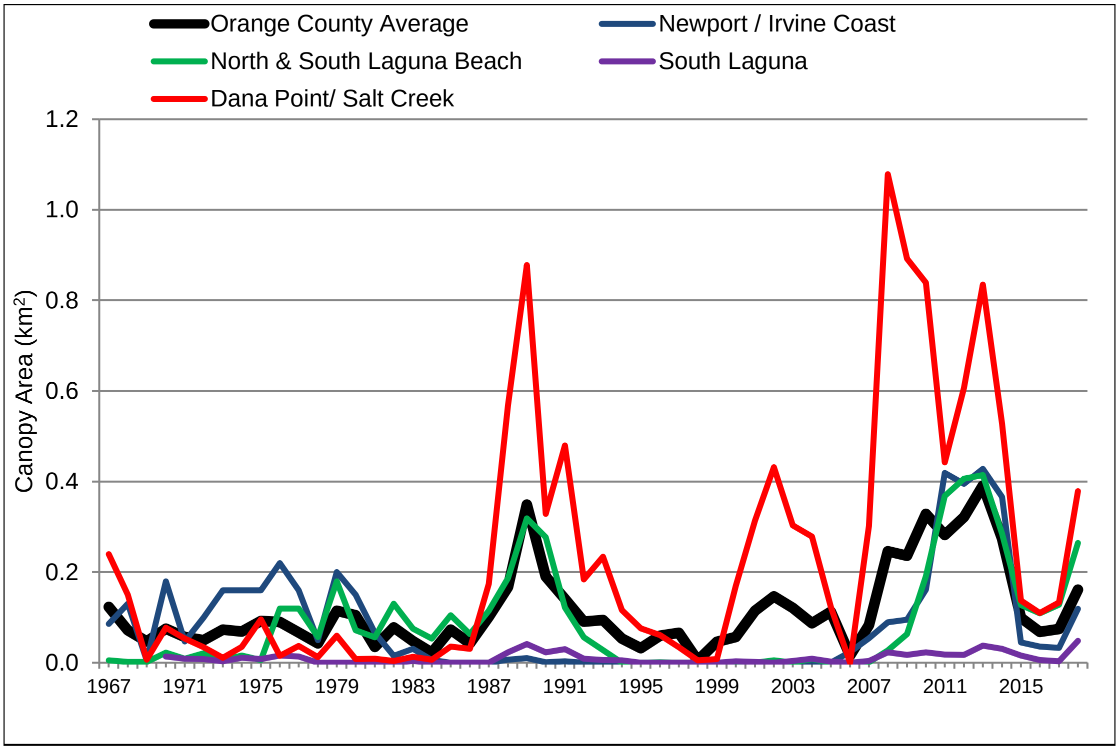


Figure 8. Comparisons between the average Orange County ABAPY and the canopy coverage of the kelp beds from Newport/Irvine Coast to Dana Point/Salt Creek from 1967 through 2018.

Dana Point/Salt Creek. This kelp bed increased in size by 185%, from 0.133 km^2 in 2017 to 0.379 km^2 in 2018 (Table 5). The canopy area in 2018 was 36% of the maximum recorded in 2008 (Appendix B.4; Figure 3).

The Dana Point/Salt Creek kelp bed (Appendix A.46) was relatively small in size from 2015 to 2017. However, in 2018, this bed increased more than the Orange County ABAPY (185% vs 116%). Despite this increase, the kelp bed remains well below the peak levels observed in 2008 and the high levels in 2009, 2010 and 2013 (Figure 8, red line).

During the January 2019 vessel survey (Table 6), the Dana Point/Salt Creek surface canopy was virtually non-existent (only one plant was observed). No subsurface kelp was visible on the fathometer to a depth of about 38 feet, but some kelp may have been present at about 48 feet deep.

Some kelp (0.036 km^2) was observed along the breakwaters in Dana Point Harbor (Appendix A.47) in 2018. This represented a considerable increase compared to 2017. This is not a designated kelp bed.

Table 5. Canopy coverage of the Region Nine kelp beds from Laguna Beach to Imperial Beach (kelp beds listed north to south) during 2017 and 2018.

Kelp Bed	2017 (km^2)	2018 (km^2)	Percentage Difference
North Laguna Beach	**0.096**	**0.133**	**+38**
South Laguna Beach	**0.032**	**0.131**	**+309**
South Laguna	**0.003**	**0.048**	**+1,500**
Dana Point/Salt Creek	**0.133**	**0.379**	**+185**
Capistrano Beach	**0.0004**	**0.018**	**+4,400**
San Clemente	**0.229**	**0.335**	**+46**
San Mateo Point	**0.033**	**0.083**	**+152**
San Onofre	**0.087**	**0.127**	**+46**
Horno Canyon	**0.011**	**0.008**	**-27**
Barn Kelp	**0.096**	**0.092**	**-4**
Santa Margarita	–	–	**no change**
North Carlsbad	**0.004**	**0.038**	**+850**
Agua Hedionda	–	–	**no change**
Encina Power Plant	**0.025**	**0.045**	**+80**
Carlsbad State Beach	**0.001**	–	**disappeared**

Table 5 (continued)

Kelp Bed	2017 (km^2)	2018 (km^2)	Percentage Difference
Leucadia	**0.010**	**0.052**	**+420**
Encinitas	**0.003**	**0.033**	**+1,000**
Cardiff	**0.003**	**0.005**	**+67**
Solana Beach	**0.029**	**0.024**	**-17**
Del Mar	–	–	**no change**
Torrey Pines	–	–	**no change**
La Jolla	**0.694**	**1.566**	**+126**
Point Loma	**1.787**	**7.920**	**+343**
Imperial Beach	–	–	**no change**
TOTAL	**3.277**	**11.037**	**+237**

Table 6. Visual observations of RNKSC kelp beds during January 2019 vessel surveys.

Kelp Bed	**Surface Canopy**		**Subsurface Kelp**
	Extent	**Appearance**	
North Laguna Beach	medium 200 m x 100 m	50% dark yellow, 50% light/medium yellow; 10% senile, 50% mature, 40% young; medium encrustation 20% apical blades	subsurface kelp extends further than surface canopy
South Laguna Beach	medium 300 m x 150 m	80% dark yellow, 20% light yellow 10% senile, 80% mature, 10% young light encrustation 5% apical blades	some subsurface kelp
South Laguna	none		
Dana Point/Salt Creek	virtually none (1 plant)		None at @38 feet, possibly some at @48 feet

Table 6 (continued)

Dana Point Harbor	none		none
Capistrano Beach	virtually none (1 plant)		none
San Clemente	none		
San Mateo Point	small (@ 10% coverage) 30 x 300 m	80% dark yellow, 20% light yellow; 30% mature, 70% young 10% encrustation 50% apical blades	Large extent subsurface
San Onofre	small (@ 10% coverage) 200 m x 100 m	90% dark yellow, 10% light yellow; 10% mature, 90% young; no encrustation 50% apical blades	more subsurface kelp than surface canopy
Pendleton Reefs	none		none
Horno Canyon	none		**see discussion of dive survey results**
Barn Kelp	none		
Santa Margarita	none		none
North Carlsbad	none		Scattered subsurface kelp @ 10 feet tall
Agua Hedionda	none		Numerous scattered single plants, @ 15 feet tall
Encina Power Plant	none		**see discussion of dive survey results**
Carlsbad State Beach	none		none
Leucadia-north	none		none
Leucadia-central	none		none
Leucadia-south	15 x 30 m	50% dark yellow, 50% light yellow; 50% senile/50% young	10-20 plants @ 10-15 feet tall
Encinitas	Virtually none (1 plant)	100% senile	Scattered subsurface kelp, 10-20 plants, 10-20 feet tall
Cardiff	none		Several single plants 10-15 feet tall
Solana Beach	none		Possibly small patches, 5-10 feet tall
Del Mar	none		none
Torrey Pines	none		none
La Jolla North	Scattered canopy, @ 100 m wide	20% dark yellow, 40% medium yellow, 40 % light yellow; 40% senile, 40% mature, 20% young light encrustation no apical blades	visible subsurface kelp
La Jolla South	Extensive near shore	20% dark yellow, 80% medium yellow; 1% senile, 80% mature, 19% young; 5% encrustation 5% apical blades	New growth visible
Point Loma North	Very scattered inshore of 55 feet		lots of subsurface kelp within 10 feet of surface
Point Loma South	Solid canopy in shallow water along shore	90% dark yellow, 10% light yellow 1% senile, 2% mature, 97% young 5% encrustation 5% apical blades	
Imperial Beach	none		none

Capistrano Beach. This kelp bed increased in size by 4,400%, from 0.0004 km^2 in 2017 to 0.018 km^2 in 2018 (Table 5). The canopy area in 2018 was 8% of the maximum recorded in 1989 (Appendix B.4; Figure 3).

The Capistrano Beach kelp bed (Appendices A.47 and A.48) nearly disappeared in 2017. Consequently, the substantial increase in size in 2018 was much greater than the slight increase in the Orange County ABAPY (4,400% versus 116%). The Capistrano Beach kelp bed is well below the peak level observed in 1989 and the high levels in 2010 and 2013 (Figure 9, blue line).

The surface canopy was virtually non-existent (one plant observed) and no subsurface kelp was visible on the fathometer during the January 2019 vessel survey (Table 6).

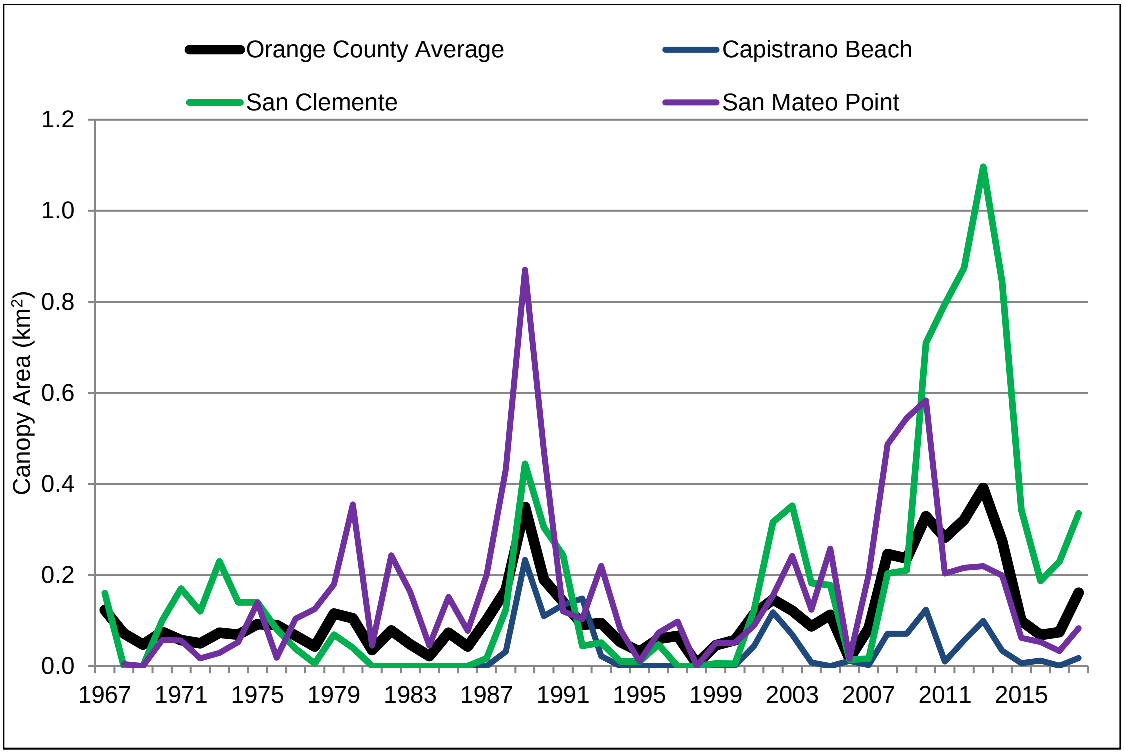


Figure 9. Comparisons between the average Orange County ABAPY and the canopy coverage from Capistrano Beach to San Mateo Point from 1967 through 2018.

III.3.B - SAN CLEMENTE TO SAN ONOFRE

Three kelp beds are located between San Clemente and San Onofre. All three beds increased in size in 2018 (Table 5).

San Clemente. This kelp bed increased in size by 46%, from 0.229 km^2 in 2017 to 0.335 km^2 in 2018 (Table 5). The canopy area in 2018 was 31% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

Although the San Clemente kelp bed increased in size in 2017 and 2018, it remains well below the peak level observed in 2013 (Appendix B.4; Figure 9, green line). This kelp bed increased less in size in 2018 than the Orange County ABAPY (46% versus 116%). No surface canopy or subsurface kelp was visible during the January 2019 vessel survey (Table 6).

San Mateo Point. This kelp bed increased in size by 152%, from 0.033 km^2 in 2017 to 0.083 km^2 in 2018 (Table 5). The canopy area in 2018 was 31% of the maximum recorded in 1989 (Appendix B.4; Figure 3).

The San Mateo Point kelp bed (Appendix A.50) had declined to a small size in 2017. In 2018, this kelp bed increased in size more than the Orange County ABAPY (152% versus 116%). Despite this, the San Mateo Point kelp bed remained well below the peak level observed in 1989 and the high level observed in 2010 (Figure 9, purple line).

During the January 2019 vessel survey (Table 6), the San Mateo Point surface canopy was small in area (approximately 10% coverage) and measured approximately 30 by 300 meters. Tissue color was 80% dark yellow and 20% light yellow, with 50% apical blades, and the fronds had light encrustation (approximately 10%). The kelp bed was composed of approximately 30% mature, and 70% young fronds. Subsurface kelp was visible on the fathometer, covering an area larger than the extent of the surface canopy (Table 6).

San Onofre. This kelp bed increased in size by 46%, from 0.087 km^2 in 2017 to 0.127 km^2 in 2018 (Table 5). The canopy area in 2018 was 16% of the maximum recorded in 1989 (Appendix B.4; Figure 3).

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 nearly peak size in 2013, the San Onofre kelp bed (Appendices A.50 and A.51) decreased considerably in size. This kelp bed increased a little less than the San Diego County average ABAPY (excluding the La Jolla and Point Loma beds, which would skew the average), increasing in size by 46% compared to 57% for the ABAPY. Despite this increase in size, the San Onofre kelp bed remains well below peak levels observed in 1989 and 2013 (Appendix B.4; Figure 10, blue line).

During the January 2019 vessel survey (Table 6), the San Onofre surface canopy was small in area (approximately 10% coverage) and measured approximately 200 by 100 meters. Tissue color was 90% dark yellow and 10% light yellow, with 50% apical blades, and the fronds had no encrustation. The kelp bed was composed of approximately 10% mature, and 90% young fronds. Subsurface kelp visible on the fathometer covered a larger area than the extent of the surface canopy.

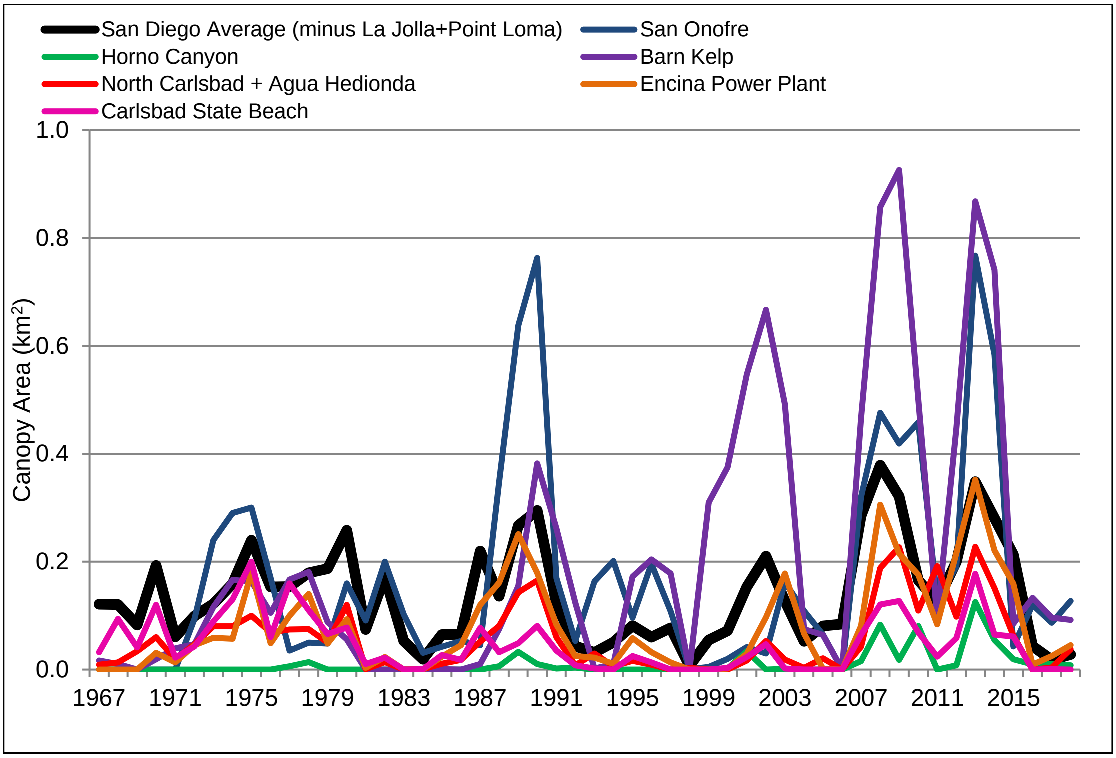


Figure 10. Comparisons between the average San Diego (minus La Jolla+Point Loma) ABAPY and canopy coverage from San Onofre to Carlsbad State Beach from 1967 to 2018.

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

Three kelp beds are located between Horno Canyon and the Santa Margarita River. In 2018, two beds decreased in size, and one was not visible (Table 5).

Horno Canyon. This kelp bed decreased in size by 27%, from 0.011 km^2 in 2017 to 0.008 km^2 in 2018 (Table 5). The canopy area in 2018 was only 6% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

Although the San Diego County ABAPY increased by 57% in 2018, the Horno Canyon canopy area decreased by 27%. Since reaching maximum size in 2013, the Horno Canyon kelp bed (Appendix A.52) has decreased to a low level (Appendix B.4; Figure 10, green line).

No surface canopy was visible during the January 2019 vessel survey, although a few subsurface plants were visible on the fathometer (Table 6). Underwater observations also were made during a dive survey on this date. The bottom was composed of approximately 80% cobble and 20% sand, with some shell hash present. *Laminaria* was present at a high density, along with some red algae (*Acrosorium*). Kelp observed included five juvenile fronds, approximately 3 to 6 feet in length, and 12 old holdfasts. Tissue color was medium to dark yellow. Some encrustation and sediment were observed on the kelp blades. Two purple urchins were observed on the bottom, but no fishes were seen.

In addition, the 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.

Barn Kelp. This kelp bed decreased in size by 4%, from 0.096 km^2 in 2017 to 0.092 km^2 in 2018 (Table 5). The canopy area in 2018 was only 10% of the maximum recorded in 2009 (Appendix B.4; Figure 3).

In 2013, Barn Kelp (Appendices A.53 and A.54) was more than three times larger than average and was the fifth largest kelp bed in Region Nine (Appendix B.4). In 2018, this kelp bed was small in size. Although the San Diego County ABAPY increased by 57% in 2018, the Barn kelp bed decreased by 4%. This kelp bed remains well below the peak level observed in 2009 and the high levels in 2002 and 2013 (Figure 10, purple line).

No surface canopy or subsurface kelp was visible during the January 2019 vessel survey (Table 6). No kelp was visible downcoast from Barn kelp offshore Camp Pendleton (Appendix A.55).

Santa Margarita. This kelp bed was not observed during 2018, nor was it visible in 2017 (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. Wheeler 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). No surface canopy or subsurface kelp was visible at Santa Margarita during the January 2019 vessel survey.

A small amount of kelp (0.004 km^2) was observed in Oceanside Harbor (Appendix A.57) in 2018, as was the case in 2017. This is not a designated kelp bed.

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

There are four kelp beds located between North Carlsbad and Carlsbad State Beach. In 2018, three of the beds increased in size, while the other still was not visible (Table 5).

North Carlsbad. This kelp bed increased in size by 850%, from 0.004 km^2 in 2017 to 0.038 km^2 in 2018 (Table 5). However, the canopy area in 2018 was 21% of the maximum recorded in 1993 (Appendix B.4; Figure 3).

The North Carlsbad kelp bed is usually comprised of several small beds (Appendices A.58 and A.59). In 2018, the North Carlsbad kelp bed increased in size more than the San Diego County ABAPY (850% versus 57%). This kelp bed was large in 2013, but subsequently disappeared in 2016. It reappeared in 2017 as a small bed, then increased in size in 2018. However, this kelp bed is well below the peak level observed in 1993 and the large size in 2013 (Appendix B.4; Figure 10, red line).

During the January 2019 vessel survey (Table 6), no surface canopy was observed at the North Carlsbad kelp bed. However, scattered subsurface kelp was visible on the fathometer, including 10-foot tall plants.

Agua Hedionda. This kelp bed was not observed in 2018, nor was it visible in 2016 or 2017 (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 (Appendix B.4; Figure 10, red line).

No surface canopy was observed at the Agua Hedionda kelp bed during the January 2019 vessel survey (Table 6). However, numerous subsurface scattered single plants (about 15-feet tall) were visible on the fathometer.

Encina Power Plant. This kelp bed increased in size by 80%, from 0.025 km^2 in 2017 to 0.045 km^2 in 2018 (Table 5). The canopy area in 2018 still was only 13% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

The Encina Power Plant kelp bed (Appendix A.60) reached its maximum size in 2013 (0.352 km^2). This kelp bed increased slightly more than the San Diego County ABAPY (80% versus 57%). The canopy decreased in size during each of the next three years through 2016. However, the Encina Power Plant kelp bed remains well below the peak level observed in 2013 (Appendix B.4; Figure 10, orange line).

No surface canopy was observed at the Encina Power Plant kelp bed during the January 2019 vessel survey (Table 6). Underwater observations were made during a dive survey on the same date. The bottom was composed of flat shale reef, with cobble and sand patches. Red alga was dominant (*Acrosorium*) and some *Egregia* and *Gigartina* also were present. Kelp observed included one juvenile plant, approximately 1 foot in length, and 25 old holdfasts. Tissue color was medium yellow. No encrustation or sediment was observed on the kelp blades. A sheepshead and a kelp bass were observed, as well as eight lobsters on the bottom.

Carlsbad State Beach. This kelp bed disappeared in 2018, decreasing from a size of 0.001 km^2 in 2017 (Table 5).

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 this kelp bed reappeared at a very small size in 2017, it disappeared once again in 2018 (Figure 10, pink line).

No surface canopy or subsurface kelp was observed at the Carlsbad State Beach kelp bed during the January 2019 vessel survey (Table 6).

III.3.E - LEUCADIA TO TORREY PINES

Leucadia. This kelp bed increased in size by 420%, from 0.010 km^2 in 2017 to 0.052 km^2 in 2018 (Table 5). However, the canopy area in 2018 was only 10% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

The Leucadia kelp bed is comprised of the North, Central, and South Leucadia kelp beds, which are 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 and remained small in 2017 and 2018 (Appendix B.4; Figure 11, blue line). Although kelp canopy was observed at all three of the beds, the Central bed accounted for 80% of the canopy area in 2018.

No surface canopy or subsurface kelp was observed the North or Central Leucadia kelp beds during the January 2019 vessel survey (Table 6). A small area of surface canopy was present at the South Leucadia kelp bed, measuring 15 x 30 meters. Tissue color was 50% dark yellow and 50% light yellow. The kelp bed was composed of approximately 50% senile and 50% young fronds. Subsurface kelp was visible on the fathometer, with 10 to 20 plants ranging in height from 10 to 15 feet.

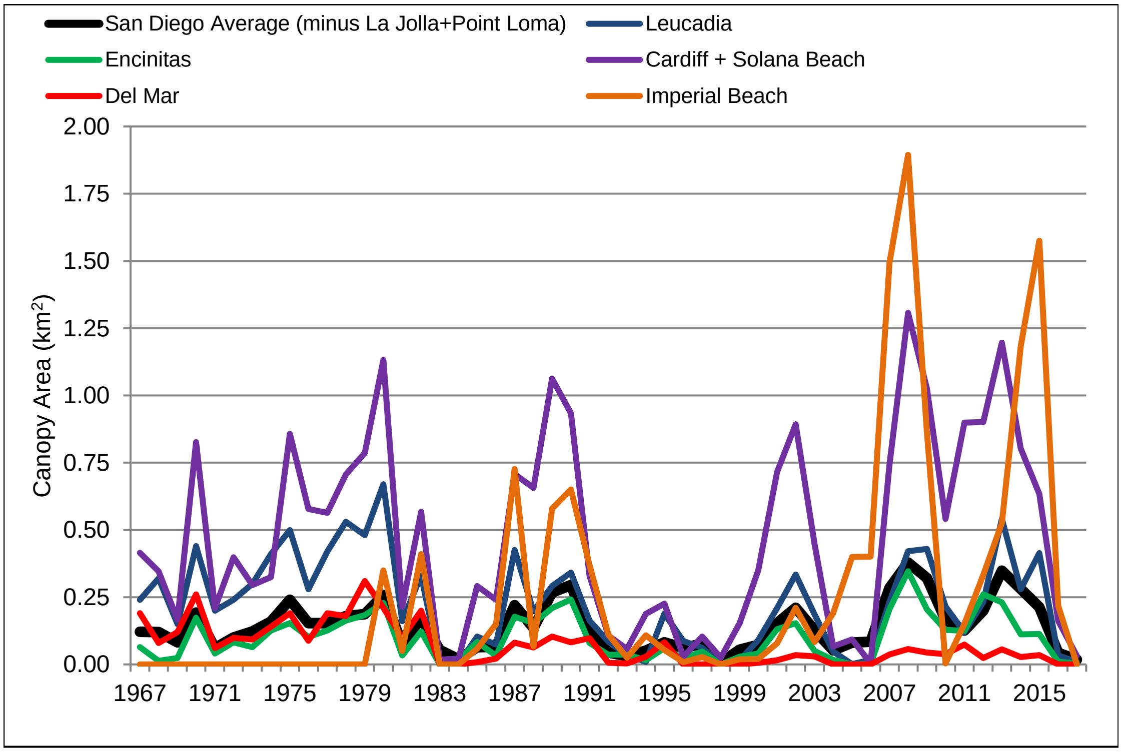


Figure 11. Comparisons between the average San Diego (minus La Jolla+Point Loma) ABAPY and canopy coverage from Leucadia to Imperial Beach from 1967 to 2018.

Encinitas. This kelp bed increased in size by 1,000%, from 0.003 km^2 in 2017 to 0.033 km^2 in 2018 (Table 5). However, the canopy area in 2018 was only 10% of the maximum recorded in 2008 (Appendix B.4; Figure 3).

The Encinitas kelp bed (Appendix A.63) decreased in size considerably between 2013 and 2017. In 2018, this kelp bed increased more than the San Diego ABAPY (1,000% versus 57%) but remains well below the peak level observed in 2008 (Appendix B.4; Figure 11, green line).

During the January 2019 vessel survey, virtually no surface canopy was present (one plant was observed, which was senile) (Table 6). Scattered subsurface kelp was visible on the fathometer, consisting of 10 to 20 plants ranging in height from 10 to 20 feet.

Cardiff. This kelp bed increased in size by 67%, from 0.003 km^2 in 2017 to 0.005 km^2 in 2018 (Table 5). The canopy area in 2018 still was only 1% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

The Cardiff kelp bed (Appendix A.64) reached a peak in 2013 (Appendix B.4). This kelp bed increased in size in 2018 by a similar amount compared to the San Diego County ABAPY (67% versus 57%) but remains well below the peak level observed in 2013 (Figure 11, purple line).

During the January 2019 vessel survey, no surface canopy was visible (Table 6). Subsurface kelp was visible on the fathometer, consisting of several single plants that were 10 to 15 feet tall.

Solana Beach. This kelp bed decreased in size by 17%, from 0.029 km^2 in 2017 to 0.024 km^2 in 2018 (Table 5). The canopy area in 2018 was only 3% of the maximum recorded in 2008 (Appendix B.4; Figure 3).

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 several years. This kelp bed is well below the peak level observed in 2008 (Appendix B.4; Figure 11, purple line).

During the January 2019 vessel survey, no surface canopy was observed at the Solana Beach kelp bed (Table 6). Small patches of subsurface kelp may have been present, with plants ranging in height from 5 to 10 feet.

Del Mar. This kelp bed was not observed in 2018, nor was it visible in 2017 (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. Although this bed was visible between 2007 and 2015, it disappeared in 2016 and was not visible in 2017 or 2018 (Appendix B.4; Figure 11, red line). No surface canopy or subsurface kelp was observed at the Del Mar kelp bed during the January 2019 vessel survey (Table 6).

Torrey Pines. This kelp bed was not observed in 2018, nor was it visible in 2017 (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 2018 (Appendix B.4). No surface canopy or subsurface kelp was visible during the January 2019 vessel survey (Table 6).

III.3.F - LA JOLLA

La Jolla. This kelp bed increased in size by 126%, from 0.694 km^2 in 2017 to 1.566 km^2 in 2018 (Table 5). The canopy area in 2018 was 33% of the maximum recorded in 1989 (Appendix B.4; Figure 3).

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 sand and kelp does not grow in this area (Appendices A.70 and A.71). The La Jolla kelp bed decreased in size considerably from 2013 through 2017, resulting in the smallest canopy size since 2006. Despite more than doubling in size in 2018, the La Jolla kelp bed still remains well below the peak level observed in 1989 and lower than the levels reported in 2008 and 2013 (Appendix B.4; Figure 12, blue line).

During the January 2019 vessel survey, the La Jolla North kelp beds were scattered, covering an area approximately 100 meters wide (Table 6). Tissue color was 20% dark yellow, 40% medium yellow, and 40% light yellow, with no apical blades, and the fronds had light encrustation. The kelp bed was composed of approximately 40% senile, 40% mature, and 20% young fronds. Subsurface kelp was visible on the fathometer. The La Jolla South kelp beds were extensive near shore. Tissue color was 20% dark yellow and 80% medium yellow, with 5% apical blades, and the fronds had 5% encrustation. The kelp bed was composed of approximately1% senile, 80% mature, and 19% young fronds. Some new growth subsurface kelp was visible on the fathometer.

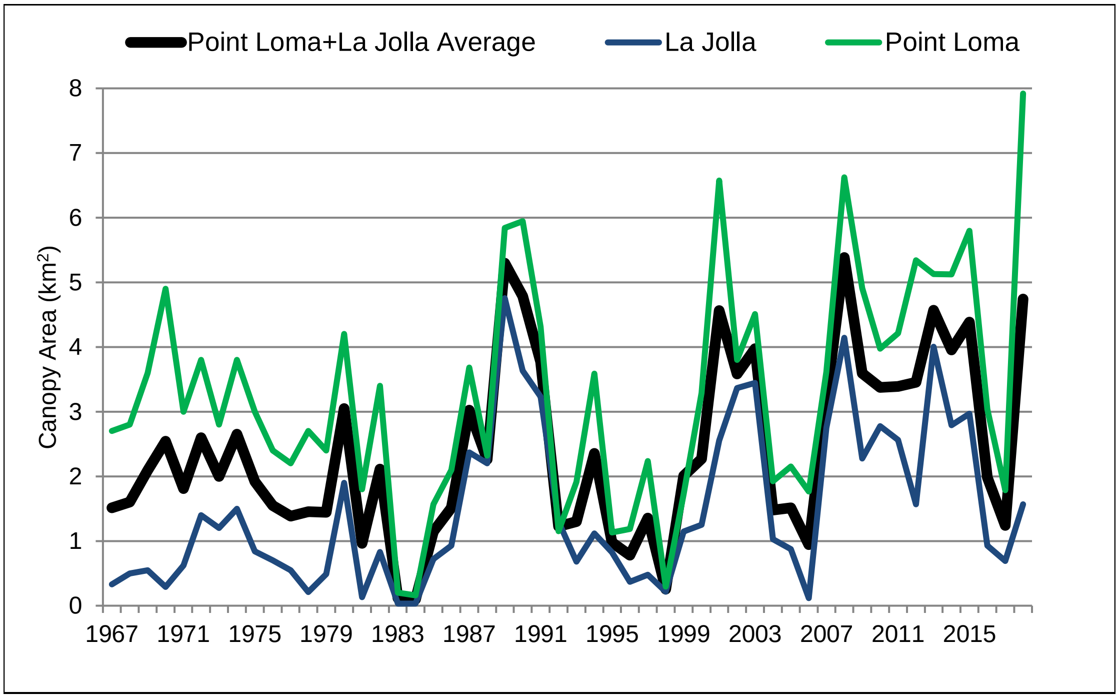


Figure 12. Comparisons between the Point Loma/La Jolla Average ABAPY and canopy coverage of the La Jolla and Point Loma kelp beds from 1967 to 2018.

III.3.G - POINT LOMA TO CORONADO BEACH

Point Loma. This kelp bed increased in size by 343%, from 1.787 km^2 in 2017 to 7.920 km^2 in 2018 (Table 5). The canopy area in 2018 was the maximum recorded since kelp surveys began in 1983 (Appendix B.4; Figure 3).

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 (more than 5 km^2) from 2013 through 2015. However, decreases in 2016 and 2017 resulted in the smallest size measured since 2006. But in 2018, the Point Loma kelp bed increased in size by 343%, reaching the maximum size observed since RNKSC surveys began in 1983 (Appendix B.4; Figure 12, green line).

During the January 2019 vessel survey, the surface canopy was very scattered inshore of 55 feet water depths at the Point Loma North kelp beds (Table 6). Lots of subsurface kelp was visible on the fathometer within 10 feet of the surface. A solid surface canopy in shallow water was visible along the shore of the Point Loma South kelp bed. Tissue color was 90% dark yellow and 10% light yellow, with 5% apical blades, and the fronds had 5% encrustation. The kelp bed was composed of approximately 1% senile, 2% mature and 97% young fronds.

No kelp was observed at Coronado Beach (Appendix A.76) or Silver Strand (Appendix A.77) during aerial overflights or during the January 2019 vessel survey.

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

Imperial Beach. This kelp bed was not observed in 2018, nor was it visible in 2017 (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 location 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 or 2018 (Appendix B.4; Figure 11, orange line). No surface or subsurface kelp was visible at the Imperial Beach kelp bed during the January 2019 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 increased in size from 4.317 km^2 to 7.868 km^2, an increase of 61% (Figure 13). This canopy coverage was the highest amount recorded in 50 years, slightly exceeding the peak level observed in 1967. As usual, the four Palos Verdes kelp beds plus the Cabrillo kelp bed accounted for more than half of the total canopy area (57% of the total) in the Central Region.

Nearly all the individual kelp beds (23 out of 24 with visible surface canopies) increased in size in 2018, including three beds (La Costa, Las Flores, and Topanga) which reappeared, and 11 of the beds more than doubled in size. The only bed to decrease in size was the Cabrillo kelp bed, which experienced a modest 5% decline, and no kelp beds disappeared.

In 2018, 18 kelp beds were at or above 40% of their historic maximum size (compared to 10 in 2017), including 12 that were at or above 80% of their historic maximum (only 4 in 2017), while only two kelp beds were at less than 20% of their historic maximum size (4 in 2017). Four kelp beds (Leo Carrillo, Lechuza, Palos Verdes III, and Los Angeles/Long Beach Harbor) reached their maximum size recorded since CRKSC surveys began in 2003.

Every kelp bed in the Central Region increased in size in 2018, except the Cabrillo bed which decreased by 5%. Approximately half of these beds more than doubled in size. Three kelp beds reappeared in 2018, two that had been absent since 2015 (La Costa and Las Flores) and one that had been absent since 2016 (Topanga). No kelp beds disappeared this year.

Total kelp canopy coverage in the Central Region has been at or above the long-term average every year for the past 10 years. However, canopy coverage attained an even higher level in 2018, increasing in size by more than 60% and slightly exceeding the 50-year peak recorded in 1967 (Figure 13). Nearly all beds were larger in 2018 than during any of the previous three years (Table 7). The four Palos Verdes kelp beds plus the Cabrillo kelp bed accounted for 61% of the total canopy coverage.

The Los Angeles County Sanitation Districts discharges highly treated wastewater effluent via ocean outfalls located approximately 1.5 miles offshore and 200 feet deep on 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 also discharges highly treated wastewater effluent via an ocean outfall into Santa Monica Bay. However, there are no designated kelp beds in proximity to the discharge point located 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 discharges highly treated wastewater effluent via an ocean outfall located approximately 1 mile offshore. However, there are no designated kelp beds in proximity to this discharge point. The Orange County Sanitation District discharges highly treated wastewater effluent via an ocean outfall located approximately five miles offshore, and there are no designated kelp beds in proximity to the discharge point. Consequently, wastewater outfalls did not appear to have any impact on kelp bed health in the Central Region.

Table 7. Canopy coverage of the kelp beds (km^2) from Deer Creek to Newport/Irvine Coast from 2009 through 2018.

Kelp Bed	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Deer Creek	0.105	0.062	0.055	0.041	0.104	0.103	0.124	0.087	0.105	0.145
Leo Carillo	0.255	0.232	0.226	0.337	0.366	0.261	0.408	0.326	0.426	0.633
Nicolas Canyon	0.433	0.291	0.130	0.240	0.369	0.288	0.347	0.279	0.179	0.321
El Pesc/La Piedra	0.238	0.164	0.136	0.173	0.236	0.244	0.246	0.160	0.157	0.304
Lechuza	0.105	0.096	0.096	0.066	0.154	0.137	0.119	0.063	0.086	0.178
Total F&W 17	1.136	0.844	0.642	0.857	1.229	1.034	1.244	0.914	0.953	1.579
Pt. Dume	0.104	0.094	0.078	0.154	0.113	0.092	0.169	0.042	0.050	0.164
Paradise Cove	0.244	0.259	0.109	0.346	0.244	0.223	0.086	0.127	0.024	0.165
Escondido Wash	0.321	0.267	0.104	0.248	0.243	0.281	0.095	0.084	0.059	0.164
Latigo Canyon	0.195	0.142	0.070	0.202	0.133	0.212	0.052	0.057	0.044	0.115
Puerco/Amarillo	0.115	0.126	0.069	0.153	0.105	0.130	0.034	0.027	0.002	0.100
Malibu Pt.	0.012	0.066	0.074	0.084	0.060	0.039	-	0.035	0.001	0.069
Total F&W 16	0.991	0.954	0.504	1.189	0.897	0.976	0.436	0.372	0.180	0.778
La Costa	0.001	0.001	-	0.003	0.003	0.001	-	-	-	0.0004
Las Flores	0.005	0.005	0.008	0.025	0.022	0.016	-	-	-	0.006
Big Rock	0.005	0.006	0.007	0.018	0.017	0.011	0.004	0.001	0.0001	0.003
Las Tunas	0.019	0.015	0.007	0.030	0.029	0.012	0.004	-	0.001	0.007
Topanga	0.002	0.052	0.041	0.048	0.044	0.016	0.005	-	-	0.016
Sunset	0.004	0.008	0.007	0.008	0.010	0.010	0.010	0.015	0.003	0.014
Total F&W 15	0.035	0.087	0.069	0.131	0.123	0.064	0.022	0.017	0.004	0.046
Malaga Cove-PV Pt. (IV)	2.122	1.136	1.139	1.337	0.974	0.264	1.410	1.420	1.048	1.758
PV Pt-PT. Vic (III)	0.570	0.624	0.452	0.488	0.502	0.468	0.750	0.430	0.576	1.021
Total F&W 14	2.692	1.760	1.591	1.825	1.476	0.732	2.160	1.850	1.624	2.779
Pt Vic to Pt Insp (II)	0.163	0.222	0.238	0.295	0.279	0.224	0.379	0.366	0.294	0.547
Pt Insp to Cabr (I)	0.980	0.389	0.465	0.384	0.672	0.533	0.478	0.610	0.935	1.143
Cabrillo	0.163	0.124	0.103	0.095	0.174	0.158	0.133	0.235	0.329	0.312
Total F&W 13	1.306	0.734	0.805	0.774	1.124	0.915	0.990	1.210	1.557	2.002
Total PV	3.998	2.494	2.396	2.599	2.600	1.647	3.149	3.060	3.181	4.781
POLA-POLB Harbor	0.151	0.277	0.397	0.495	0.337	0.196	0.359	0.359	0.531	0.565
Horseshoe	-	-	-	-	-	-	-	-	-	-
Huntington Flats	-	-	-	-	-	-	-	-	-	-
Newport-Irvine Coast	0.095	0.161	0.419	0.395	0.428	0.366	0.045	0.036	0.033	0.119
Total F&W 10	0.246	0.438	0.816	0.890	0.765	0.561	0.404	0.395	0.563	0.684
TOTAL	6.406	4.817	4.427	5.665	5.614	4.283	5.255	4.757	4.881	7.869

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

"-" = no canopy area

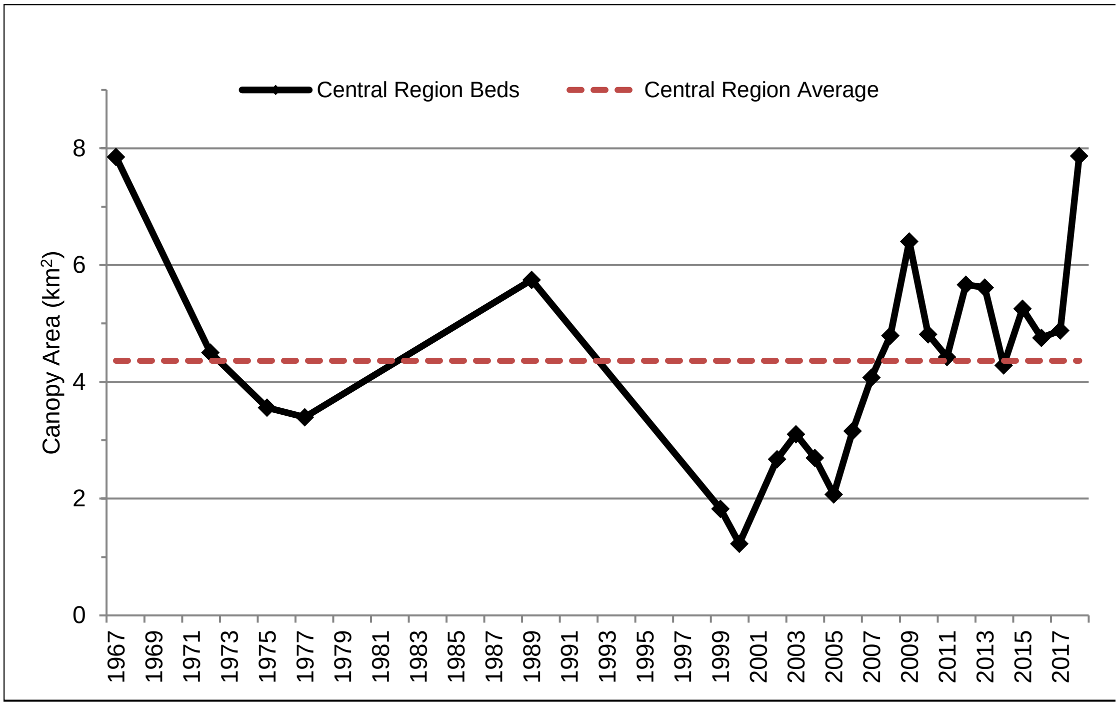


Figure 13. Combined canopy coverage of all kelp beds in the Central Region from Ventura to Newport Harbor/Irvine Coast from 1967 to 2018.

IV.2 - REGION NINE KELP BEDS

The combined canopy coverage within the 24 kelp beds of Region Nine increased in size from 3.277 km^2 to 11.037 km^2, an increase of 237% (Figure 13). Despite nearly tripling in size in 2018, total canopy coverage remained below levels recorded in 2008 and 2014 (Figure 14). The La Jolla and Point Loma kelp beds accounted for most of the total canopy coverage (86%) as usual. Both beds increased substantially in 2018, as the La Jolla kelp bed more than doubled and the Point Loma kelp bed more than quadrupled in size. The kelp beds in the northern portion of Region Nine (North Laguna Beach to San Onofre) generally were larger in 2018 than during any of the previous three years (Table 8). However, kelp beds to the south (Horno Canyon to Torrey Pines) generally were smaller in 2018. The La Jolla kelp bed was larger than in 2016 or 2017, and the Point Loma kelp bed was larger than at any time over the past 10 years.

All but four kelp beds in Region Nine increased in size in 2018; only the Horno Canyon, Barn Kelp, Solana Beach, and Carlsbad State Beach declined. Approximately half of these beds more than doubled in size. Carlsbad State Beach was the only kelp bed that disappeared in 2018. No kelp beds reappeared this year.

Vessel surveys of all Region Nine kelp beds conducted in January 2019 indicated that the amounts of surface canopy and subsurface kelp in the northern area (North and South Laguna) and southern area (La Jolla and Point Loma) were similar to levels observed during the previous year's surveys (December 2017 and January 2018). However, surface canopy at the other kelp beds in the region generally was less in January 2019 than during the prior survey and very little subsurface kelp was observed. Diver surveys conducted in January 2019 at the

Horno Canyon and Encina Power Plant kelp beds in January 2019 indicated that few kelp plants were observed on the bottom at either of these two locations.

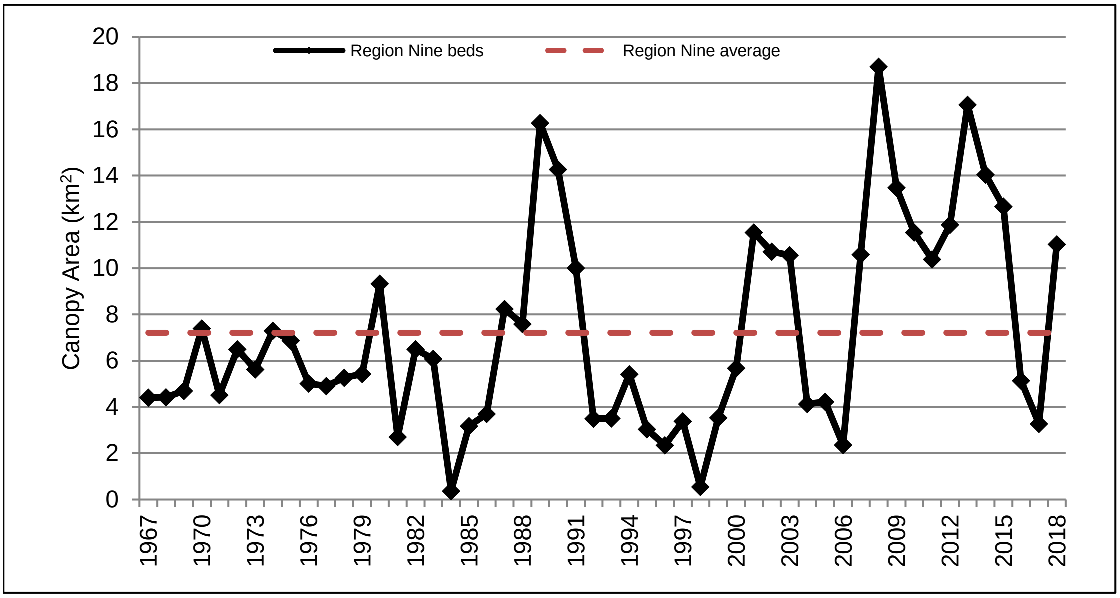


Figure 14. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2018.

IV.3 - ENVIRONMENTAL VARIABLES

The general correspondence between seawater temperature and the geographical distribution of kelp 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).

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.

Table 8. Canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 2009 through 2018.

Kelp Bed	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
N Laguna Beach	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133
S Laguna Beach	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131
South Laguna	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003	0.048
Dana Pt/Salt Crk	0.892	0.839	0.442	0.607	0.835	0.528	0.137	0.110	0.133	0.379
Capistrano Beach	0.071	0.124	0.010	0.056	0.099	0.034	0.007	0.012	0.0004	0.018
Total F&W 9	1.043	1.178	0.838	1.086	1.385	0.879	0.287	0.237	0.264	0.709
San Clemente	0.210	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229	0.335
San Mateo Point	0.545	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033	0.083
San Onofre	0.419	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087	0.127
Total F&W 8	1.174	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349	0.545
Horno Canyon	0.018	0.081	-	0.008	0.125	0.055	0.019	0.010	0.011	0.008
Barn Kelp	0.926	0.500	0.095	0.442	0.868	0.741	0.085	0.133	0.096	0.092
Santa Margarita	-	-	-	-	0.080	-	-	-	-	-
Total F&W 7	0.944	0.581	0.095	0.450	1.073	0.795	0.104	0.143	0.107	0.100
North Carlsbad	0.135	0.078	0.017	0.052	0.125	0.086	0.047	-	0.004	0.038
Agua Hedionda	0.092	0.031	0.022	0.046	0.102	0.065	0.016	-	-	-
Encina Power Plant	0.215	0.176	0.084	0.216	0.352	0.221	0.159	0.009	0.025	0.045
Carlsbad St. Bch	0.127	0.069	0.024	0.058	0.178	0.065	0.061	-	0.001	-
Total F&W 6	0.569	0.354	0.147	0.372	0.757	0.437	0.282	0.009	0.031	0.083
Leucadia	0.429	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010	0.053
Encinitas	0.205	0.128	0.124	0.260	0.231	0.112	0.113	0.009	0.003	0.033
Cardiff	0.520	0.213	0.395	0.459	0.590	0.299	0.318	0.024	0.003	0.005
Solana Beach	0.505	0.328	0.504	0.442	0.606	0.504	0.316	0.138	0.029	0.024
Del Mar	0.044	0.038	0.074	0.024	0.056	0.027	0.034	-	-	-
Torrey Pines	0.0004	0.003	0.031	0.034	0.081	-	-	-	-	-
Total F&W 5	1.703	0.925	1.247	1.452	2.106	1.221	1.195	0.204	0.045	0.114
La Jolla F&W 4	2.274	2.776	2.565	1.569	4.006	2.790	2.968	0.927	0.694	1.566
Point Loma F&W 3&2	4.909	3.977	4.212	5.340	5.127	5.121	5.806	3.037	1.787	7.920
Imperial Beach F&W 1	0.861	0.004	0.152	0.333	0.526	1.183	1.576	0.217	-	-
TOTAL	13.476	11.545	10.379	11.882	17.064	14.053	12.667	5.134	3.277	11.037

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

"-" = no canopy area

Sea surface temperatures (SST) from Point Dume, Santa Monica, and Newport Pier, as well as the long-term harmonic mean (1917 to 2018) 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 generally were cooler than average during March, April, and May of 2018, but generally were warmer than average from June through December (Figures 15 and 16). In the CRKSC area, there were occasional periods of cooler than normal water temperatures from June through September (Figure 15), likely associated with upwelling events. In the RNKSC area, limited periods of cooler than normal water temperatures occurred in June at all four sites (Figure 16) but were limited to Newport Pier from July through September. Daily SST values in both areas fell below 14ºC (a threshold below which nutrient availability is much greater than at higher water temperatures) slightly more often in 2018 than was observed in 2017, but only during the period from late February through early May.

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.

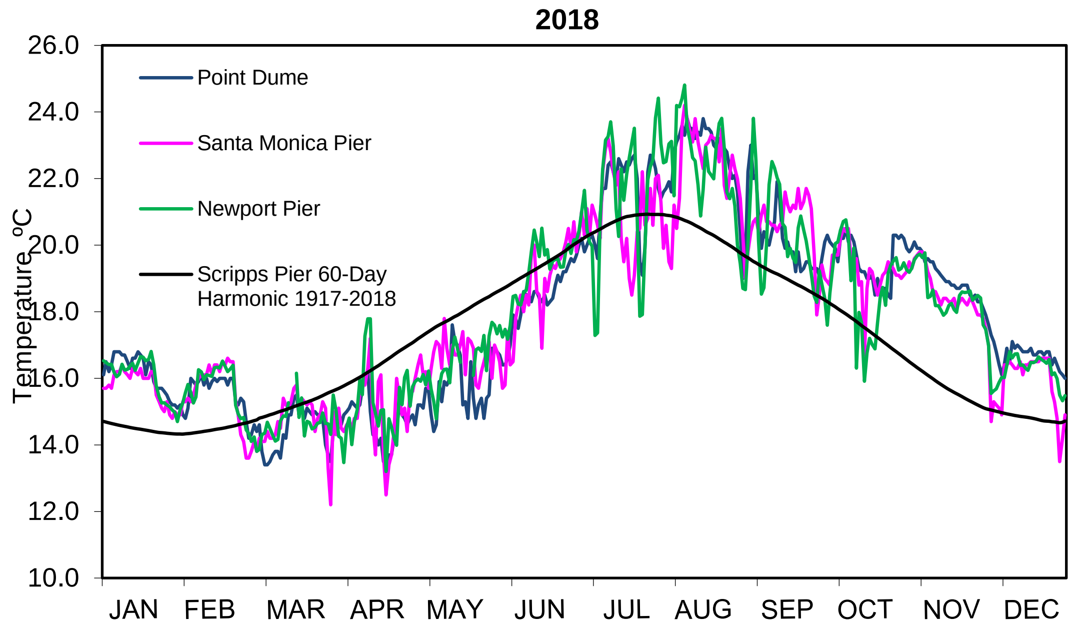


Figure 15. Daily sea surface temperatures (SSTs) at Point Dume, Santa Monica Pier, and Newport Pier for 2018, and the long-term harmonic mean for Scripps Pier 60-Day Harmonic calculated from 1917 through 2018. Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

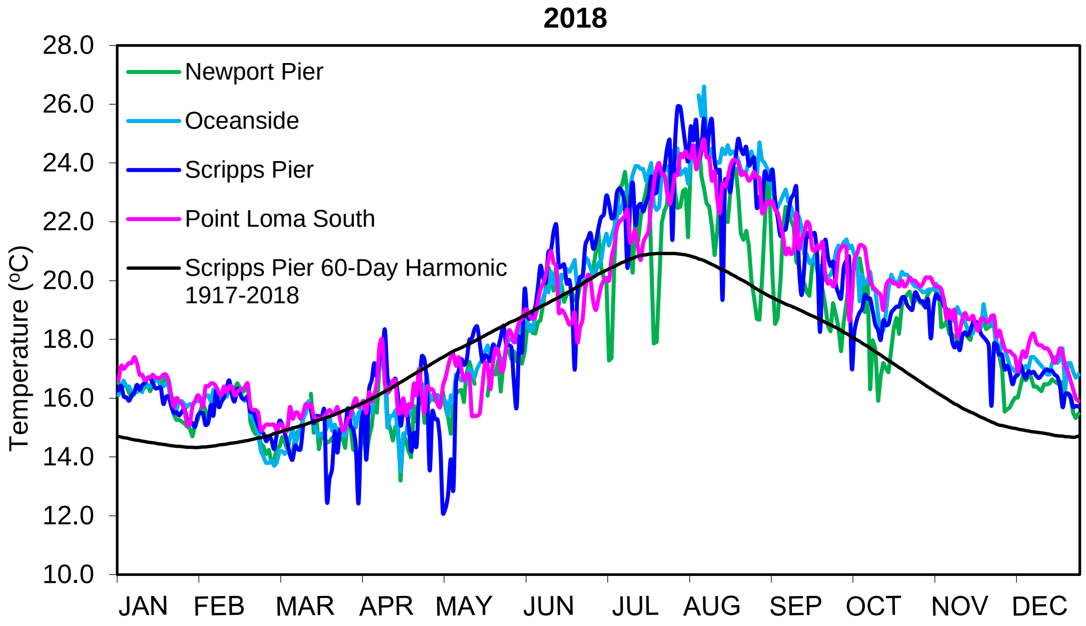


Figure 16. Daily sea surface temperatures (SSTs) at Newport Pier, Oceanside, Scripps Pier, and Point Loma South for 2018, and the long-term harmonic mean for Scripps Pier SIO 60-Day Harmonic calculated from 1917 through 2018). Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

Water temperatures at each depth (surface, 2 meters, 11 meters, and 23 meters) were similar at the Palos Verdes North and South stations, becoming cooler from the surface to the deepest depth (Figure 18 A and B). Water temperatures in 2018 often were below 14ºC at the 11-meter and 23-meter depths from February through July at both stations, but this rarely occurred at the surface or the 2-meter depth. 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 are available throughout most of the CRKSC and RNKSC area, sub-surface water temperature data are not as extensive or readily available.

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 2018) (Figure 19). Unfortunately, data are missing for most of the period from February through June. From July through October, water temperatures were warmest in the upper 15 to 20 meters of the water column. In November and December, warm temperatures were observed from the surface down to 30 meters depth over many days and extended deeper at times.

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 (top 10 meters of the water column) were rarely below 14ºC, indicating potentially poor nutrient availability for kelp in surface waters (Figure 20). However, water temperatures below 14ºC occurred frequently at depths of 35 to 60 meters from January through July. Water temperatures were cooler from January through mid-April and in December throughout the water column than during other times of the year, and were highest in July, August and September. Throughout the year, water temperatures consistently decreased with increasing depth.

The number of days with SSTs <14°C increased slightly in 2018 at Point Dume (from 9 to 14 days) and at Scripps Pier (from 6 to 12 days) but were almost non-existent at Newport Pier (1 day) (Figure 21). These values were well below the long-term means (1994-2017) for Point Dume (76 days) and Newport Pier (54 days) and slightly lower for Scripps Pier (16 days). This continues the trend observed over the past few years, as the number of days with water temperatures <14°C has been lower than usual since 2014.

The number of days with warmer temperatures (SSTs >16°C, >18°C, and >20°C) increased in 2018 at Point Dume and Scripps Pier but remained approximately the same at Newport Pier (Figure 21). At Point Dume, SSTs were greater than 16°C on 87 days (compared to an average of 23 per year), greater than 18°C on 175 days (compared to an average of 74 per year), and greater than 20°C on 254 days (compared to an average of 163 days per year). The same trend was observed for all three temperatures at Newport Pier and Scripps Pier.

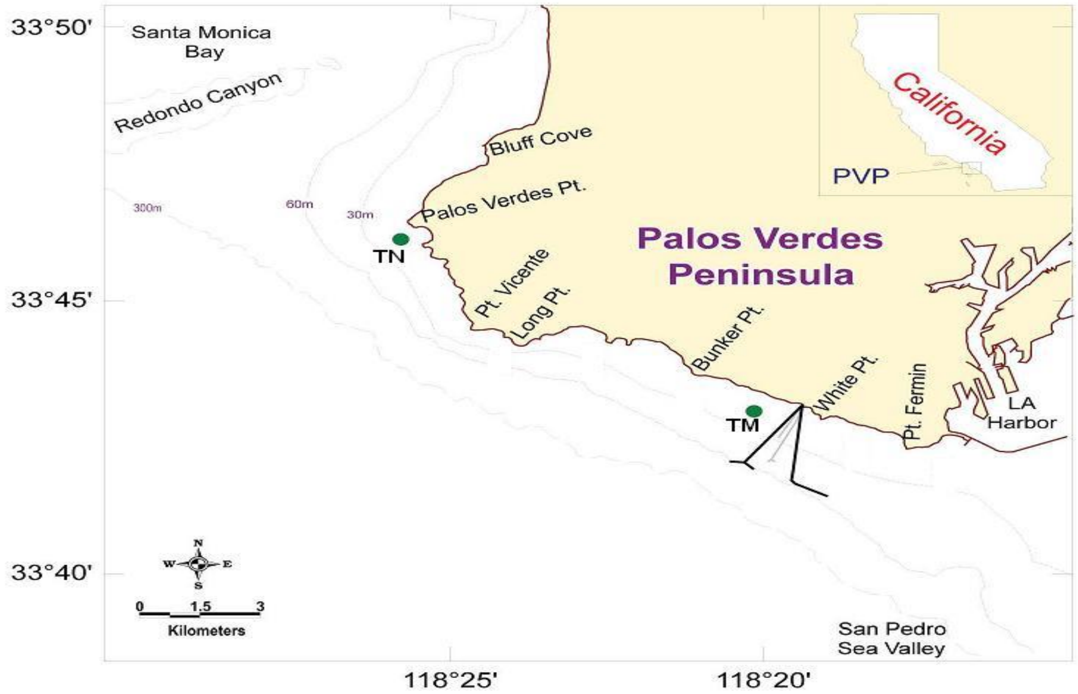


Figure 17. Location of Los Angeles County Sanitation Districts' Palos Verdes Shelf temperature monitoring deployments.

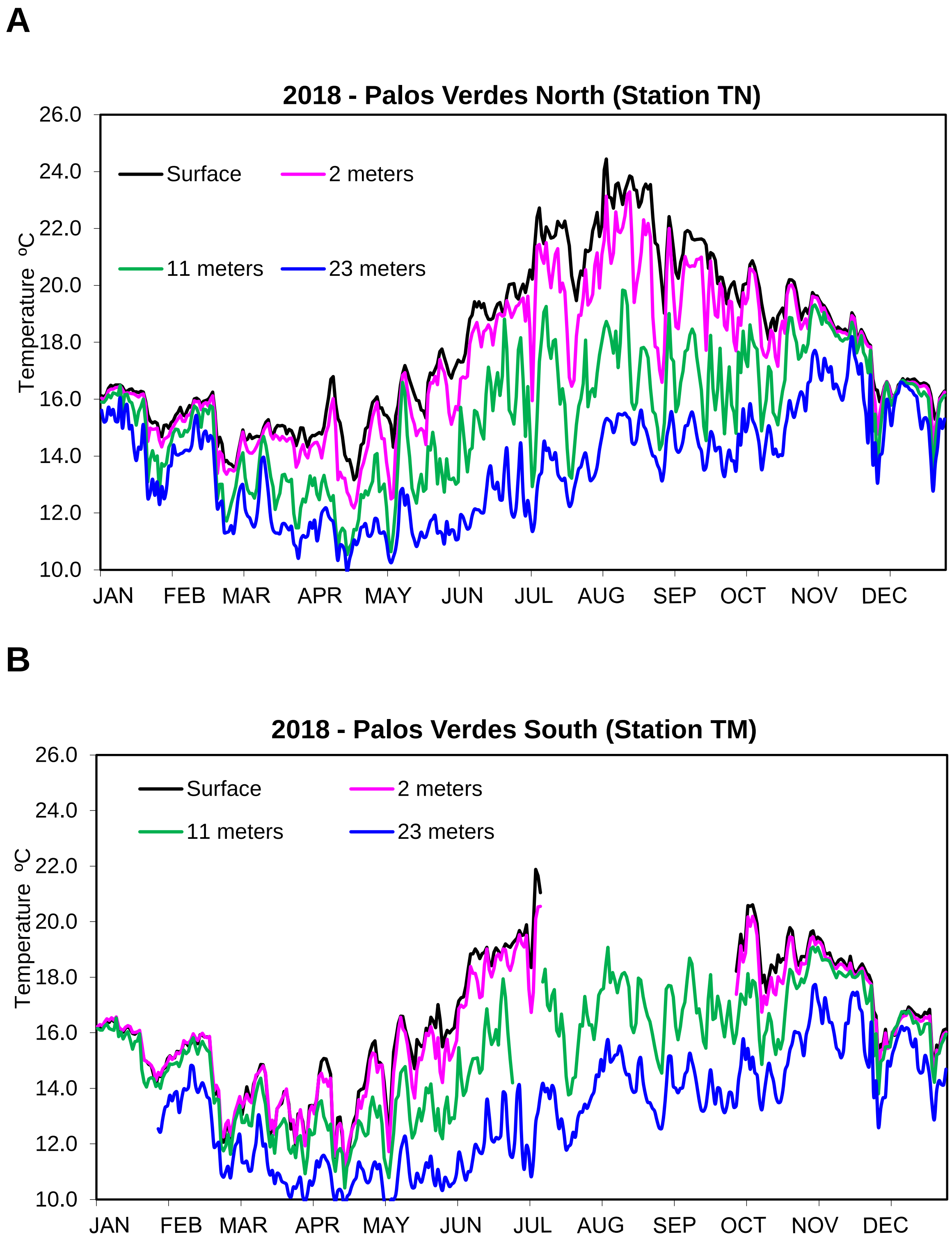


Figure 18. Daily sea surface temperatures (SSTs) off Palos Verdes at (A) Palos Verdes North Station (TN) and (B) Palos Verdes South Station (TM) in 2018. Source: LACSD (2018).

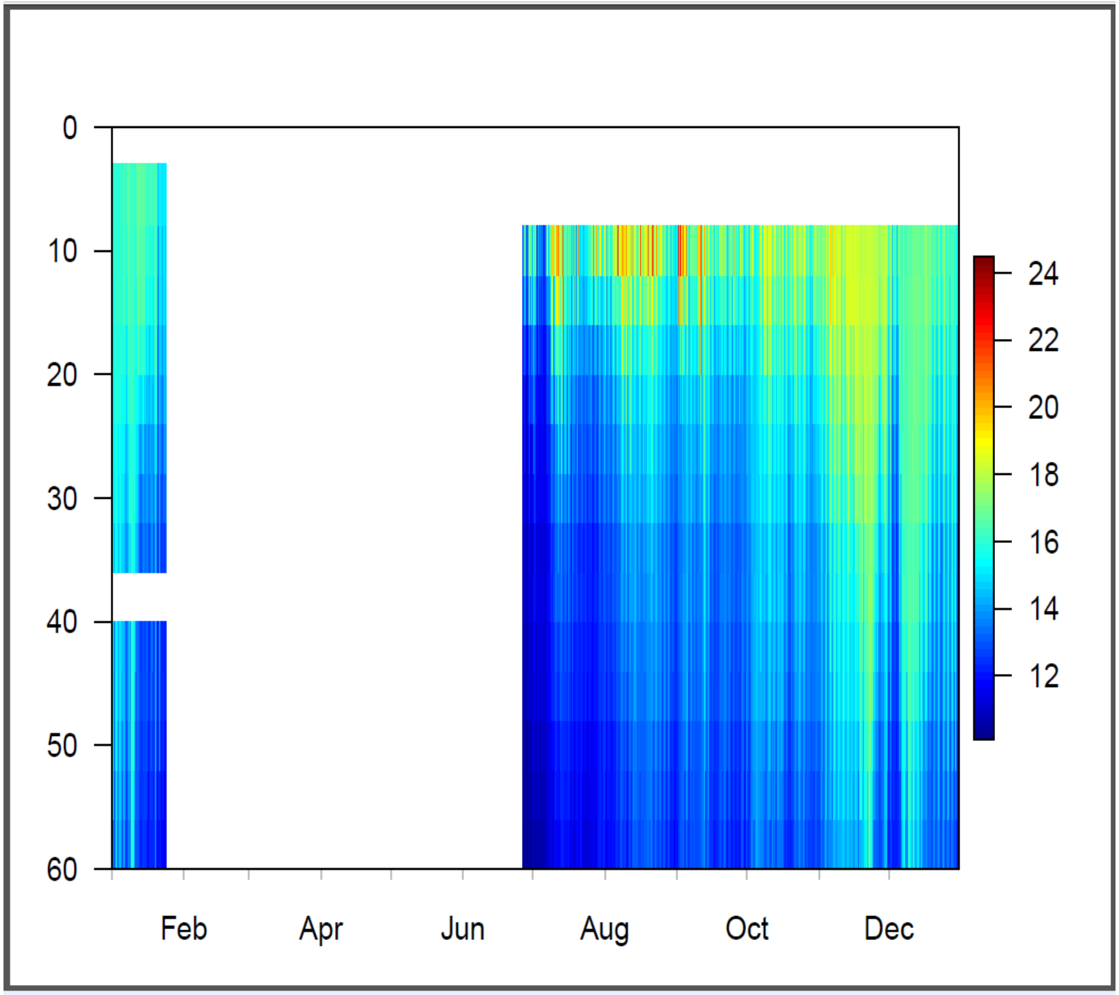


Figure 19. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2018. Source: City of San Diego, 2018.

The annual mean SST values in 2018 were higher than in 2017 for Point Dume, Newport Pier, and Scripps Pier, ranging from 17.9 °C to 18.6°C (Table 9). At Point Dume, the annual mean SST increased considerably from 17.5 °C in 2017 to 18.0°C in 2018 and was well above the long-term mean (1994 to 2017) of 16.1 °C. At Newport Pier, the annual mean SST increased slightly in 2018 (from 17.8 °C to 17.9 °C) and remained well above the long-term average of 16.6 °C. At Scripps Pier, the annual mean SST increased considerably from 17.9 °C in 2017 to 18.6 °C in 2018 and remained well above the long-term mean of 17.7 °C. Although high, the 2018 annual mean SST values still were lower than the annual means recorded at all three locations in 2014 and 2015.

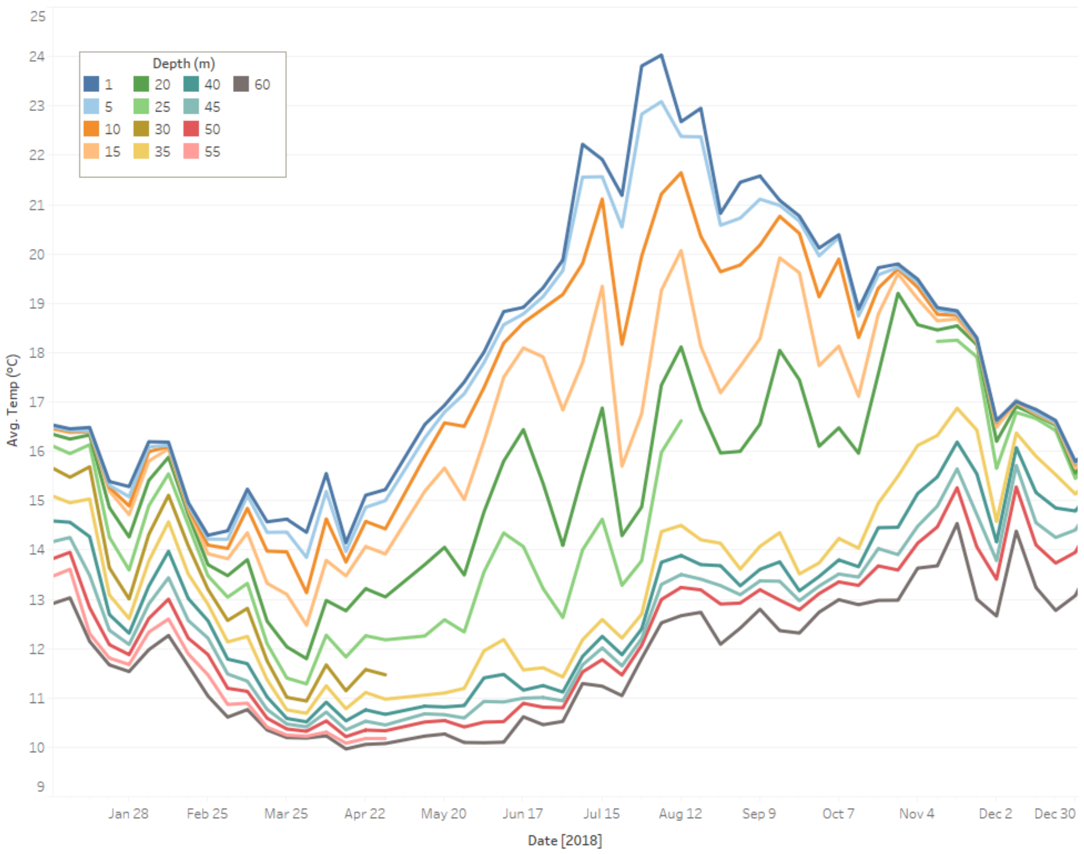


Figure 20. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Orange County during 2018. Source: Orange County Sanitation District, 2019.

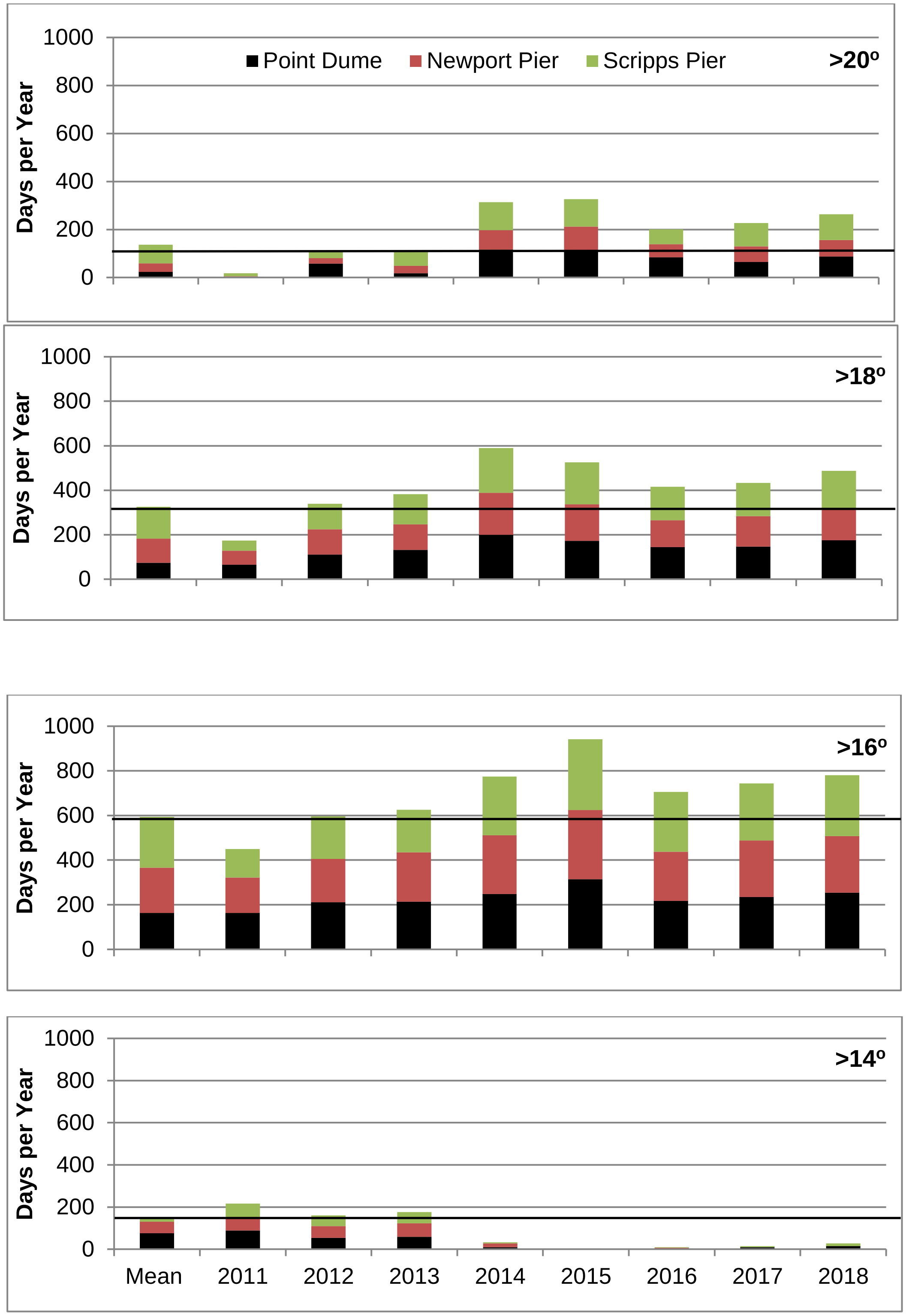


Figure 21. Number of days with SSTs >20°C, >18°C, >16°, and <14°C at Point Dume, Newport Pier, and Scripps Pier from 2011 to 2018, and the mean from 1994 to 2017 (black line).

Table 9. Comparison of mean temperature from 1994 through 2018 versus annual mean temperature from 2011 through 2018 at Point Dume, Newport Pier, and Scripps Pier.

		Annual Mean SST (°C)							
	Mean SST (°C) (1994–2017)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Point Dume	**16.1**	15.7	16.8	16.8	18.2	18.6	17.6	17.5	18.0
Newport Pier	**16.6**	15.9	16.6	16.7	18.0	18.4	17.8	17.8	17.9
Scripps Pier	**17.7**	15.7	16.6	17.0	18.8	18.9	17.7	17.9	18.6

Note: red cells indicate years above the long-term mean, white cells indicate years equivalent to the mean, and blue cells indicate years below the long-term mean.

IV.3.B - NUTRIENTS

The NQ calculations for the six locations in 2018/2019 are shown in Table 10. The 2018/2019 NQ Index was calculated to be 17 for Point Dume,12 for Santa Monica Pier, 11 for Newport Pier, 9 for Oceanside, 8 for Scripps Pier, and 7 for Point Loma (Table 10). In the Central Region, the NQ Index for Point Dume in 2018/2019 was higher than the previous year, while Santa Monica Pier and Newport Pier indices remained similar to the prior year. However, the NQ Indices still are well below average and lower than the levels observed from 2010 to 2012 (Figure 22). In Region Nine, the NQ Indices for Oceanside and Scripps Pier in 2018/2019 were lower than the previous year, while the Point Loma index remained the same. The NQ Indices were below average and once again lower than the levels observed from 2010 to 2012 (Figure 23).

The extent of surface canopy in the kelp beds in 2018 would be related primarily to the 2017/2018 NQ Index (covering the period from July 2017 through June 2018). Although the NQ Indices for the Central Region (Point Dume, Santa Monica Pier, and Newport Pier) were lower than average, average monthly water temperatures were low enough from January through May of 2018 to contribute points to the index calculation, indicating more nutrient availability during this period than was the case in 2017. This nutrient availability could help explain why total kelp canopy in the Central Region was high in 2018, given that nearly all kelp beds were at their peak during the March quarterly survey.

Table 10. Nutrient Quotient calculation for period from July 2018 to June 2019.

Sites	Monthly Average Temperature Ranges (ºC) (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			Feb 2019 Mar 2019 Apr 2019	Jan 2019 May 2019	Dec 2018	**17** (4 pts x 3) + (2 pts x 2) + (1 pt x 1)
Santa Monica Pier			Feb 2019	Dec 2018 Jan 2019 Mar 2019	Apr 2019 May 2019	**12** (4 pts x 1) + (2 pts x 3) + (1 pt x 2)
Newport Pier				Jan 2019 Feb 2019 Mar 2019 Apr 2019 May 2019	Dec 2018	**11** (4 pts x 0) + (2 pts x 5) + (1 pt x 1)
Oceanside			Feb 2019	Jan 2019 Mar 2019	Apr 2019	**9** (4 pts x 1) + (2 pts x 2) + (1 pt x 1)
Scripps Pier			Feb 2019	Jan 2019	Dec 2018 Apr 2019	**8** (4 pts x 1) + (2 pts x 1) + (1 pt x 2)
Point Loma				Feb 2019 Mar 2019	Jan 2019 Apr 2019	**7** (4 pts x 0) + (2 pts x 2) + (1 pt x 3)

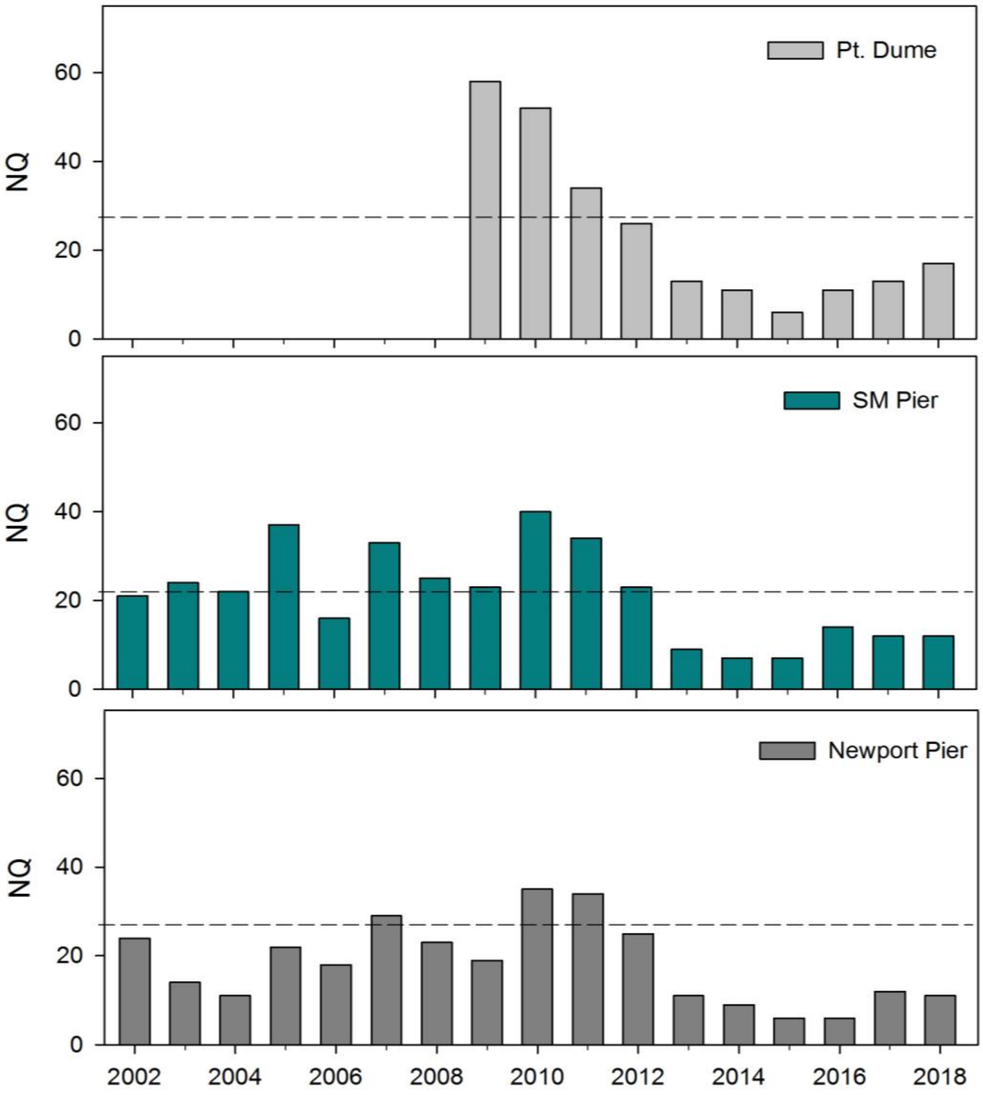


Figure 22. Nutrient Quotient (NQ) values in the Central Region, 2002 to 2018 (dotted line = long-term mean for site).

The NQ Indices for Region Nine (Oceanside, Scripps Pier, and Point Loma) also were lower than normal, but once again average monthly water temperatures were low enough from January through May of 2018 to indicate nutrient availability. Most of the kelp beds in the northern part of the region were at their peak during the March quarterly survey, while all beds in the southern portion peaked during the July survey.

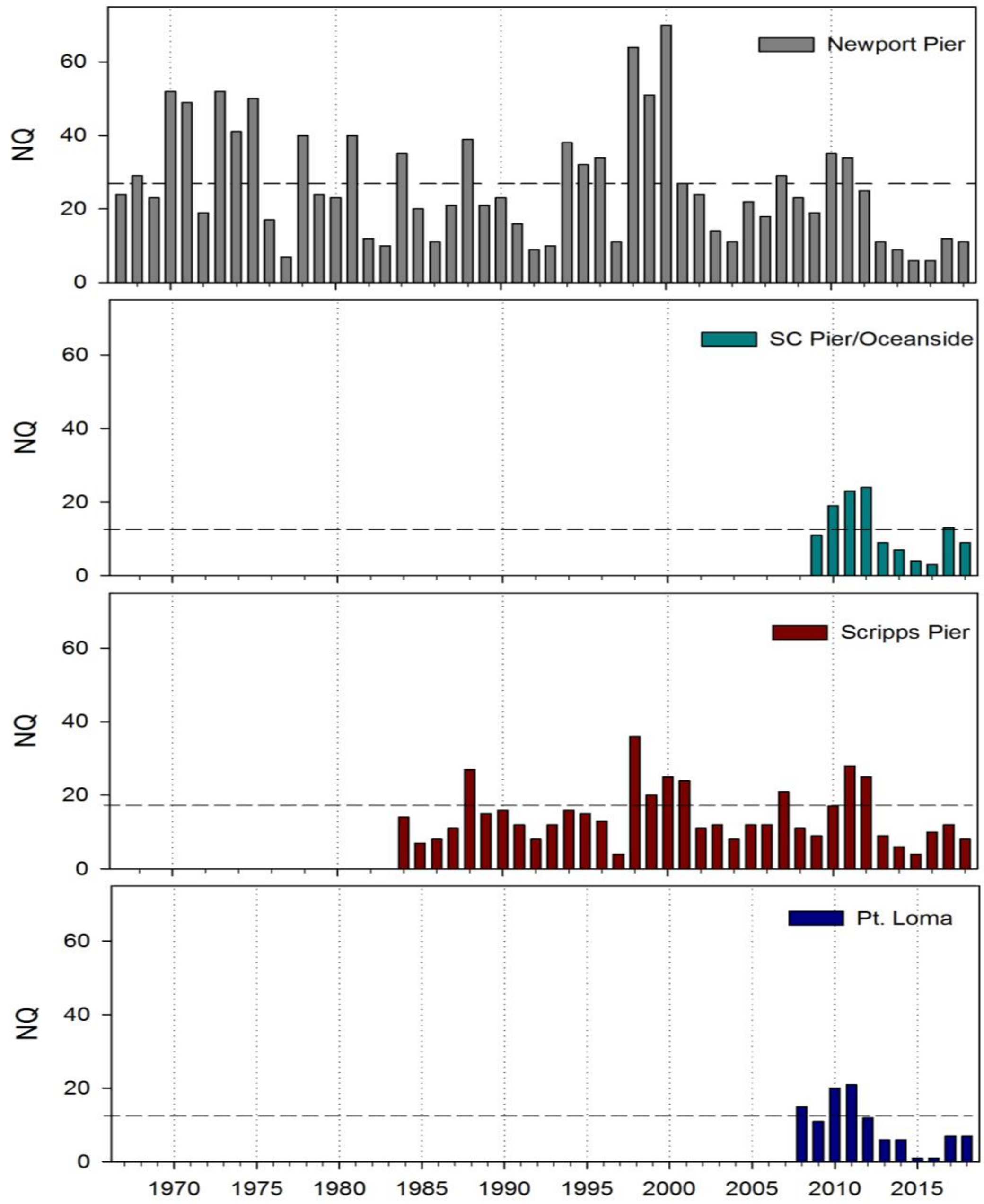


Figure 23. Nutrient Quotient (NQ) values in Region Nine, 1967 to 2018 (dotted line = long-term mean for site).

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

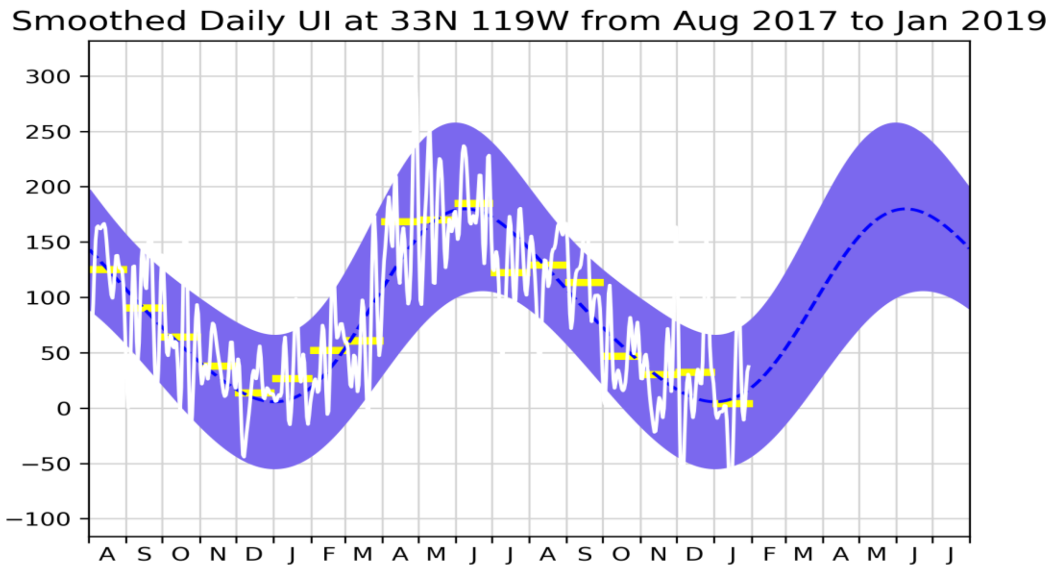
(Parnell et al. 2010). The NQ index recorded during the 1997/1998 El Niño indicated a particularly bad year for kelp beds in the SCB. During that season, NQ values ranged from 3 to 11. In contrast, during 1988/1989 (a year in which kelp beds reached their maximum extents in several decades) NQ values 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.

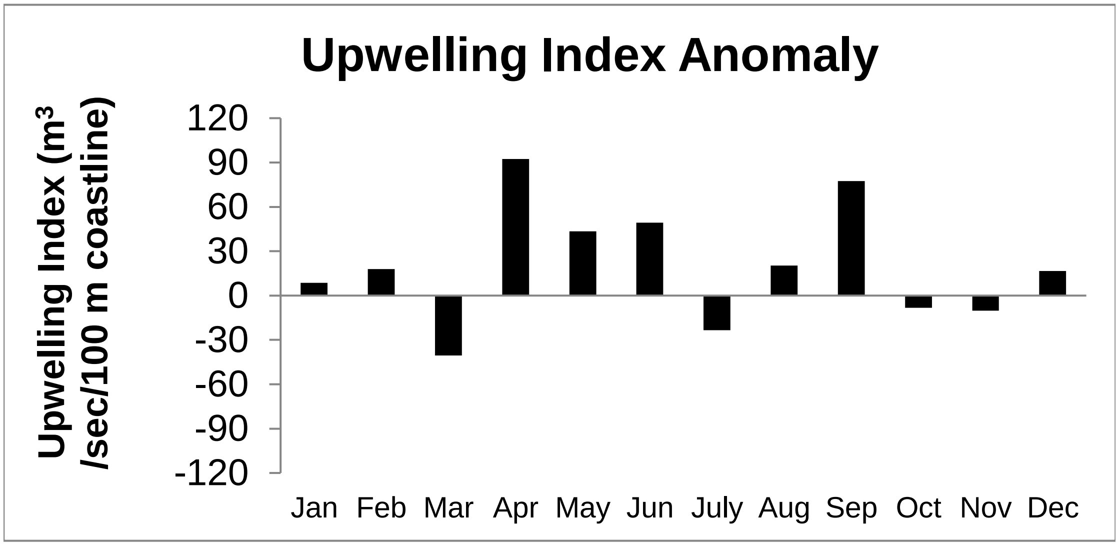
Upwelling in 2018 (at a location approximately 161 km west of Solana Beach) increased each month from January through June, then decreased through December (Figure 24 A). The Upwelling Anomaly Index demonstrates that upwelling in 2018 was much higher than the long-term mean (1946-2016) during the months of April, May, and June (Figure 24 B). Upwelling was higher in during most months in 2018 than during 2017, particularly during April, May, June, and September (Figure 25). However, upwelling was higher in 2017 during March, July, October, and November.

A



Note: 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.

B



Note: positive values indicate upwelling greater than long-term mean; negative values indicate upwelling less than long-term mean.

Figure 24. (A) Daily Upwelling Index (UI) at 33°N 119°W for 2018. (B) UI anomaly at 33°N 119°W in 2018 (compared to 71-year monthly mean from 1946 through 2017). Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

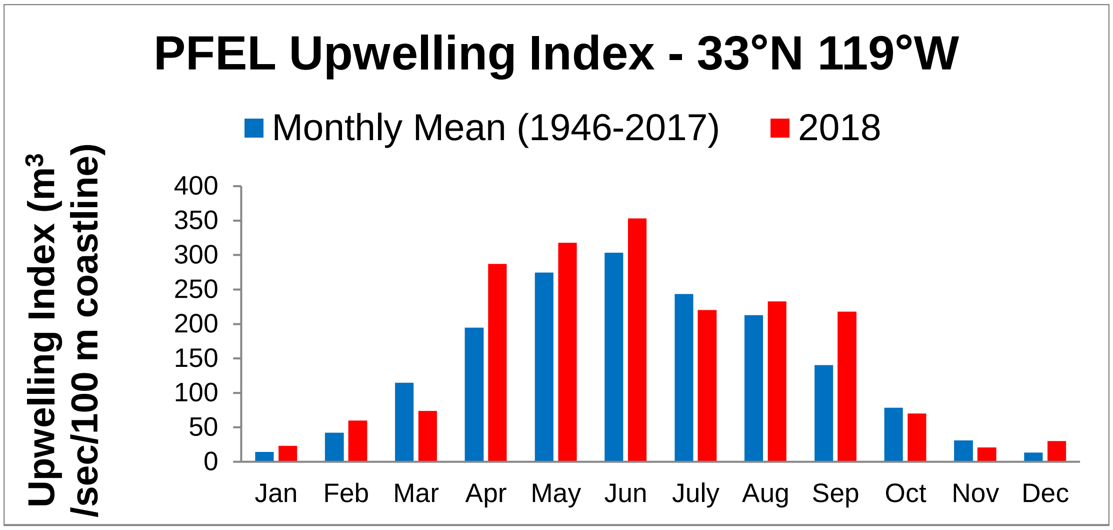


Figure 25. Monthly upwelling index for 2018 (compared to 72-year monthly mean from 1946 through 2017. Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

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).

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 2018). 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 MEI continued to be negative in early 2018 but shifted to positive in May and for the remainder of the year. The PDO has remained positive since 2014, but index values indicated more neutral conditions were present in 2018. The NPGO changed from positive to negative in October 2013 and has stayed negative for most of the time since then (although it was positive for five months in 2016). NPGO values were strongly negative throughout all of 2017 and 2018 (Figure 26; 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 2018. At the upcoast portion of the region near Port Hueneme (Anacapa Passage), waves approached from the west (270º) about 56% of the time and from the west-southwest (247.5º) about 17% of the time (Table 11, Figure 27). Off San Pedro, waves originated out of the west about 50% of the time and from the south about 16% of the time (Table 11, Figure 27). Off Oceanside, waves approached from the south-southwest (202.5º) about 43% of the time and from the south about 21% of the time (Table 11, Figure 27). Offshore of Point Loma, waves were from the west about 26% of the time, from the west-northwest (292.5º) about 26% of the time, and from the south about 21% 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. Waves at Anacapa Passage (CDIP Buoy 111 off Ventura) were predominately from the west (Table 11), and wave heights in 2018 exceeding five meters were recorded on November 30 and December 1 (5.5 meters maximum) and exceeding four meters on February 19 and 20 (4.2 meters maximum), April 12-13 (4.6 meters maximum), and November 23 and 24 (4.4 meters maximum). Waves exceeding three meters were recorded every month of the year. Waves in 2018 were larger than those recorded during the previous year (MBC 2018).

Waves at San Pedro (CDIP Buoy 092) were predominately from the west (Table 11) and wave heights exceeded six meters on February 19 (6.1 meters maximum), exceeded five meters on February 20 and 23 (5.4 meters maximum) and November 30 (5.8 meters maximum), and exceeded four meters on April 13 (4.3 meters maximum), October 5 (4.1 meters maximum), December 1 and 2 (4.9 meters maximum), and December 6 (4.1 meters maximum). Waves exceeding three meters were recorded every month of the year, except during July and August. Waves in 2018 were larger than those recorded during the previous year (MBC 2018).

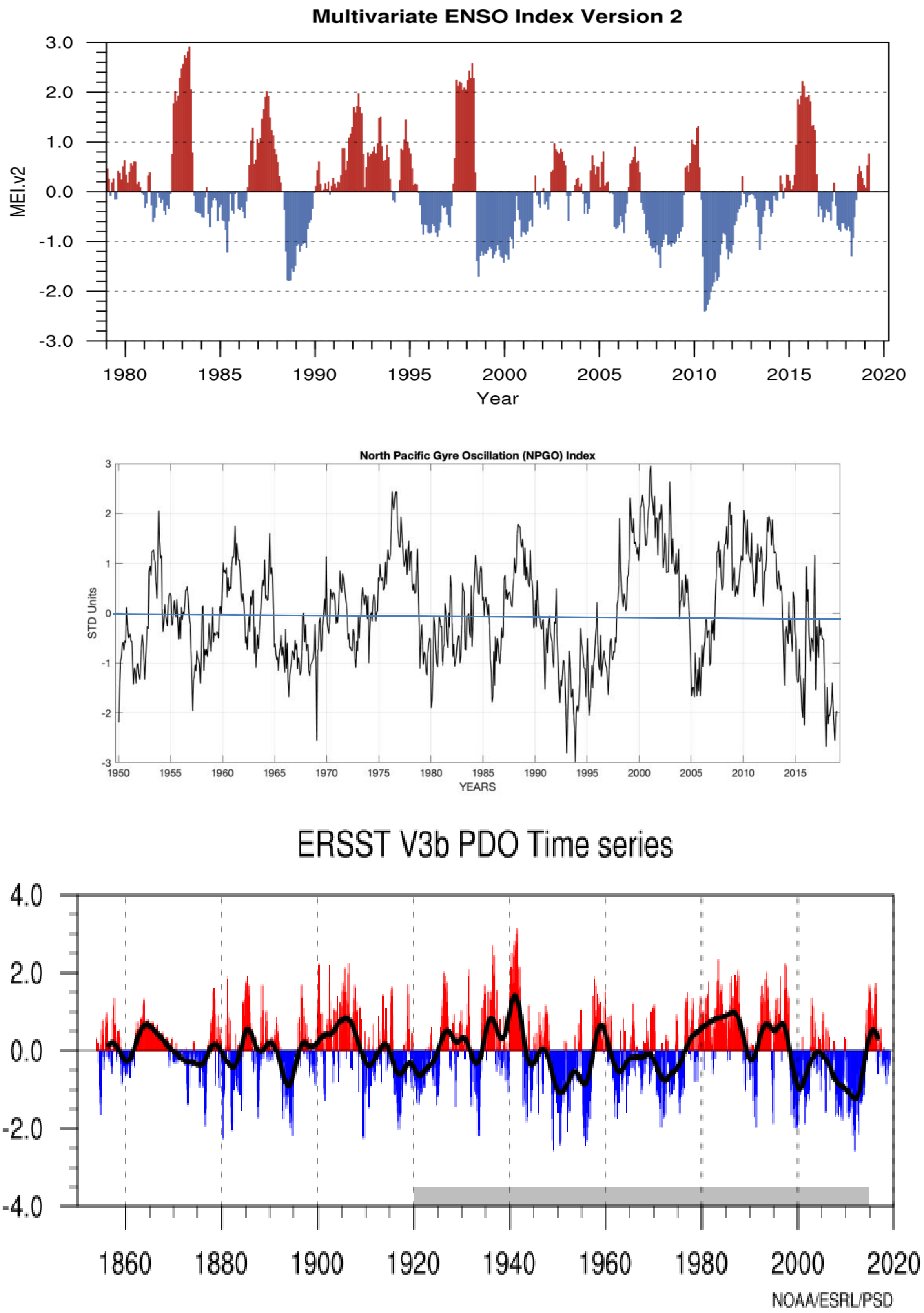


Figure 26. The Multivariate Enso Index (MEI), the North Pacific Gyre Oscillation Index (NPGO), and the Pacific Decadal Oscillation Index (PDO).

Table 11. Direction of swells in 2018. Source: http://cdip.ucsd.edu.

Direction	**Anacapa Passage**	**San Pedro**	**Oceanside**	**Pont Loma South**
West (270º)	56%	50%	15%	26%
South (180º)		16%	21%	21%
West-southwest (247.5º)	17%	9%	7%	7%
South-southeast (157.5º)		10%		1%
South-southwest (202.5º)	3%	6%	43%	26%
Southwest (225º)	6%	5%	10%	10%
West-northwest (292.5º)	5%	3%	2%	9%
Southeast (135º)	4%			

Wave heights at Oceanside (CDIP Buoy 045) exceeded four meters on February 19, 20, and 23 (maximum of 4.9 meters), and on November 30 and on December 1 and 2 (4.9 meters maximum) (Table 12). Waves originated primarily from the south and south-southwest (Table 11), which would tend to have less effect on kelp beds than waves originating from the west. Waves exceeding three meters were rarely recorded from May through October.

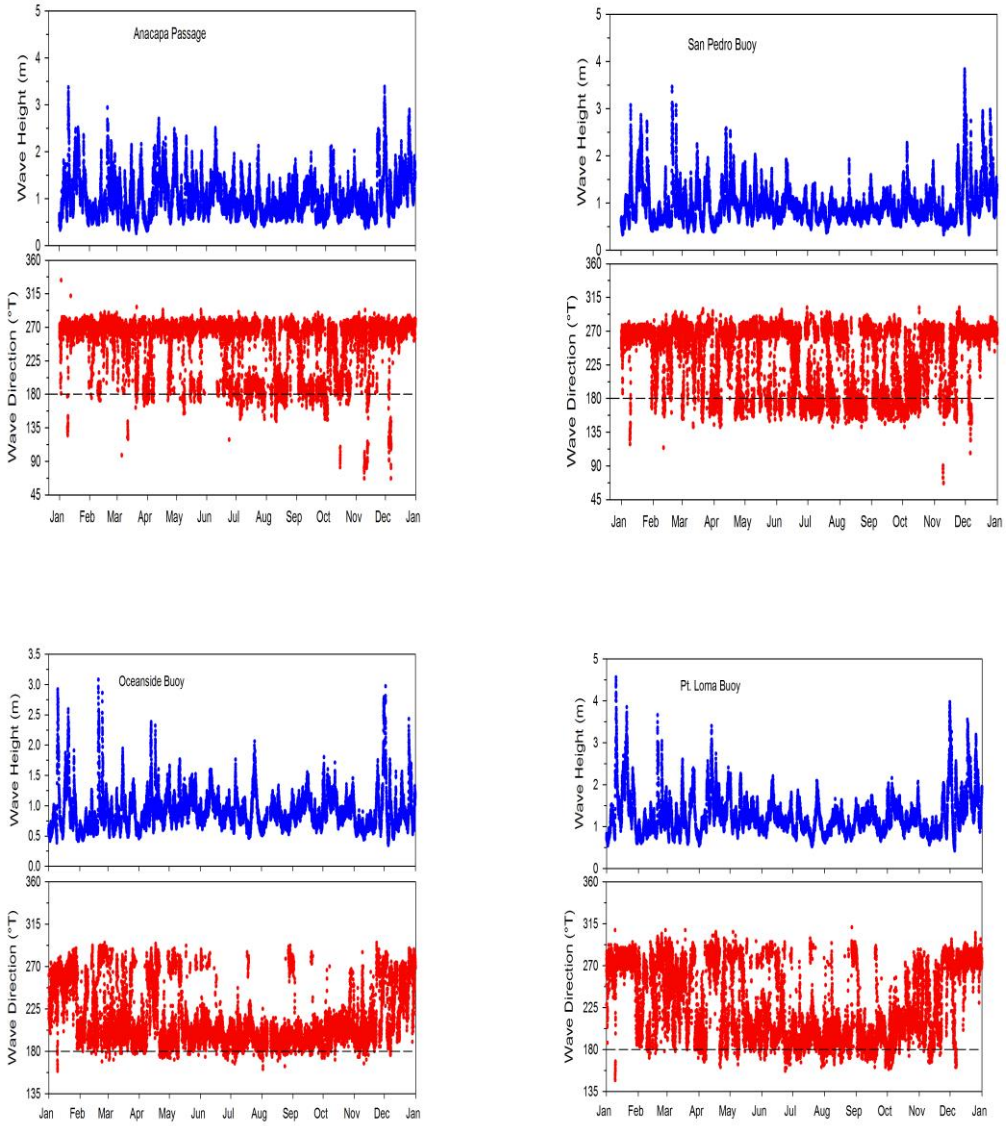


Figure 27. Wave height (blue) and direction (red) at Anacapa Passage Buoy, San Pedro Buoy, Oceanside Buoy, and Point Loma Buoy from January through December 2018.

Table 12. Large waves in 2018.

Date	Anacapa Passage (maximum height in meters)	San Pedro (maximum height in meters)	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
January 9/10/11	---/5.2/3.6		3.3/4.5/3.4	4.7/7.5/4.8
January 16/17/18/ 19/20/21	3.5/4.0/3.2/ 3.6/3.9/3.5	3.1/3.6/3.1/ 3.9/4.4/3.8	---/3.1/---/ ---/4.0/3.8	3.8/4.2/4.1/ 4.4/6.6/5.4
January 25/26/27	3.4/3.9/---	---/4.4/---	---/3.4/---	---/3.8/3.8
February 19/20	4.2/4.2	6.1/5.4	4.9/4.5	6.5/4.8
February 23/24	3.5/---	5.3/3.1	4.5/---	5.2/4.1
March 15/16	3.1/3.8	3.4/3.4	3.0/---	4.2/4.2
March 25/26/27	3.1/3.4/---	3.7/3.4/3.1	---/---/---	4.0/3.9/3.7
April 8/9/10	3.3/3.5/---	---/---/---	---/---/---	3.7/4.4/3.4
April 12/13/14	4.0/4.6/3.0	4.3/4.3/---	3.4/3.7/---	5.1/5.7/4.2
April 17/18/19/20/21	3.6/---/3.5/4.1/3.2	3.8/---/---/3.4/---	3.8/---/---/---/---	4.5/3.2/3.3/3.4/---
April 23	---	---	---	3.1
April 28/29/30 May 1	3.6/4.5/4.0/ 3.6	---/---/3.2/ ---	---/---/---/ ---	3.3/3.8/3.6/ 3.9
May 6	3.1	---	---	---
May 10/11	3.4/3.7	3.5/3.6	---/---	3.4/3.8
May 17	3.2	---	---	---
May 27	3.2	3.4	---	3.2
June 9/10/11	3.3/4.0/3.4	3.3/3.1/---	---/---/---	3.2/3.5/3.4
June 28/29	3.5/3.4	---/---	---/---	---/3.1

Note: “---" indicates maximum wave height was less than 3.0 meters

Table 12 (continued). Large waves in 2018.

Date	Anacapa Passage (maximum height in meters)	San Pedro (maximum height in meters)	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
July 5/6/7	---/3.0/3.2	---/---/---	---/---/---	3.0/---/---
July 24/25	3.2/---	---/---	3.2/3.1	3.5/3.4
August 30/31	3.2/3.2	---/---	---/---	---/3.1
September 16	3.6	---	---	3.2
October 1/2	---/---	---/---	---/---	3.7/3.0
October 5/6/7/8/9	---/3.6/3.1/3.5/3.5	4.1/---/---/---/---	---/---/---/---/---	3.5/3.7/---/---/---
October 30/31	3.1/---	---/3.3	---/---	3.3/3.0
November 23/24/25	4.4/4.0/3.5	---/3.3/3.1	---/3.0/---	3.1/3.5/3.4
November 28/29/30 December 1/2	---/3.4/5.5 5.4/3.7	---/3.6/5.8 4.6/4.9	---/---/4.9 4.4/4.8	3.6/3.9/6.3 5.8/5.0
December 6/7	---/---	4.1/---	3.0/---	4.3/3.4
December 11/12	3.2/---	3.1/---	---/---	3.4/3.3

Note: “---" indicates maximum wave height was less than 3.0 meters

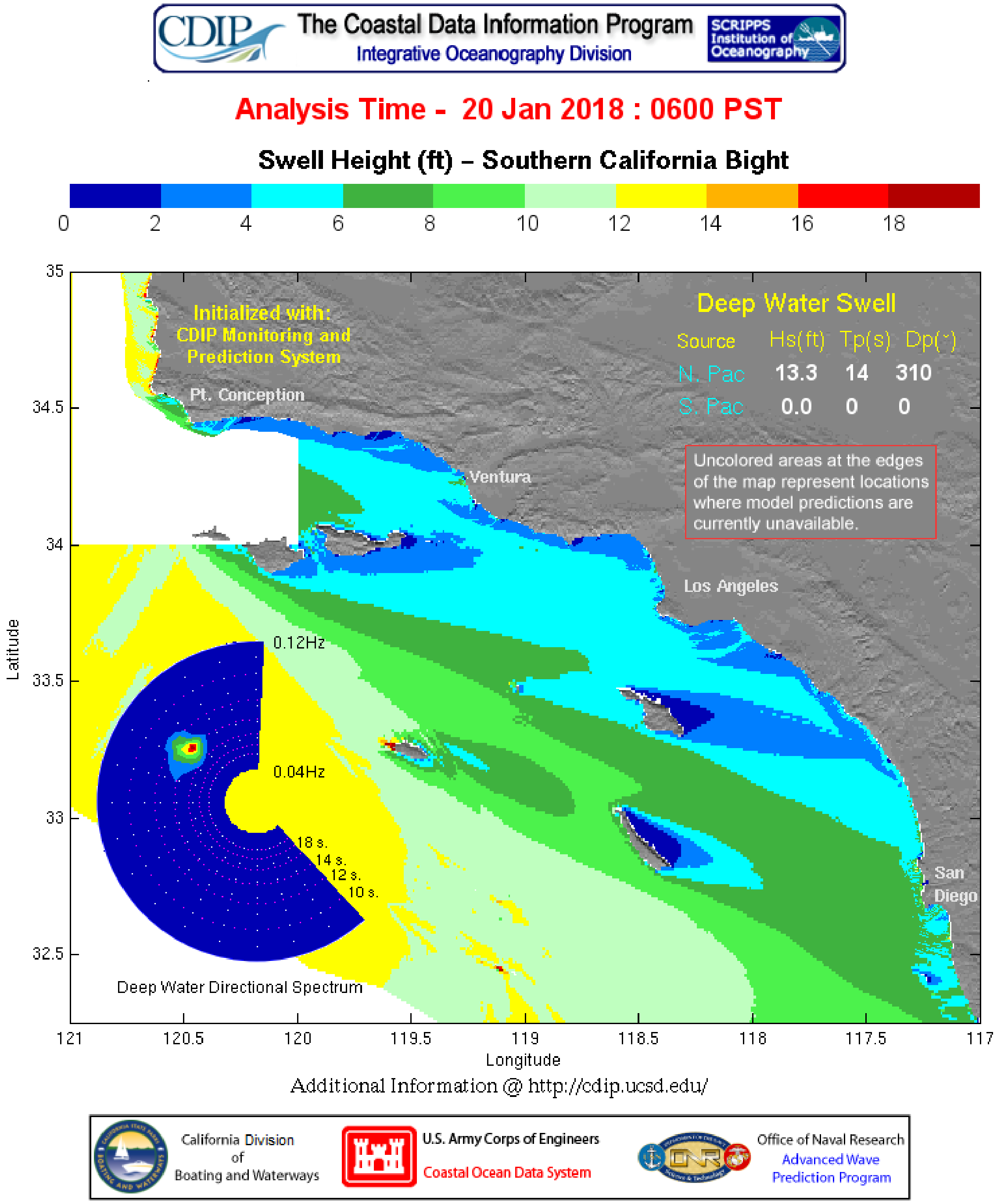


Figure 28. Swell height and direction in the Southern California Bight on January 20, 2018. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

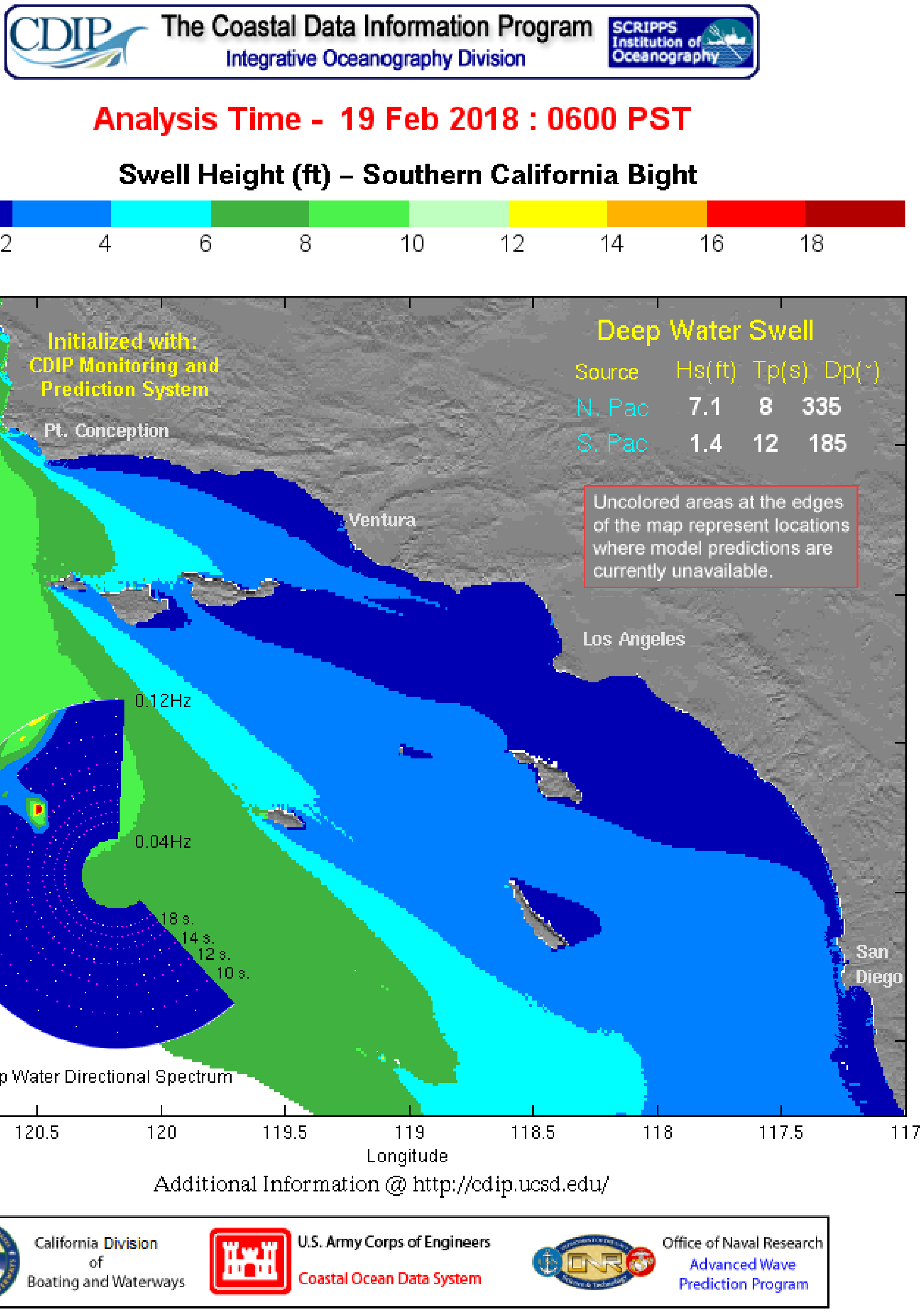
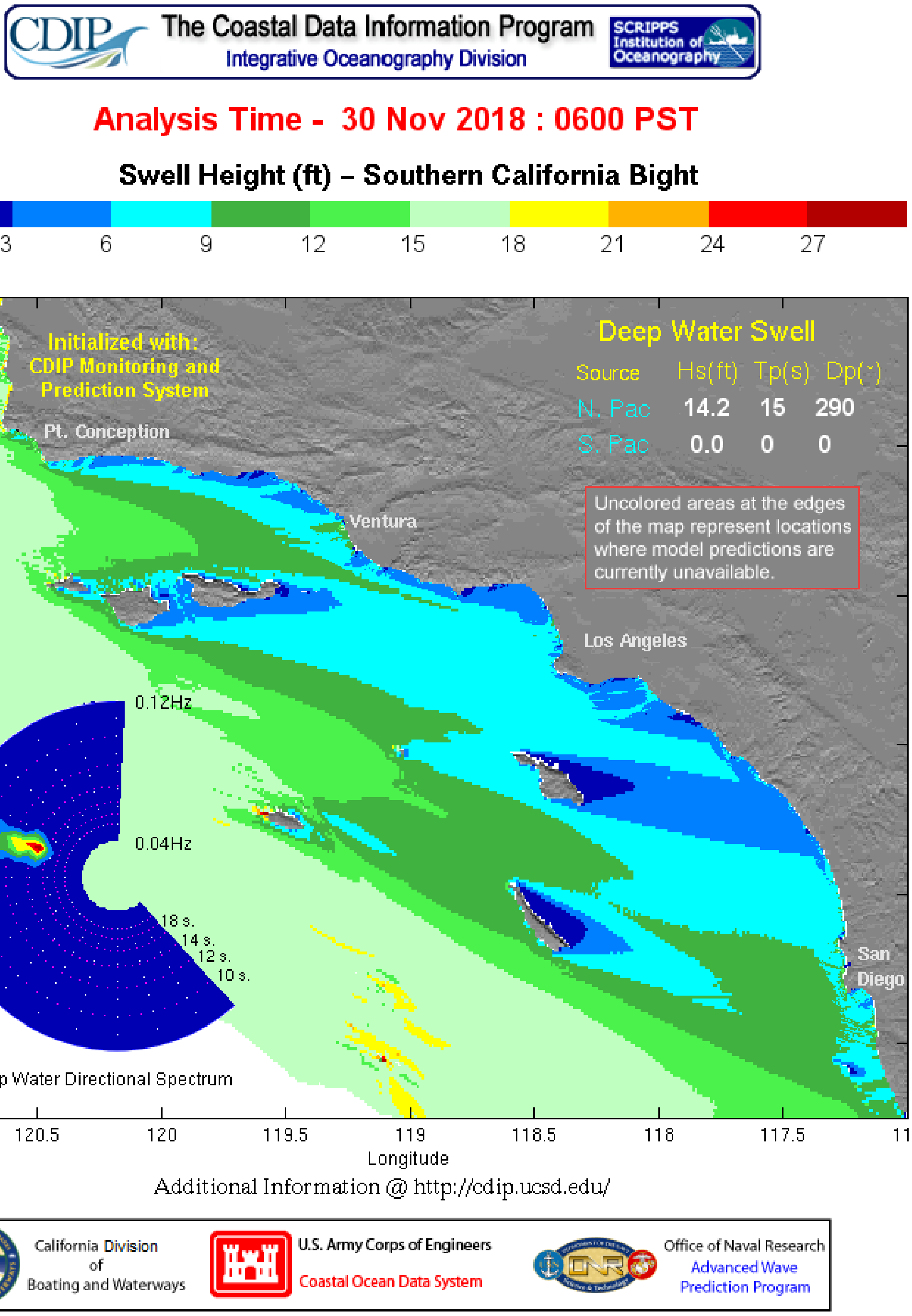


Figure 29. Swell height and direction in the Southern California Bight on February 19, 2018. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.



Source	Hs(ft)	Tp(s)	Dp(°)
N. Pac	14.2	15	290
S. Pac	0.0	0	0

Uncolored areas at the edges of the map represent locations where model predictions are currently unavailable.

Figure 30. Swell height and direction in the Southern California Bight on November 30, 2018. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

Waves originated from the west at Point Loma South (CDIP Buoy 191) approximately one-fourth of the time. Very large waves were recorded from January 9 through 11 (7.5 meters maximum) and from January 19 through 21 (6.6 meters maximum), on February 19 and 20 (6.5 meters maximum), and on November 30 and on December 1 and 2 (6.3 meters maximum) (Table 12). Waves exceeding five meters were recorded on April 12 and 13 (5.7 meters maximum) and exceeding four meters were recorded on January 17 and 18 (4.2 meters maximum), March 15 and 16 (4.2 meters maximum), April 9 (4.3 meters maximum), April 14 and 17 (4.5 meters maximum), and December 6 (4.3 meters maximum). Waves were larger during 2018 than during the previous year (MBC 2018).

The storms that occurred from January 19 through 21 produced large wave heights (Table 12) and large nearshore swells were evident along almost the entire area of the Central Region and Region Nine on January 20, 2018 (Figure 28), with the largest waves hitting the coast in the San Diego area. The storms that occurred from February 19 through the 21 also produced large waves throughout both regions, although swells were not as large along the San Diego coastline as was the case in mid-January (Figure 29). The storms that occurred from November 30 through December 2 were similar to the January storms, producing large waves throughout both regions and largest waves in the San Diego area (Figure 30).

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 2018 was below average in all areas. Most rain fell during the months of January and March, and November and December in all four areas (Figure 31). Oxnard recorded the highest rainfall in 2018 at 10 inches, below the annual average of 15.6 inches. Los Angeles, Costa Mesa and San Diego recorded similar amounts of rainfall in 2018 (7 to 7.8 inches), all below their annual averages. These low rainfall levels were unlikely to generate any extended periods of high turbidity.

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 and *Pseudo-nitzschia delicatissima* group (phytoplankton associated with harmful algal blooms) were often recorded at the Santa Monica Pier from January through June, and throughout the year at Newport Pier (Figures 32 A and 33 A). Domoic acid, a toxin produced by these phytoplankton, was not recorded at Santa Monia Pier in 2018, and was only recorded at Newport Pier on two occasions (March 5 and April 23) at Newport Pier (Figures 32 B and 33 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). However, the concentrations recorded in 2018 appear unlikely to have impacted kelp beds.

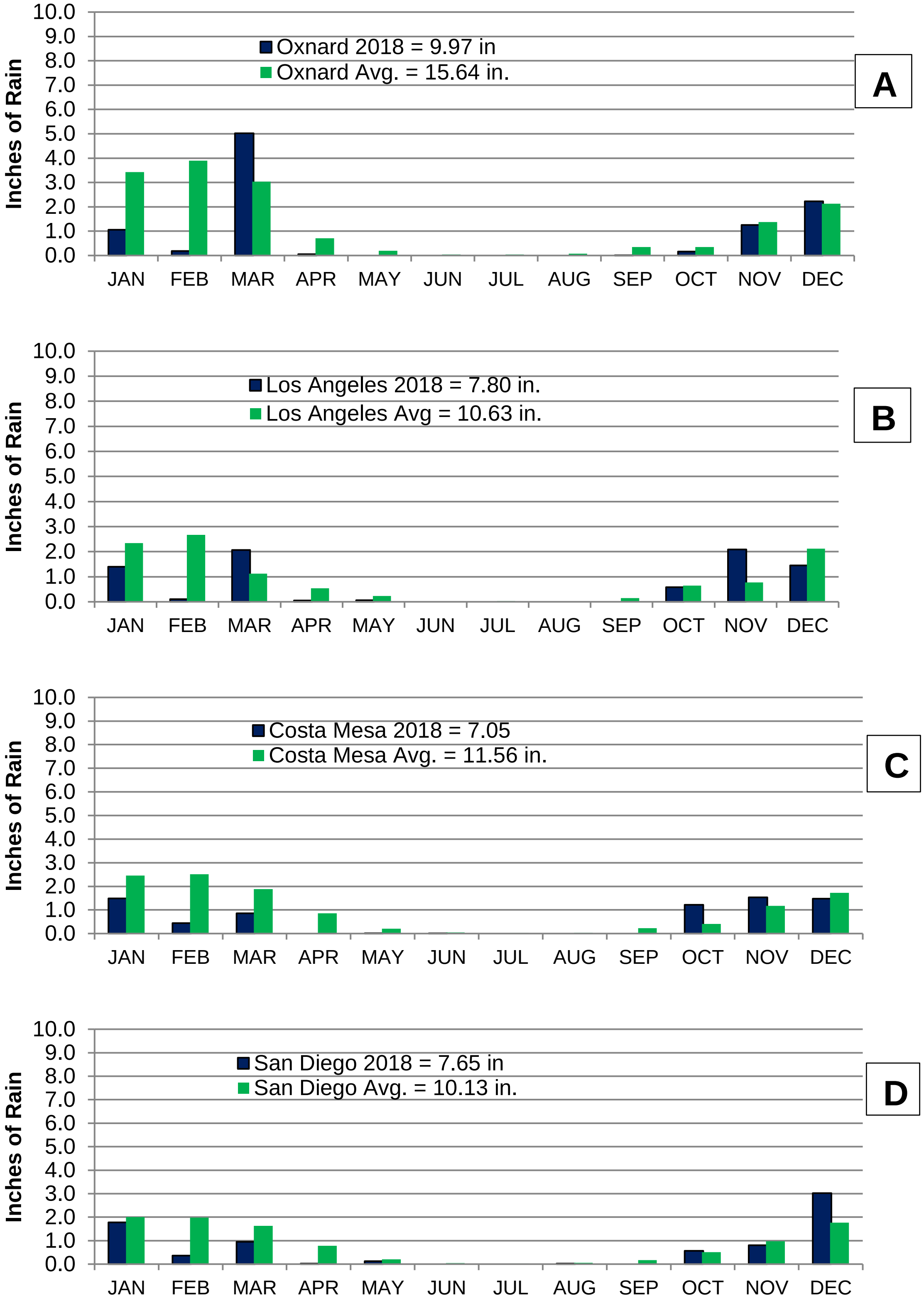


Figure 31. Monthly 2018 rainfall and average monthly rainfall recorded for (A) Oxnard, (B) Los Angeles International Airport (Los Angeles), (C) Costa Mesa, and (D) Lindbergh Field (San Diego).

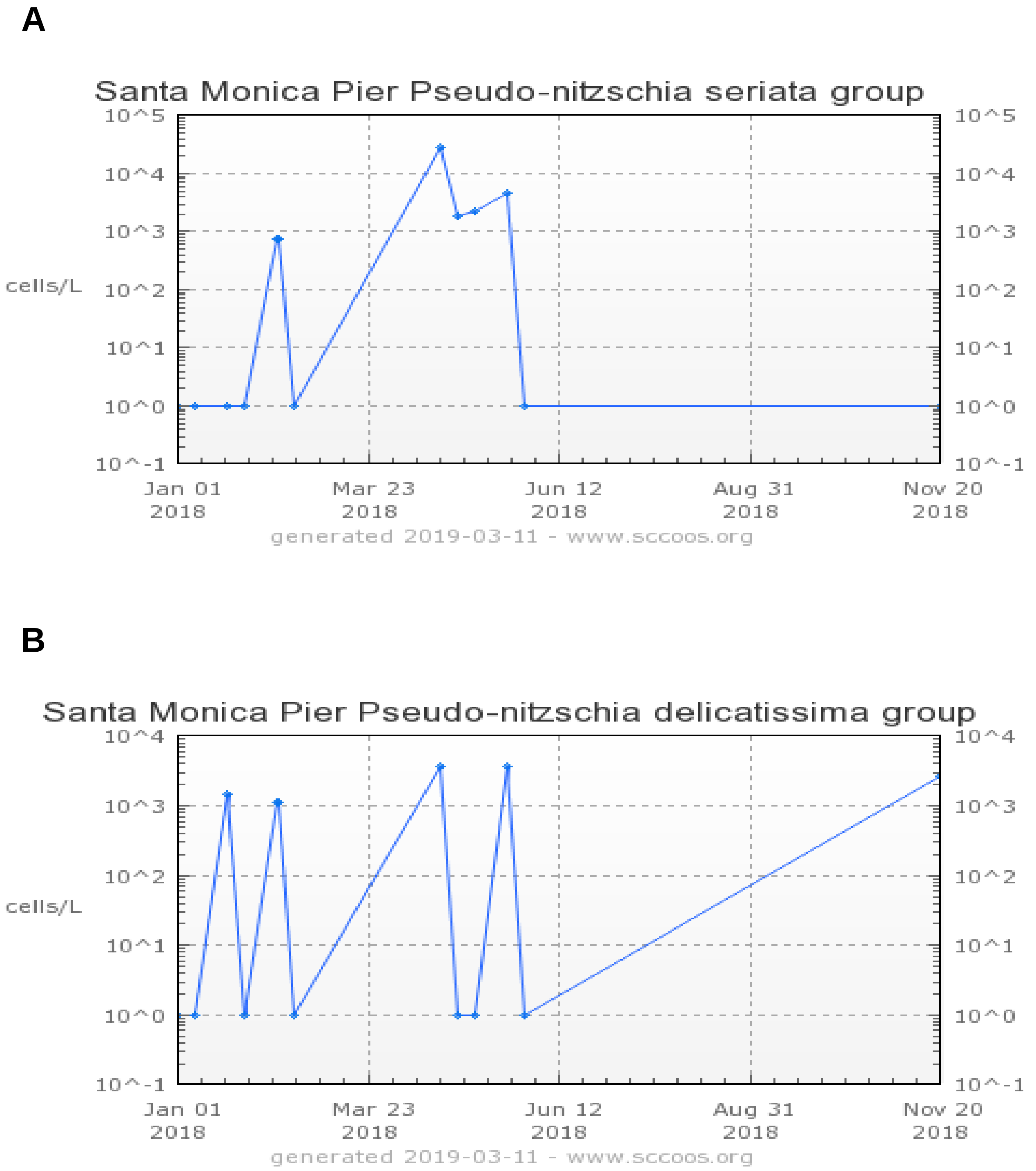


Figure 32. Concentrations of the Harmful Algal Bloom species at Santa Monica Pier. Data includes (A) *Pseudo-nitschia seriata* group and (B) *Pseudo-nitschia delicatissima* group). Source: http://www.sccoos.org/data/habs/history.php?location=Santa%20Monica%20Pier.

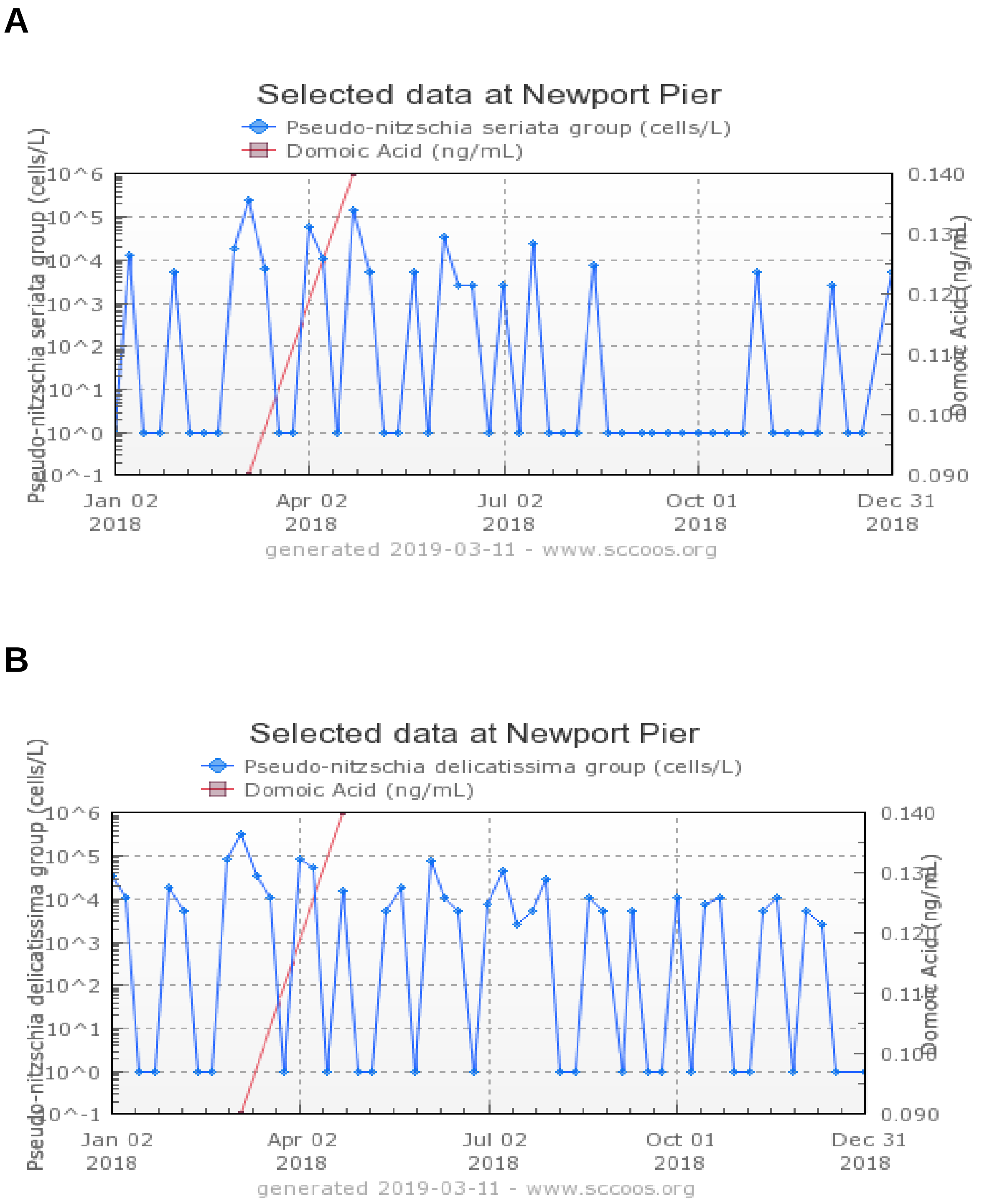


Figure 33. Concentrations of the Harmful Algal Bloom species and domoic acid concentrations at Newport Pier. Data includes (A) *Pseudo-nitschia seriata* group and (B) *Pseudo-nitschia delicatissima* group).

Source: http://www.sccoos.org/data/habs/history.php?location=Scripps%20Pier.

IV.4 - KELP RESTORATION

IV.4.A – CENTRAL REGION

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 to 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 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 61.5 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 (Figure 34). 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 later 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.

Restoration and monitoring activities have been conducted in restoration, control and reference sites since July 2013 and are ongoing. Restoration efforts at 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 8.3 acres for Honeymoon Cove and 8.4 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 8.8 acres for Marguerite, 4.3 acres for Hawthorne and 3.9 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).

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 (House et al, 2019). 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. In February 2019, the Coastal Commission approved the SCE proposal to add construct an additional 210-acre kelp reef to expand the existing 174-acre Wheeler North Reef. SCE proposes to place 175,000 tons of quarried rock in 23 new polygons north and inshore of the existing reef. The expansion project is scheduled to begin in July 2019 and expected to be completed in 2020.

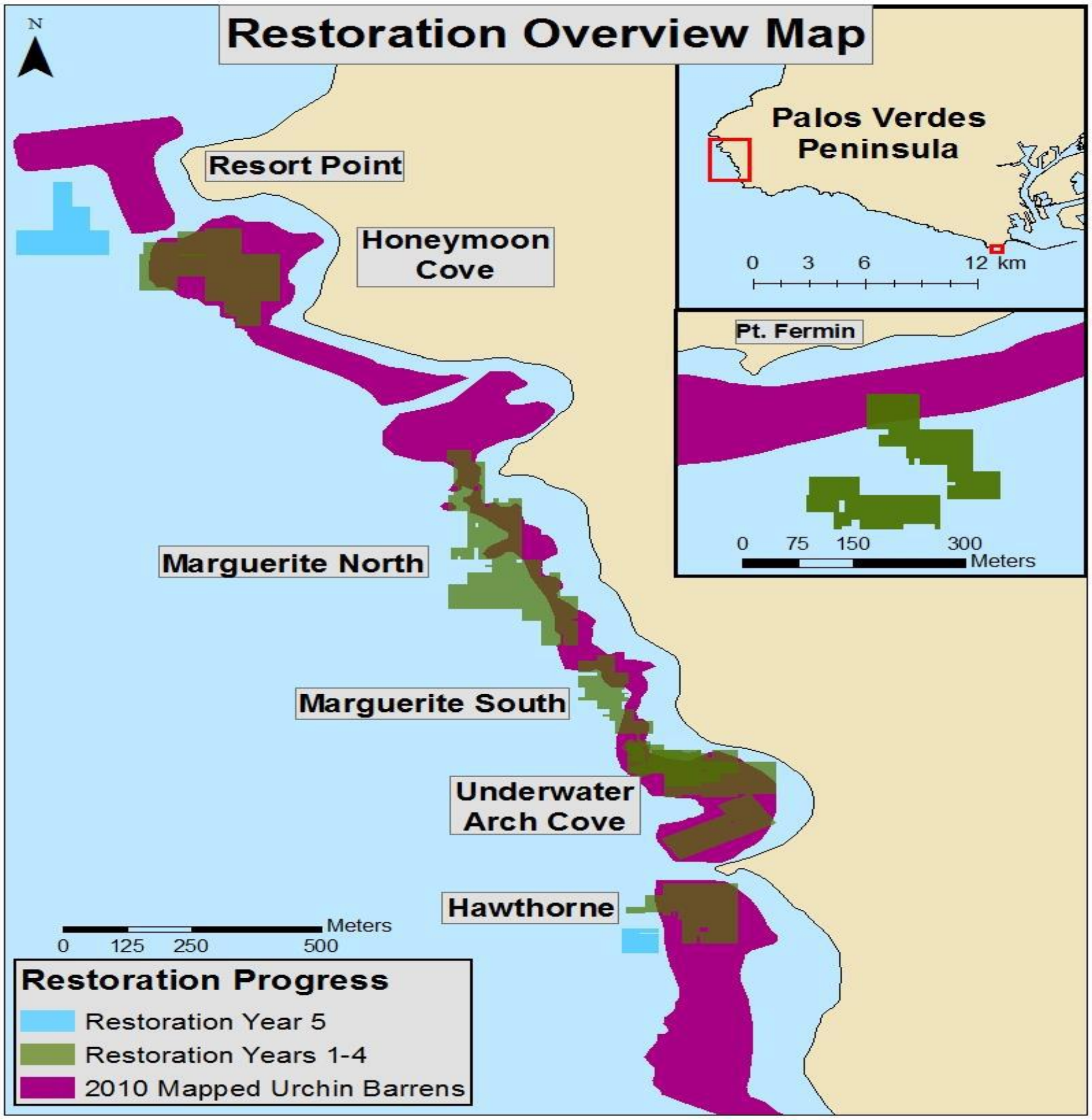


Figure 34. Urchin barrens as mapped in 2010 and kelp bed restoration areas of the Bay Foundation's Kelp Project. Source: House et al., 2019.

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 (ensuring 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.

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. Commonly harvested kelp and marine algae include bull kelp (*Nereocystis luetkeana*), giant kelp (*Macrocystis pyrifera*), grapestone or Turkish washcloth (*Mastocarpus papillatus*), bladderwrack (*Fucus distichus*), kombu (*Laminaria setchellii*), wakame (*Alaria marginata*), sea cabbage or sweet kombu (*Saccharina sessilis*), bladder chain kelp or sea fern (*Stephanocystis osmundacea*), nori *Pyropia* species), and sea lettuce (*Ulva* species).

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 35. 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 36. 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 37 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 No. 3 lease issued in July 2013. Bed No. 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. The lease renewal was approved by F & W in June 2018. F & W subsequently authorized Dr. Matthew Edwards, San Diego State University, to perform research activities involving giant kelp in Kelp Bed No. 3 (August 2018).

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 in the Central Region or Region Nine.

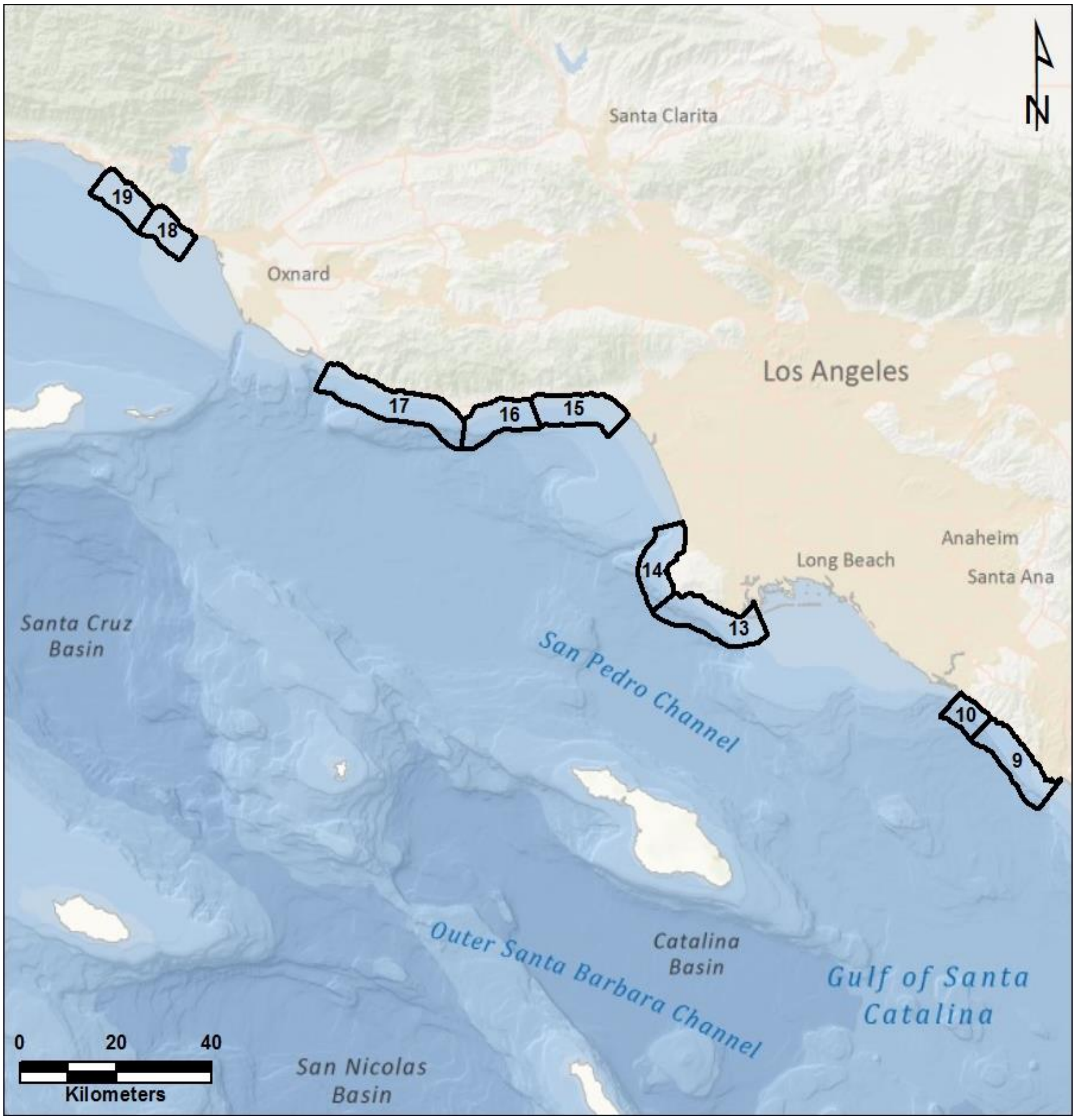


Figure 35. Administrative kelp bed leases in the Central Region study area.

Source: California Department of Fish and Wildlife. (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134676&inline).

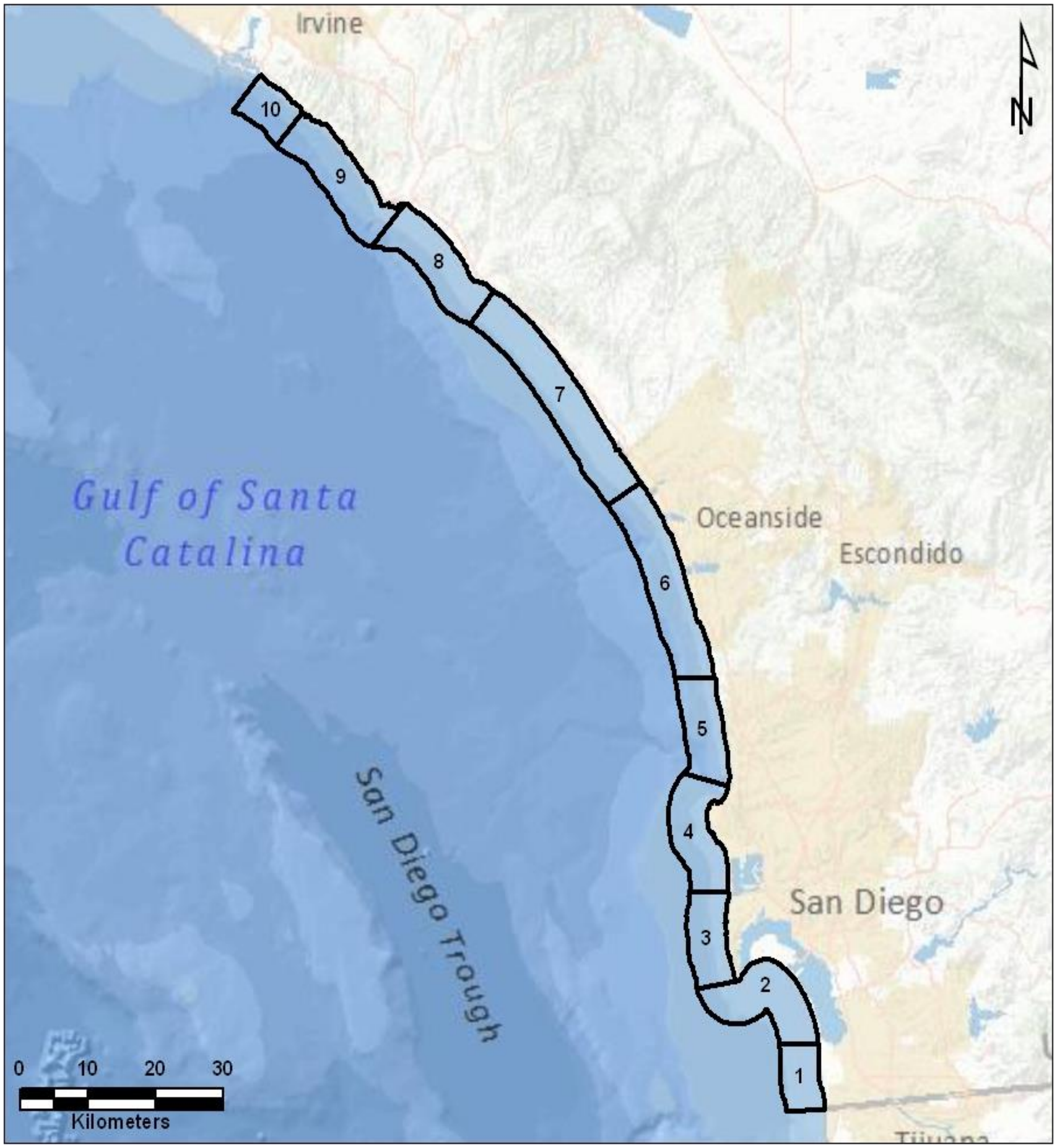


Figure 36. Administrative kelp bed lease areas in the Region Nine study area.

Source: California Department of Fish and Wildlife (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134676&inline).

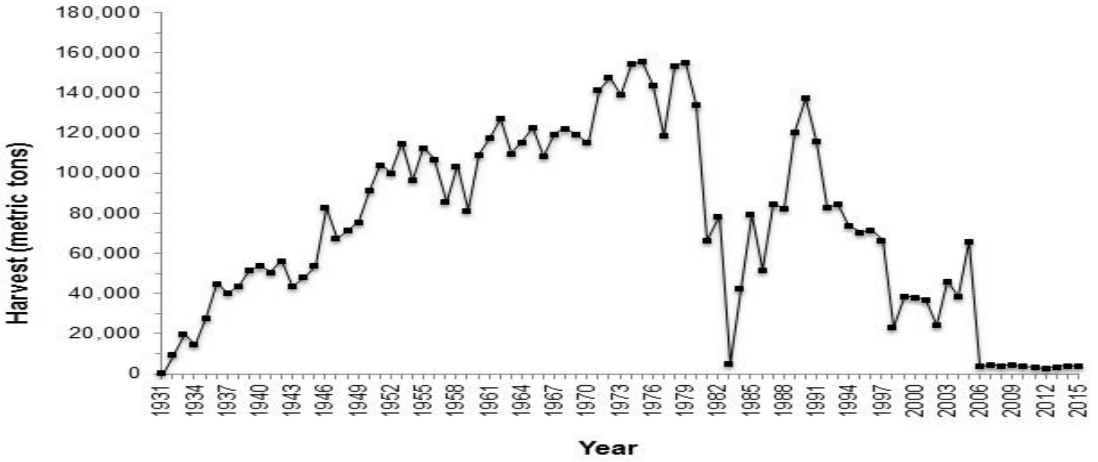


Figure 37. Commercial kelp harvest landings for giant and bull kelp from 1931 through 2015. Source: California Department of Fish and Wildlife (https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest).

V - UPDATE TO PRESENT

The first aerial survey for 2019 was conducted on March 31, 2019. Kelp beds in the northern portion of the Central Region (Deer Creek to Sunset) were moderate in size, but smaller than in 2018. The Palos Verdes kelp beds were much smaller than in 2018 (estimated sizes of 0.5 or 1.0 in March 2019 versus 4.0 in March 2018). Little or no kelp surface canopy was observed throughout most of Region Nine in March 2019. However, the La Jolla Lower and Point Loma (Upper and Lower) kelp beds were extensive, although smaller than the maximum observed in 2018.

VI - CONCLUSIONS

Total combined kelp surface canopy increased substantially in 2018 in both the Central Region and Region Nine. The Central Region kelp beds increased in size from 4.3 km^2 to 7.9 km^2, an increase of 61%. This canopy coverage was the highest amount recorded in 50 years, slightly exceeding the peak level observed in 1967. Nearly all kelp beds increased in size in 2018, and three kelp beds reappeared. The Region Nine kelp beds more than tripled in size, increasing from 3.3 km^2 in 2017 to 11.0 km^2 in 2018, an increase of 237%. However, although this was higher than the levels recorded for the past two years, it remained well below the levels attained in 2013 through 2015. Most kelp beds increased in size in 2018, but no kelp beds reappeared and one disappeared.

Sea surface water temperatures were warmer than average the second half of the year in both the Central Region and Region Nine, but cooler than normal temperatures were recorded in March, April, and May. These cooler temperatures, along with stronger upwelling in the first half of 2018 than occurred during 2017, may have accounted for the considerable increases in size of most kelp beds in both regions during 2018, all of which reached their maximum extent during the March or July surveys. These gains occurred despite little change in Nutrient Quotient values from 2017 to 2018.

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			

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PERSONAL COMMUNICATIONS

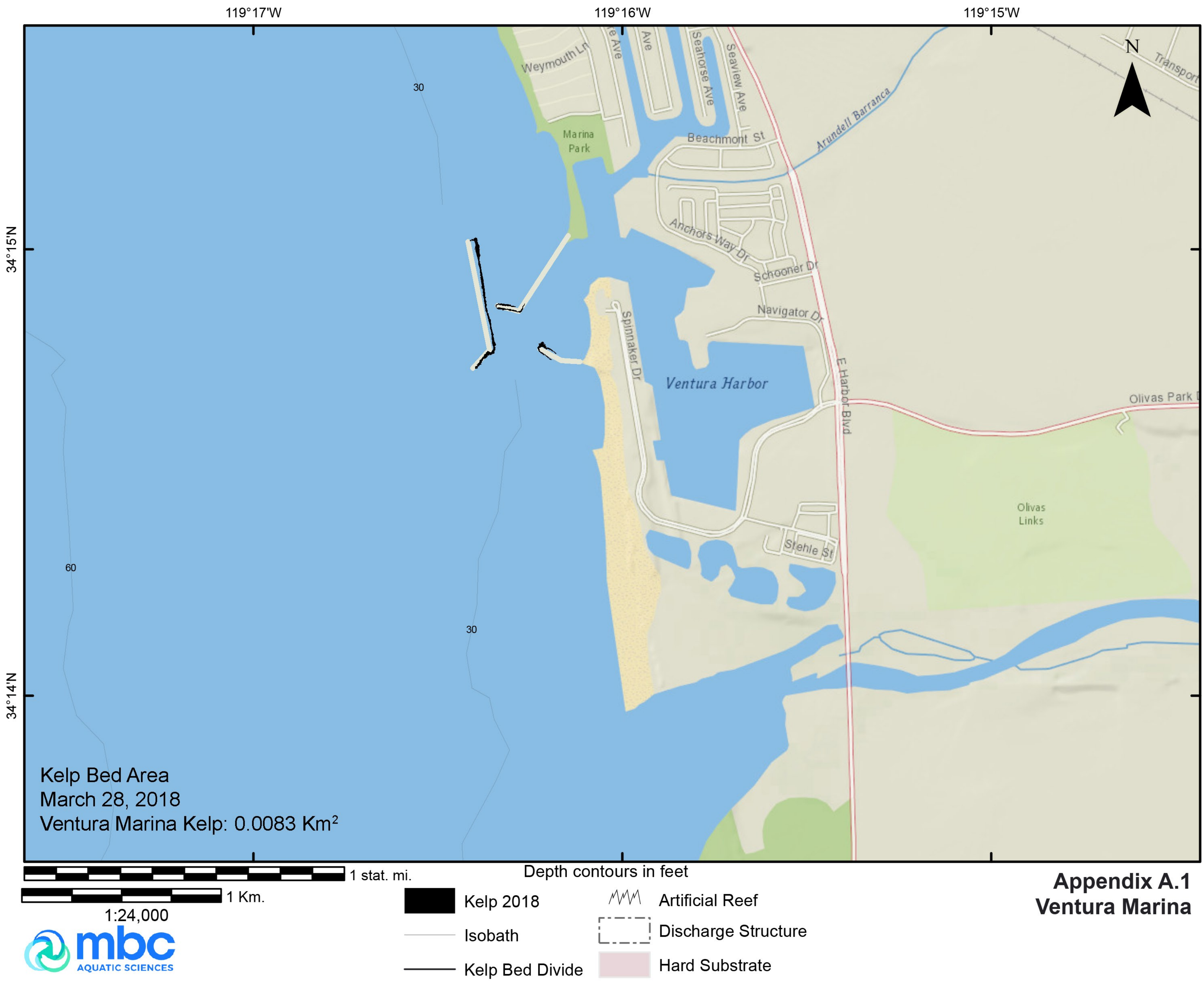
Anthony, K. 2016. Kim Anthony, Southern California Edison. Comments transmitted by email to S. Beck (MBC) on 11 July 2016.

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

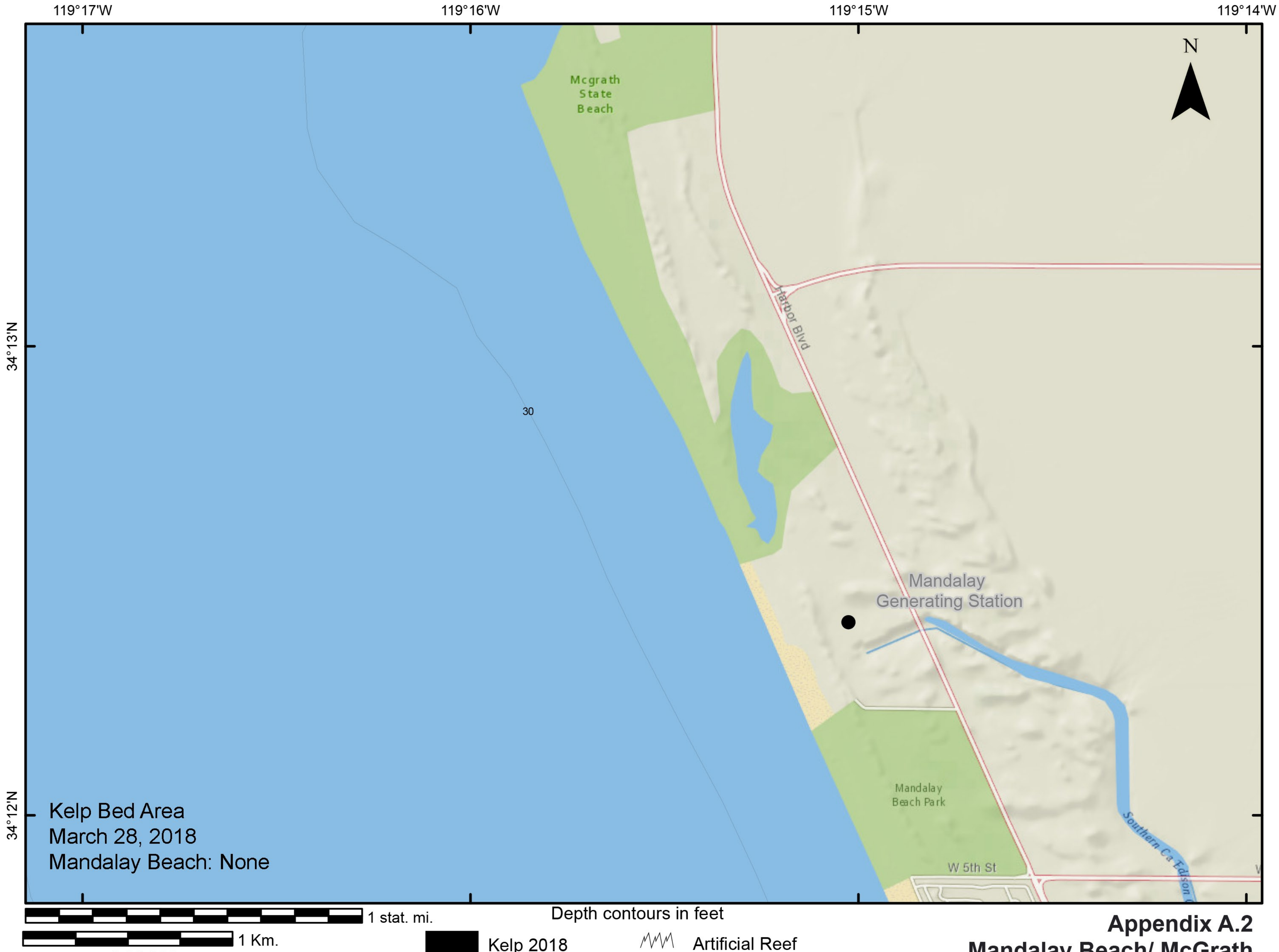
APPENDIX A

Kelp Canopy Maps

Appendix A.1
Ventura Marina



Kelp Bed Area
March 28, 2018
Ventura Marina Kelp: 0.0083 Km^2



Kelp Bed Area
March 28, 2018
Mandalay Beach: None

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
ʌʌʌ	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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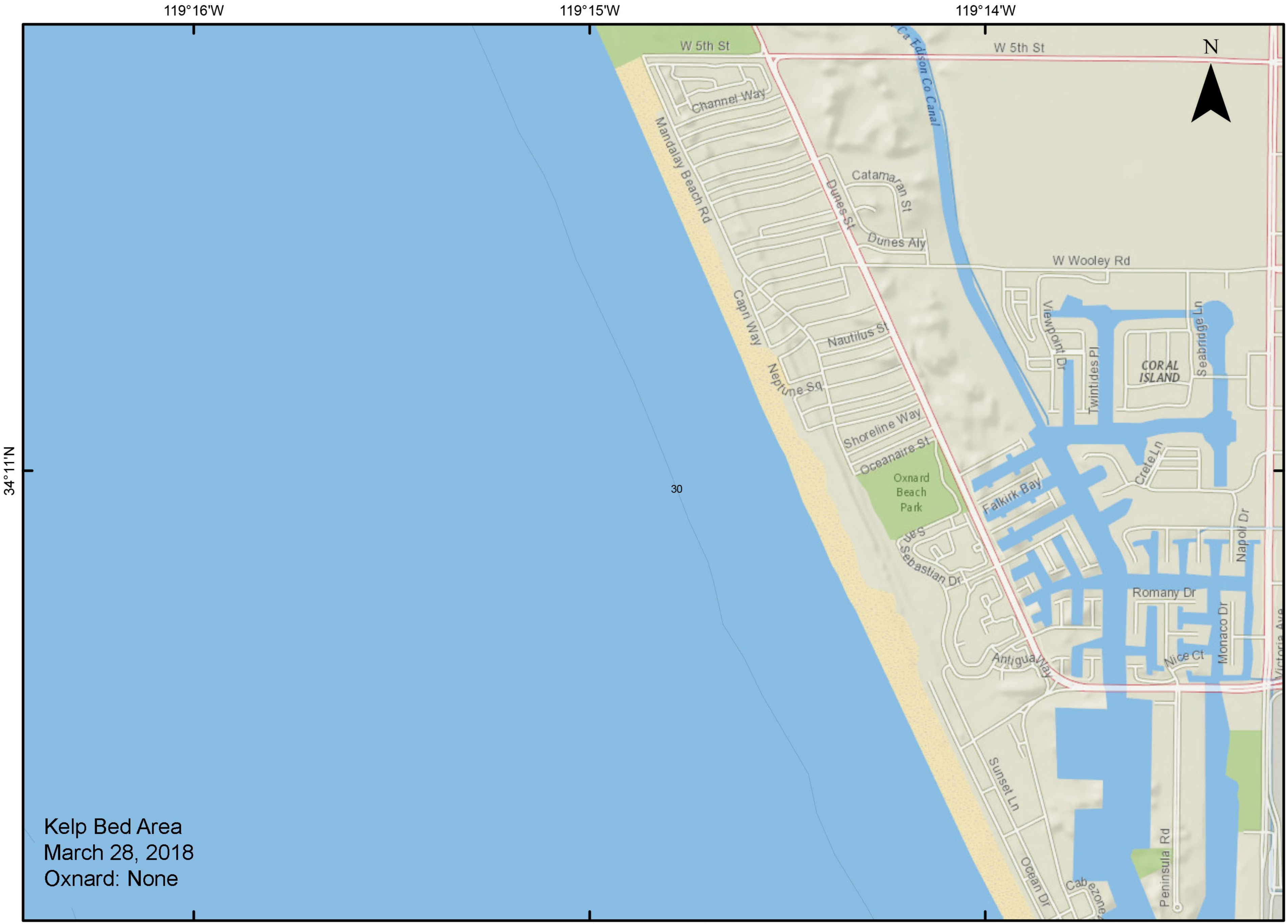
Appendix A.2
Mandalay Beach/ McGrath



Kelp Bed Area
March 28, 2018
Oxnard: None

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
⩘⩘	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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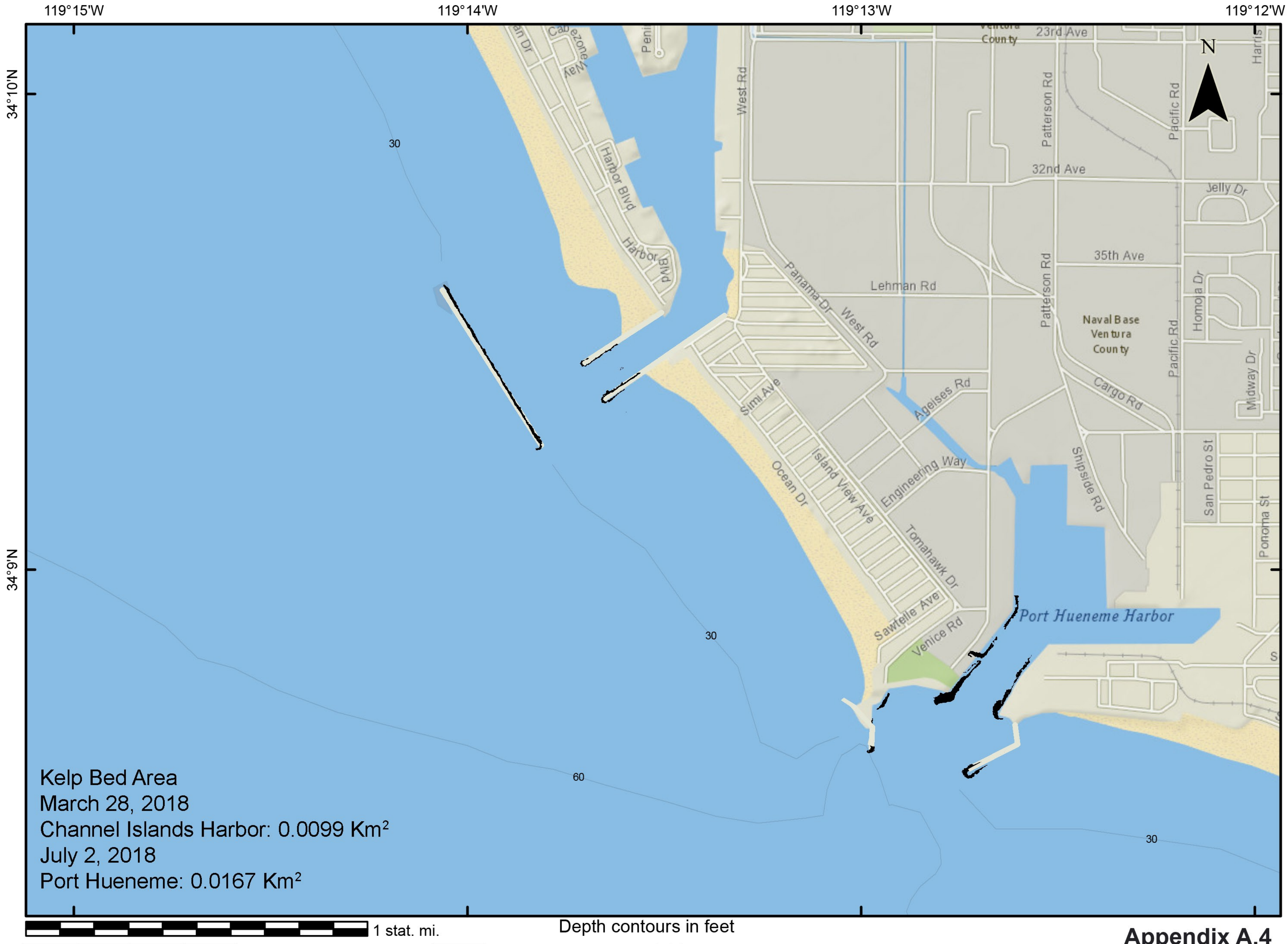
Appendix A.3
Oxnard (Silver Strand)



Kelp Bed Area
March 28, 2018
Channel Islands Harbor: 0.0099 Km²
July 2, 2018
Port Hueneme: 0.0167 Km²

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

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
⋀⋀⋀	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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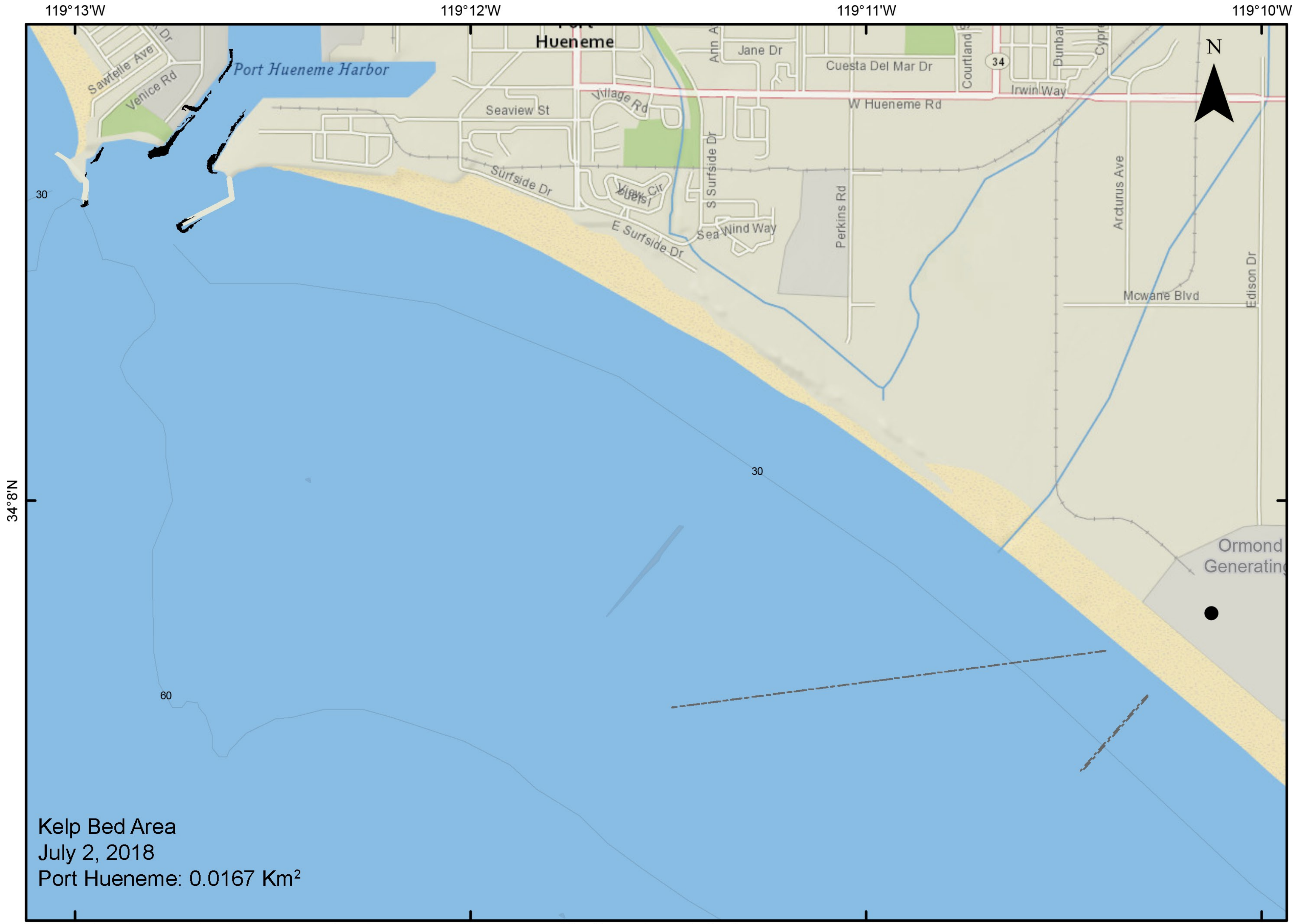
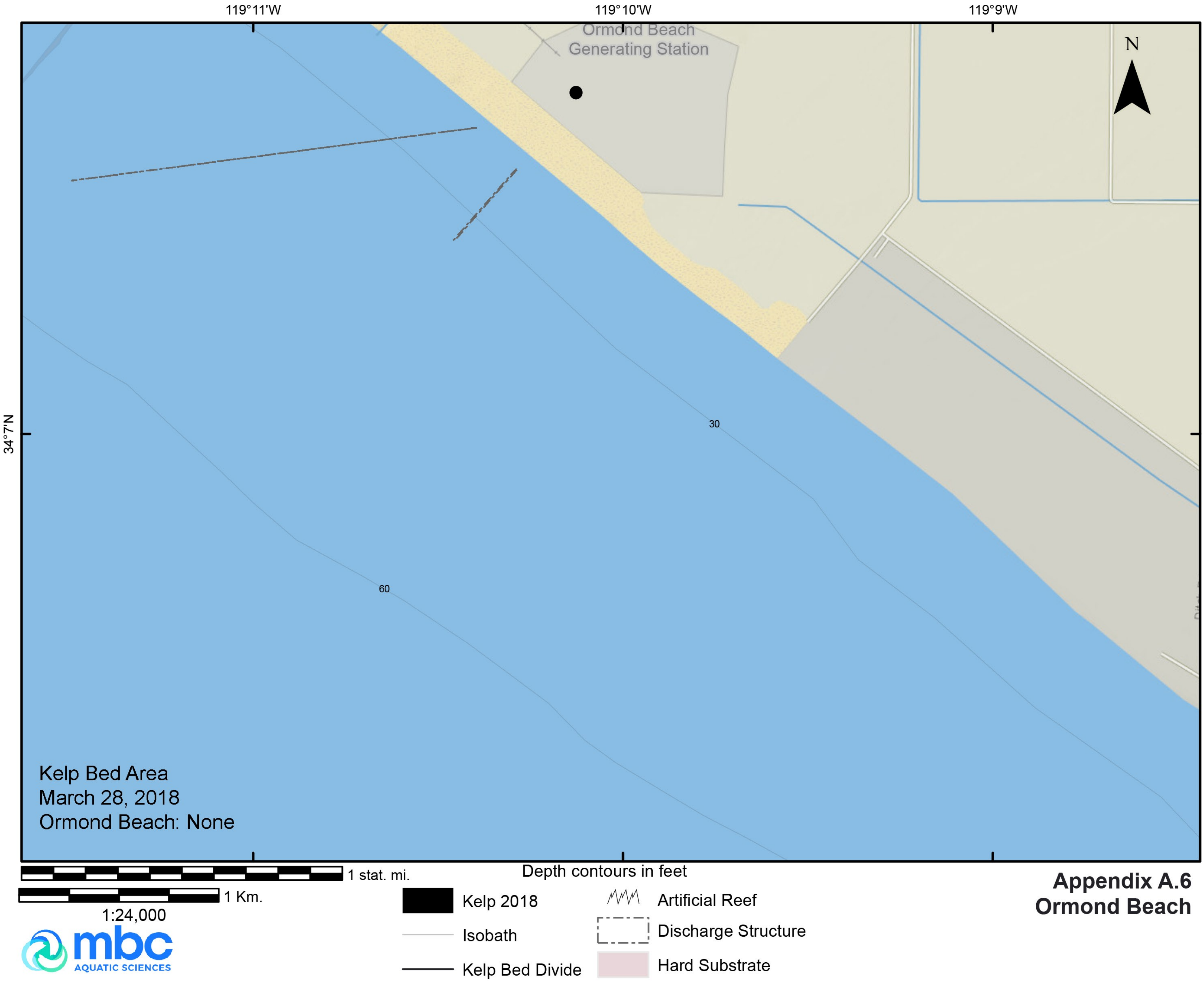
Appendix A.4
Channel Island Harbor/ Port Hueneme Harbor

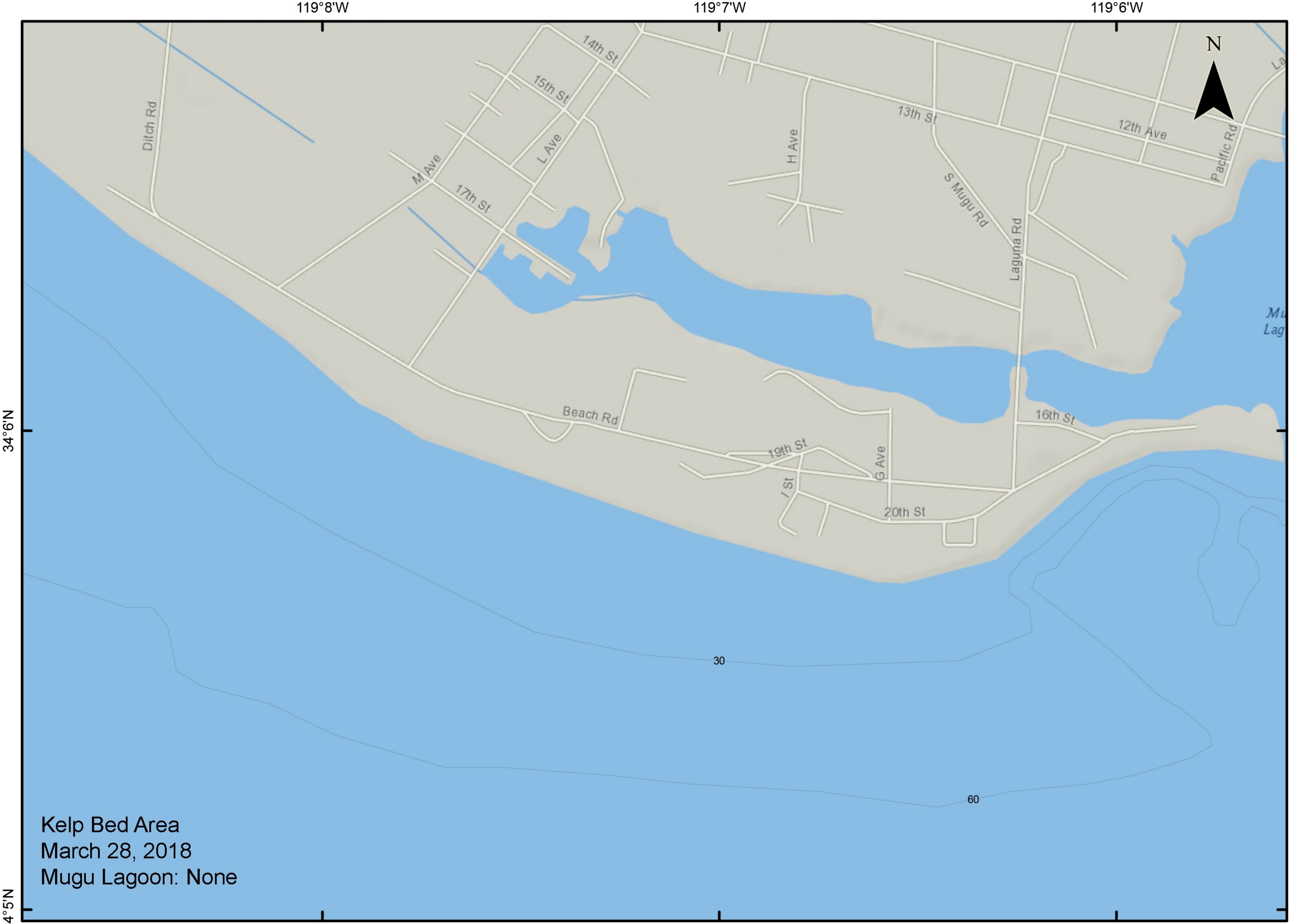


Kelp Bed Area
July 2, 2018
Port Hueneme: 0.0167 Km²

Appendix A.5
Port Hueneme Beach



Appendix A.6
Ormond Beach



Kelp Bed Area
March 28, 2018
Mugu Lagoon: None

1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

■ Kelp 2018

Isobath

Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.7
Mugu Lagoon/ Base

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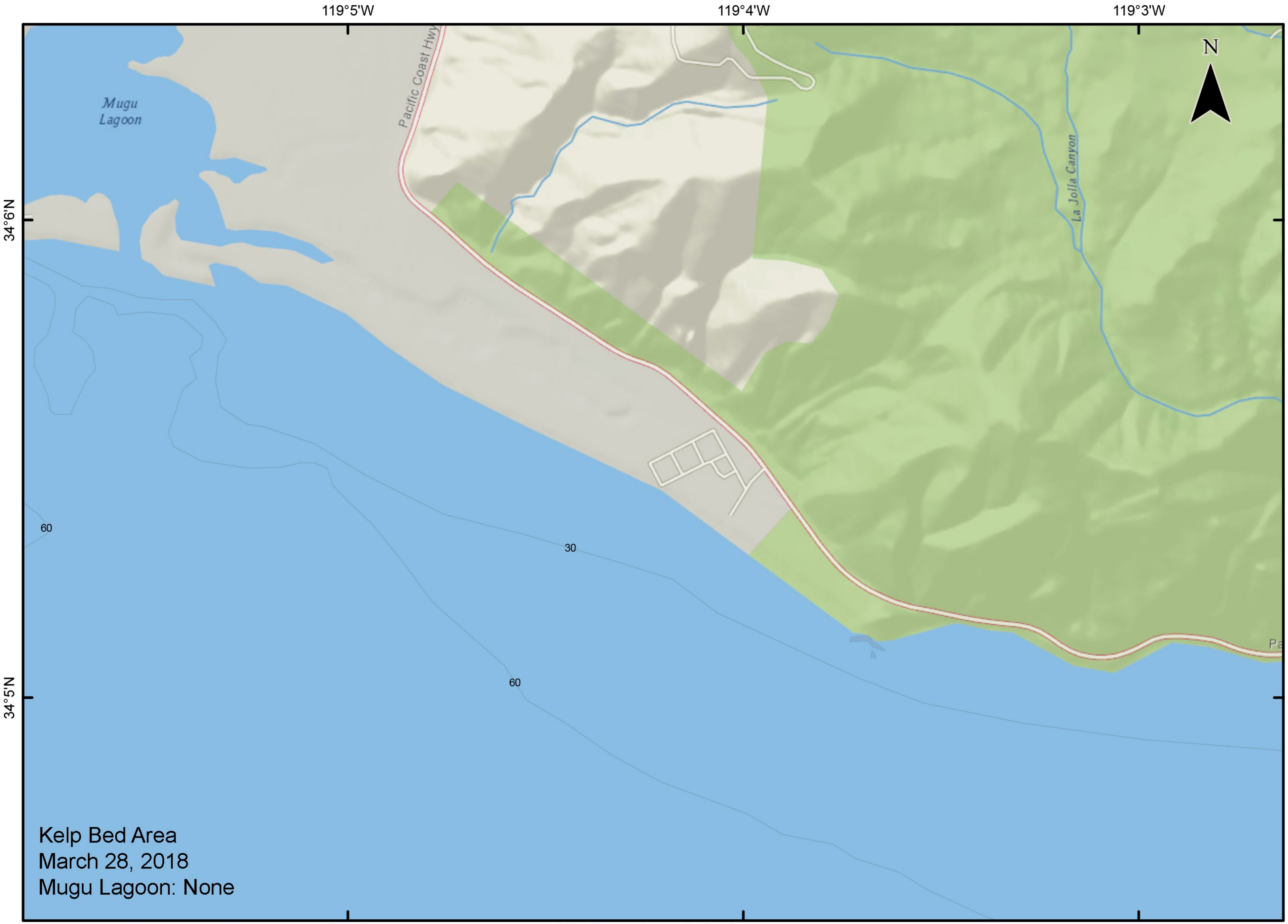


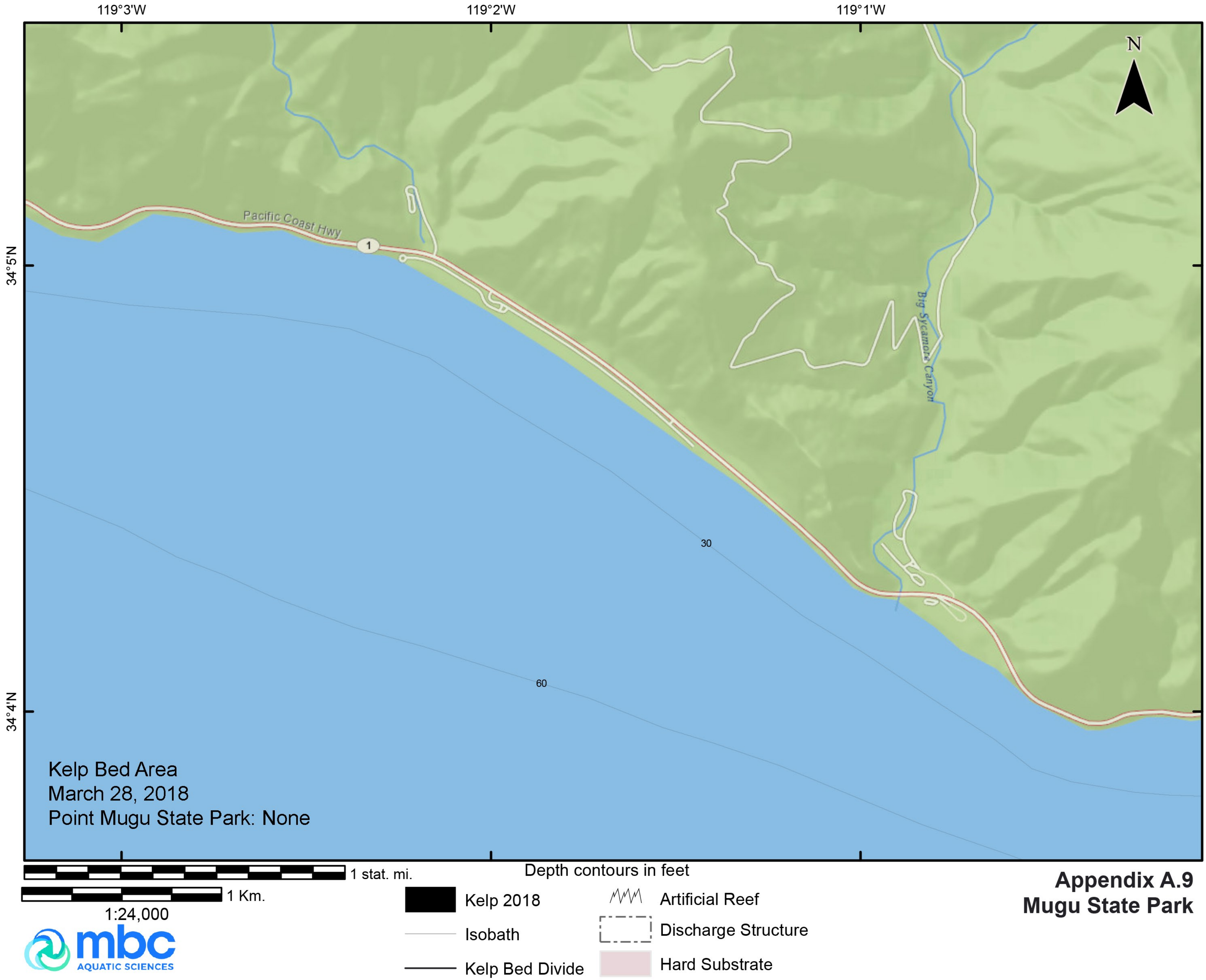
Kelp Bed Area
March 28, 2018
Mugu Lagoon: None

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

Depth contours in feet

■ Kelp 2018
— Isobath
— Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

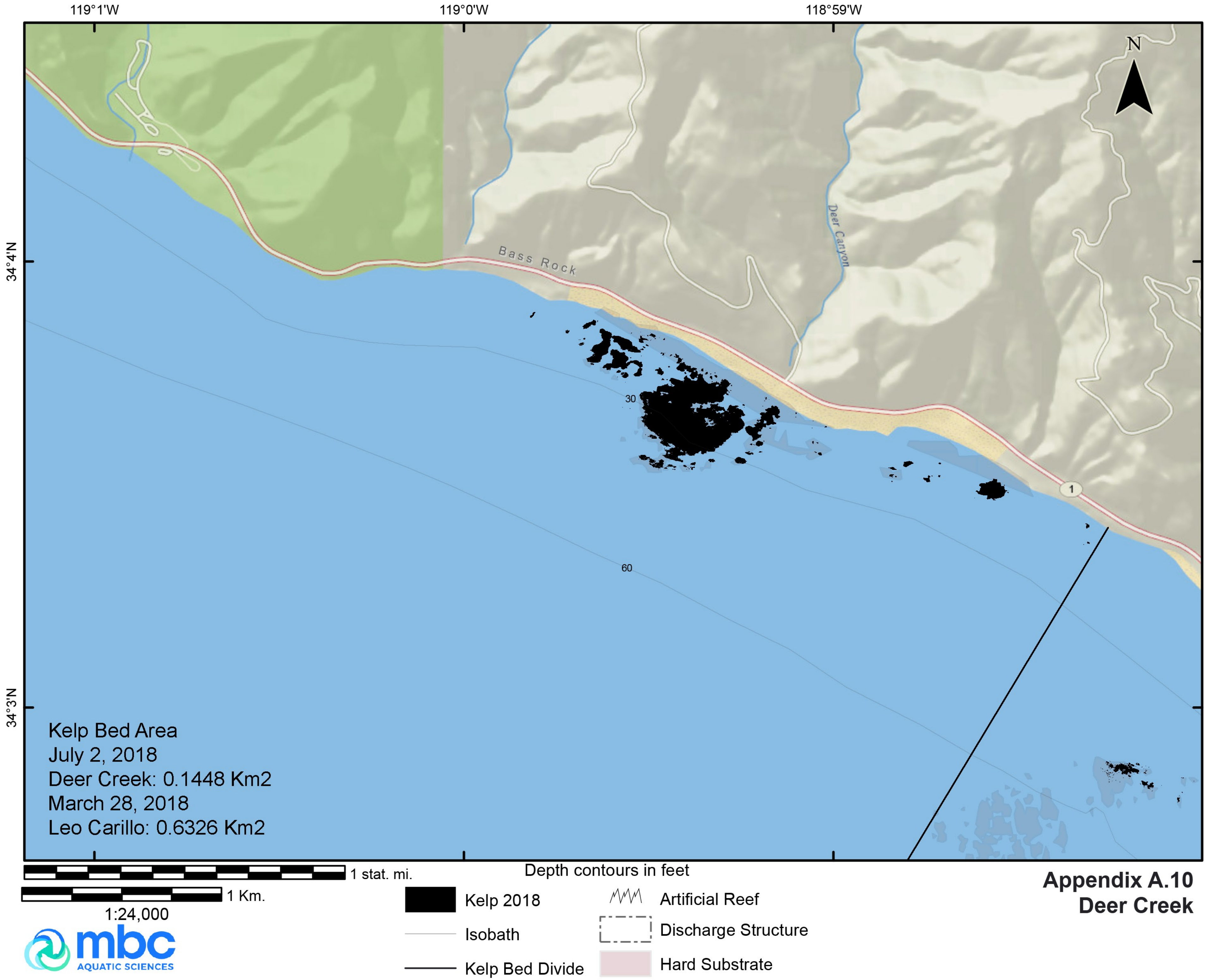
Appendix A.8
Mugu Coast and Point



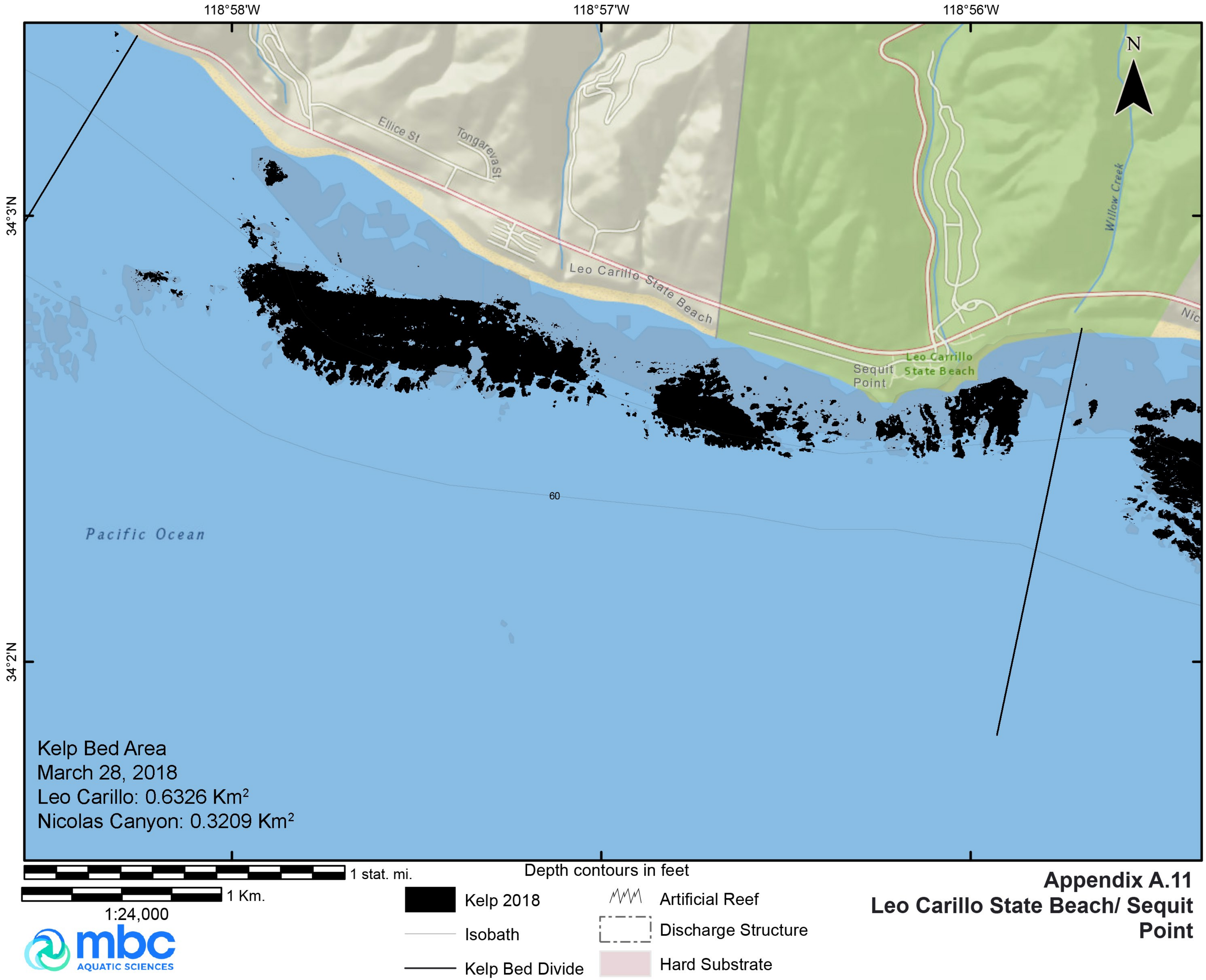
Kelp Bed Area
March 28, 2018
Point Mugu State Park: None

Appendix A.9
Mugu State Park

Appendix A.10
Deer Creek

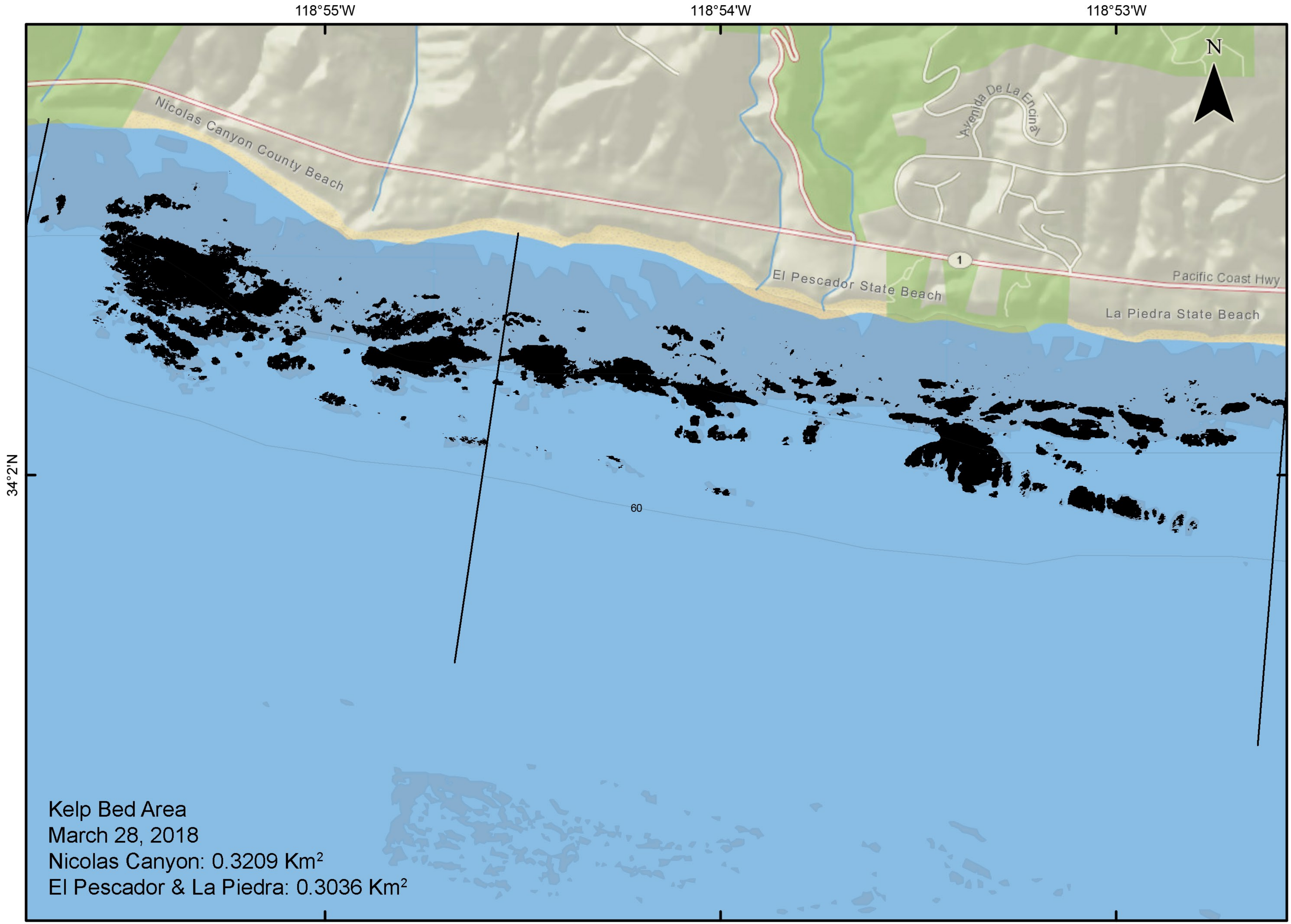


Kelp Bed Area
July 2, 2018
Deer Creek: 0.1448 Km2
March 28, 2018
Leo Carillo: 0.6326 Km2



Kelp Bed Area
March 28, 2018
Leo Carillo: 0.6326 Km^2
Nicolas Canyon: 0.3209 Km^2

Appendix A.11
Leo Carillo State Beach/ Sequit Point



Kelp Bed Area
March 28, 2018
Nicolas Canyon: 0.3209 Km^2
El Pescador & La Piedra: 0.3036 Km^2

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

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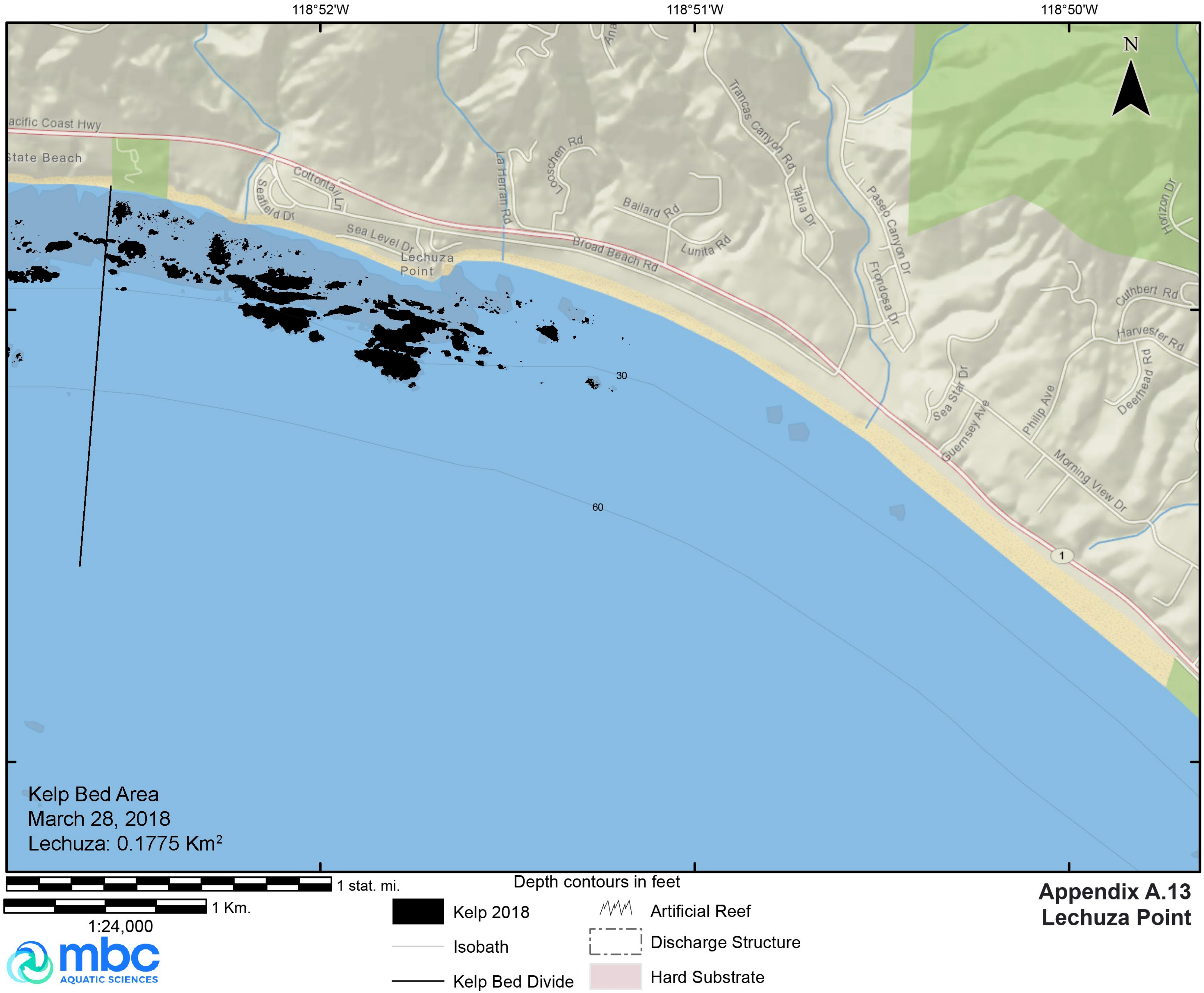
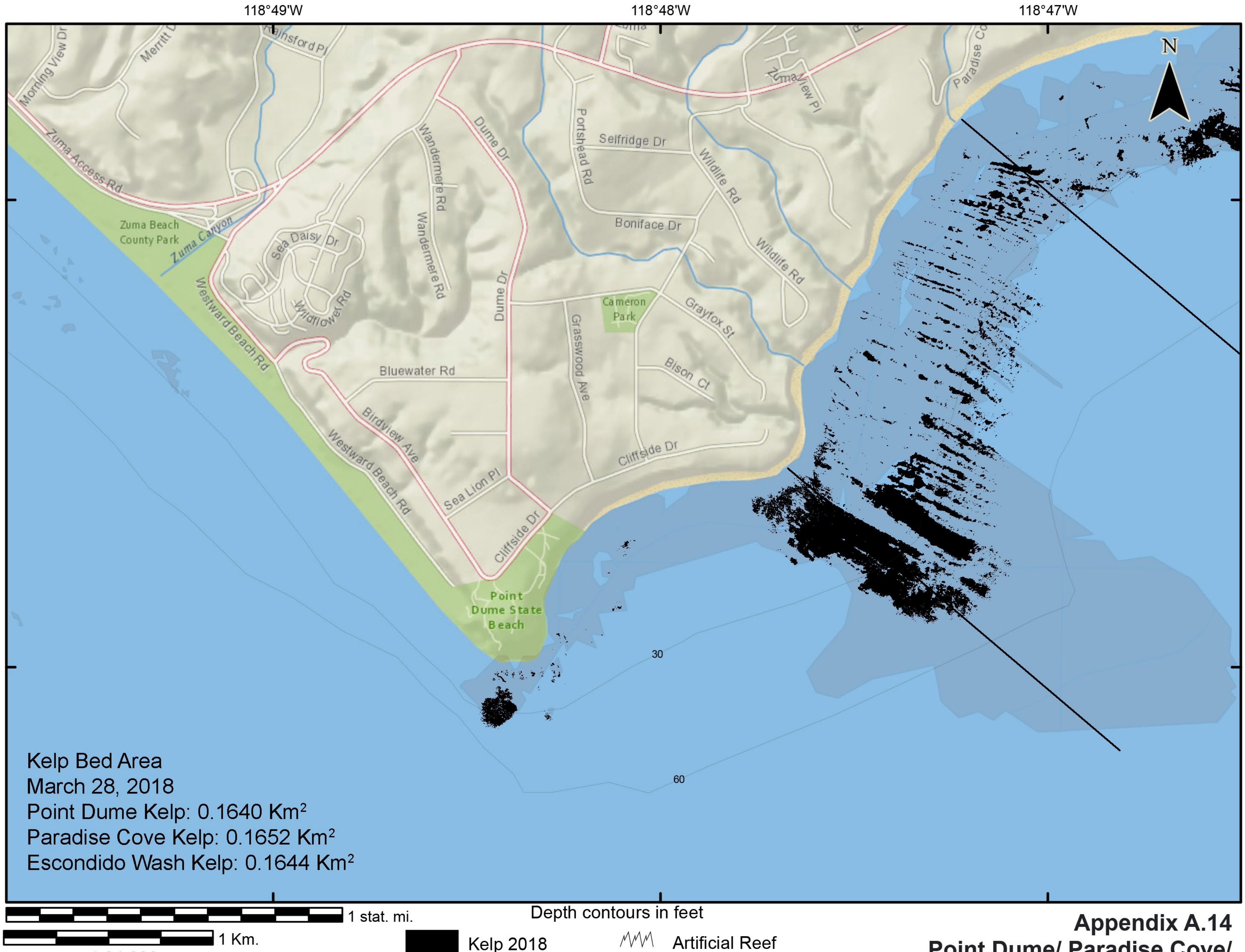
Appendix A.13
Lechuza Point



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



Kelp Bed Area
March 28, 2018
Point Dume Kelp: 0.1640 Km²
Paradise Cove Kelp: 0.1652 Km²
Escondido Wash Kelp: 0.1644 Km²

1:24,000

Depth contours in feet

■	Kelp 2018
―	Isobath
―	Kelp Bed Divide
/\/\/\	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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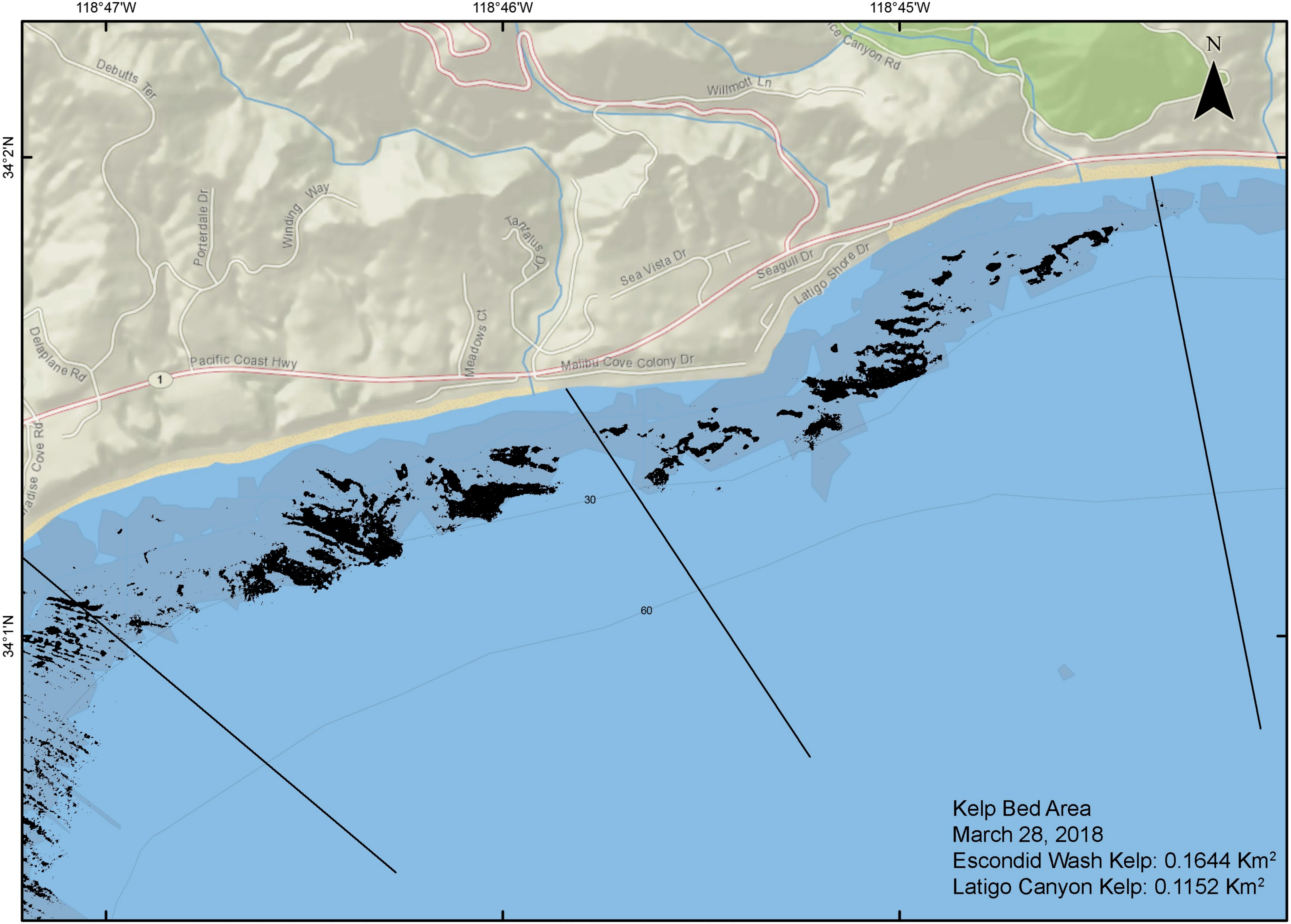
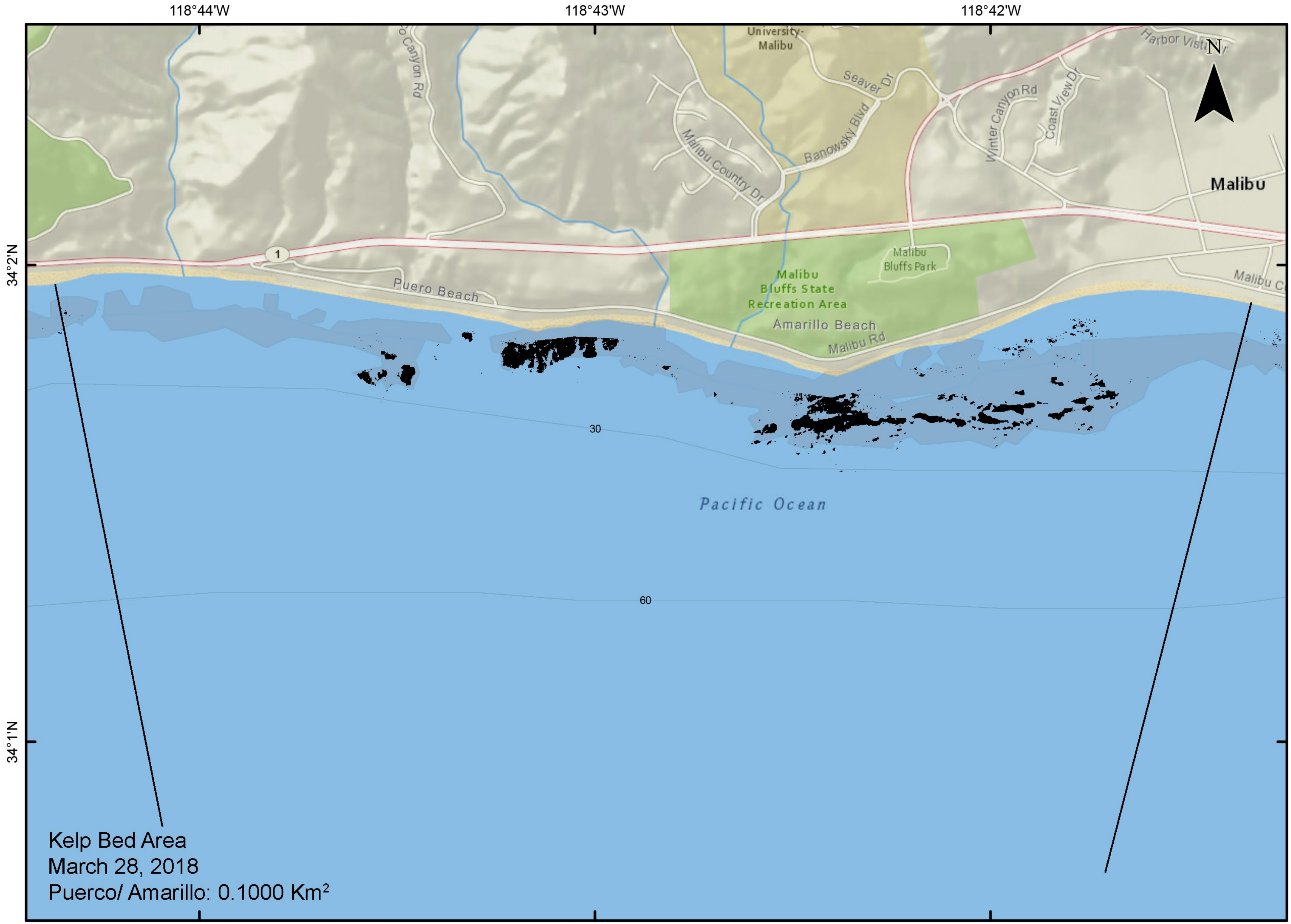


Kelp Bed Area
March 28, 2018
Escondid Wash Kelp: 0.1644 Km^2
Latigo Canyon Kelp: 0.1152 Km^2

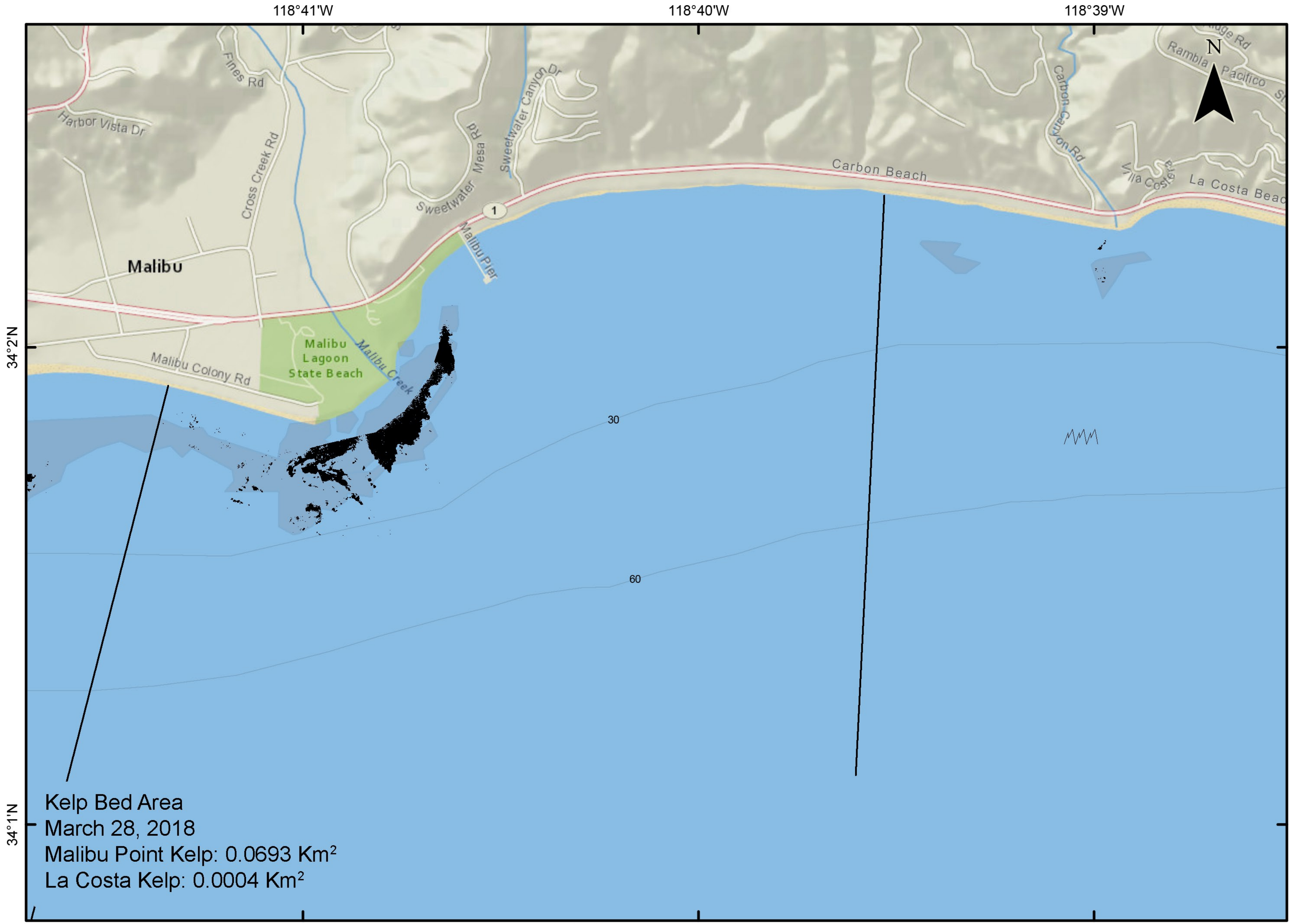
Appendix A.15
Escondido Wash/ Latigo Canyon



Kelp Bed Area
March 28, 2018
Puerco/ Amarillo: 0.1000 Km^2

- ■ Kelp 2018
- ─ Isobath
- ─ Kelp Bed Divide
- ⋀⋀⋀ Artificial Reef
- ⬚ Discharge Structure
- ▨ Hard Substrate

Appendix A.16
Puerco/ Amarillo Beach



Kelp Bed Area
March 28, 2018
Malibu Point Kelp: 0.0693 Km²
La Costa Kelp: 0.0004 Km²

1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

■ Kelp 2018

— Isobath

— Kelp Bed Divide

ΛΛΛ Artificial Reef

▭ Discharge Structure

▨ Hard Substrate

Appendix A.17
Malibu Point/ La Costa Beach

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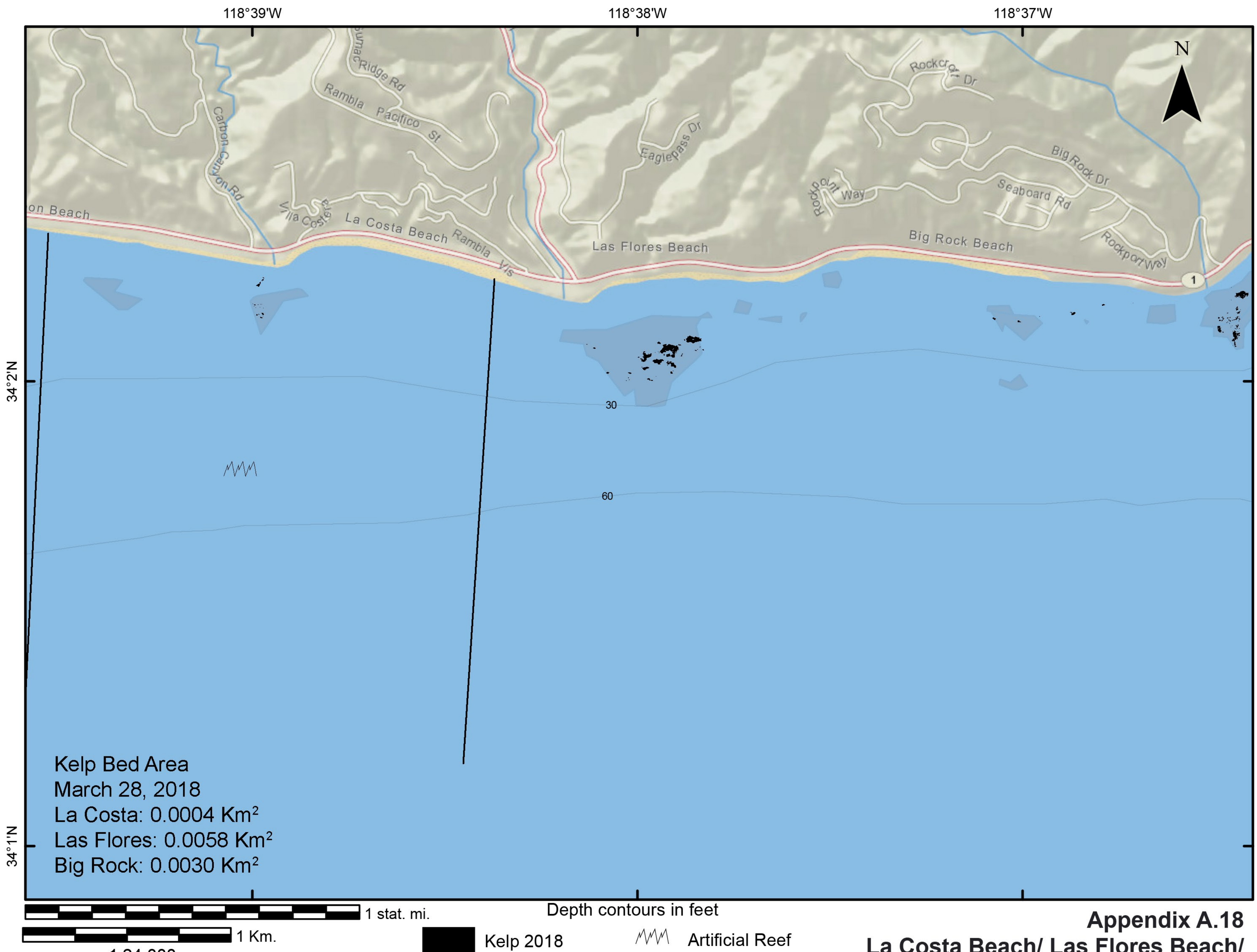


Kelp Bed Area
March 28, 2018
La Costa: 0.0004 Km^2
Las Flores: 0.0058 Km^2
Big Rock: 0.0030 Km^2

Depth contours in feet

■ Kelp 2018

― Isobath

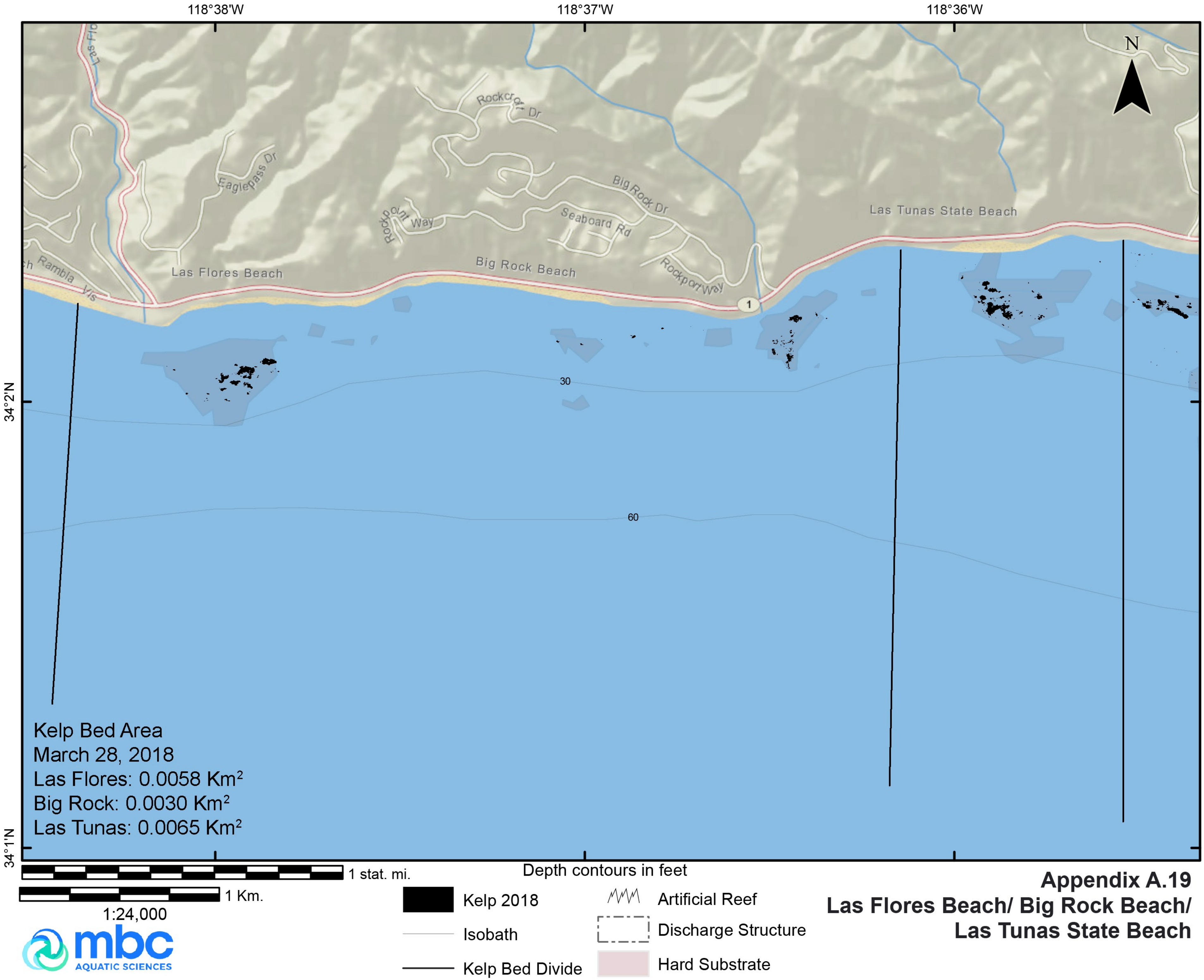
― Kelp Bed Divide

⋀⋀⋀ Artificial Reef

☐ Discharge Structure

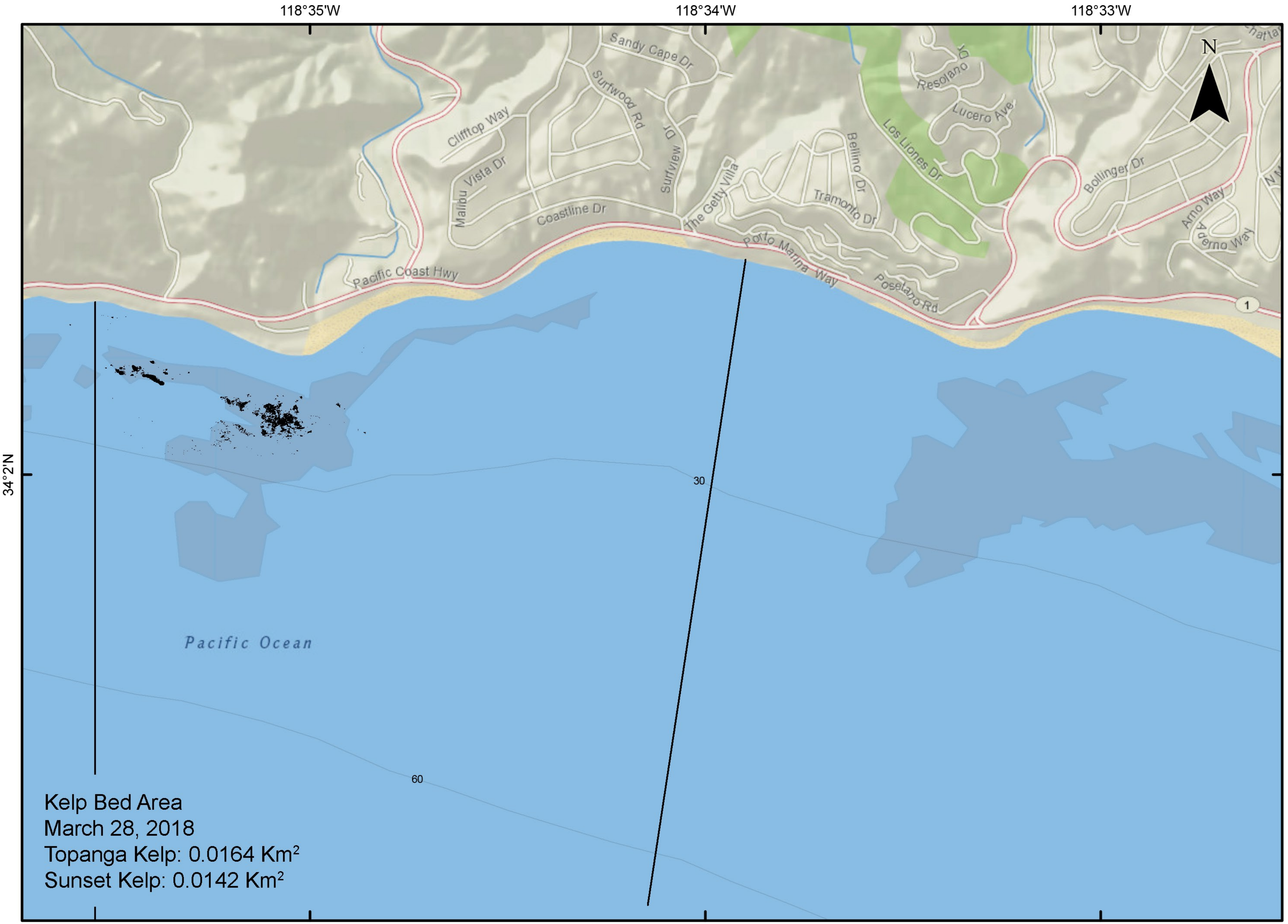
▨ Hard Substrate

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



Kelp Bed Area
March 28, 2018
Las Flores: 0.0058 Km^2
Big Rock: 0.0030 Km^2
Las Tunas: 0.0065 Km^2

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



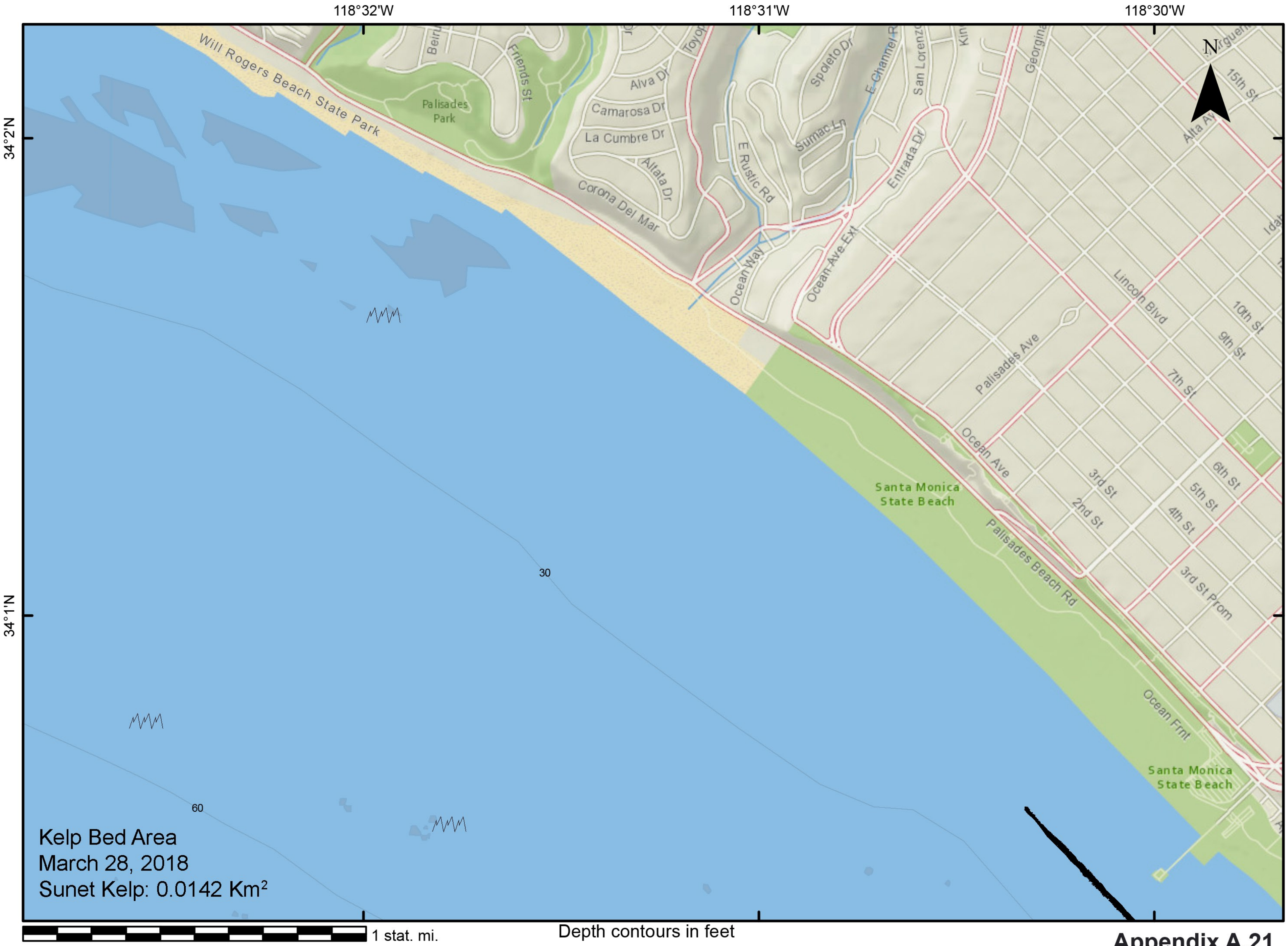
Kelp Bed Area
March 28, 2018
Topanga Kelp: 0.0164 Km^2
Sunset Kelp: 0.0142 Km^2

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

Depth contours in feet

■ Kelp 2018
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.20
Topanga Canyon Rd/ Sunset Blvd



Kelp Bed Area
March 28, 2018
Sunet Kelp: 0.0142 Km^2

Depth contours in feet

■	Kelp 2018
―	Isobath
―	Kelp Bed Divide
/\/\/\/\	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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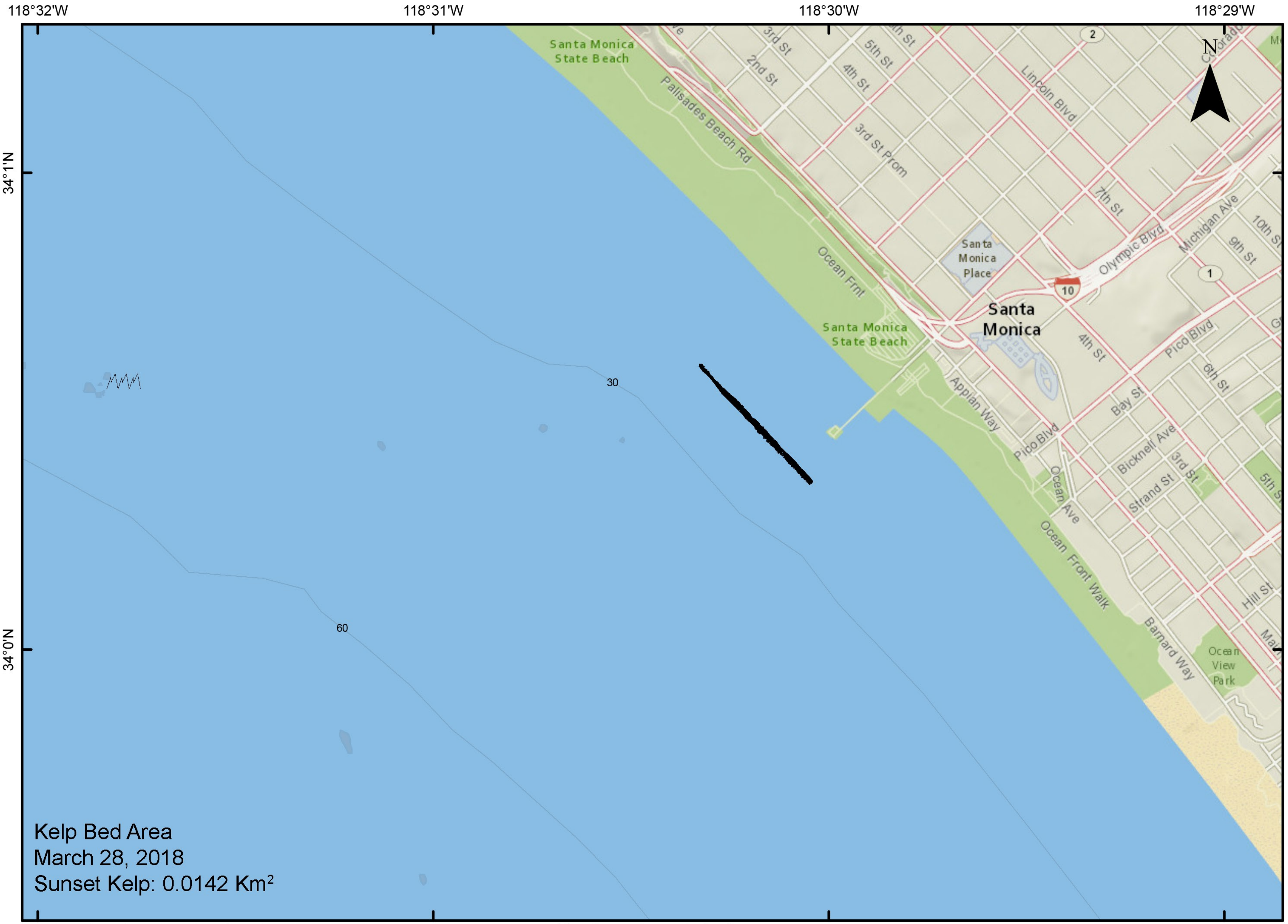
Appendix A.21
Sunset



Kelp Bed Area
March 28, 2018
Sunset Kelp: 0.0142 Km^2

1 stat. mi.

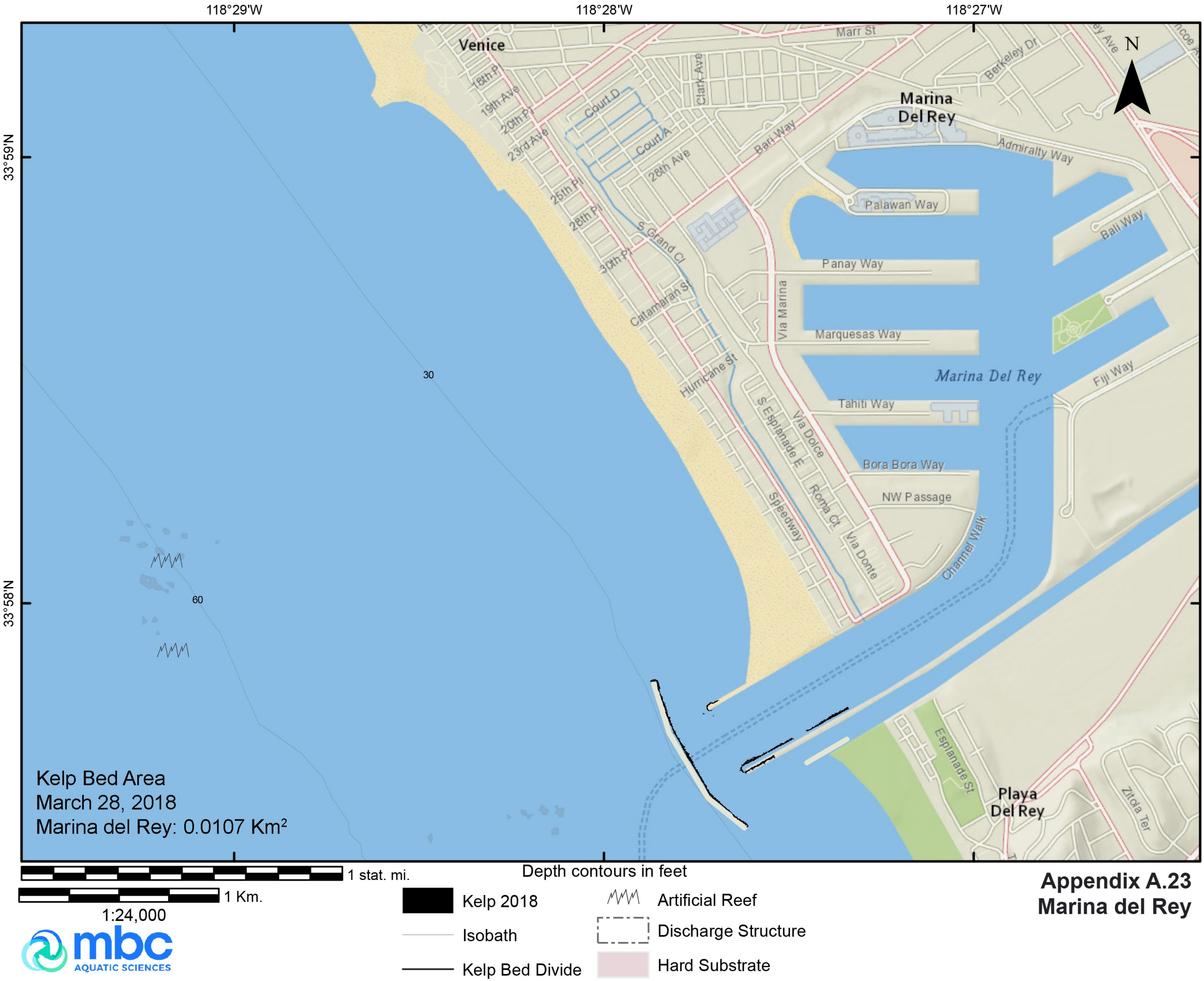
1 Km.

1:24,000

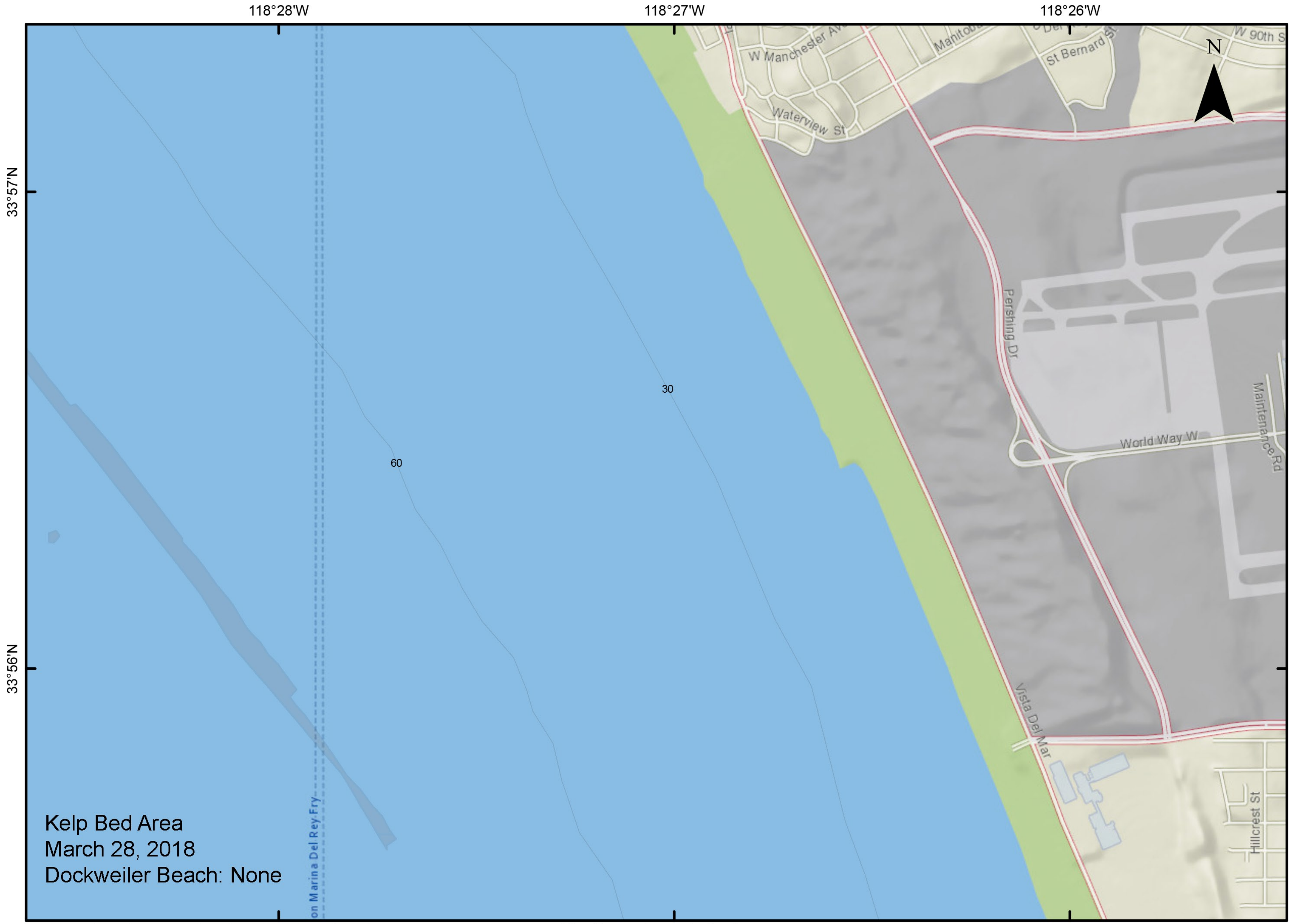
Depth contours in feet

■	Kelp 2018
─	Isobath
━	Kelp Bed Divide
⋀⋀⋀	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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



Appendix A.23
Marina del Rey



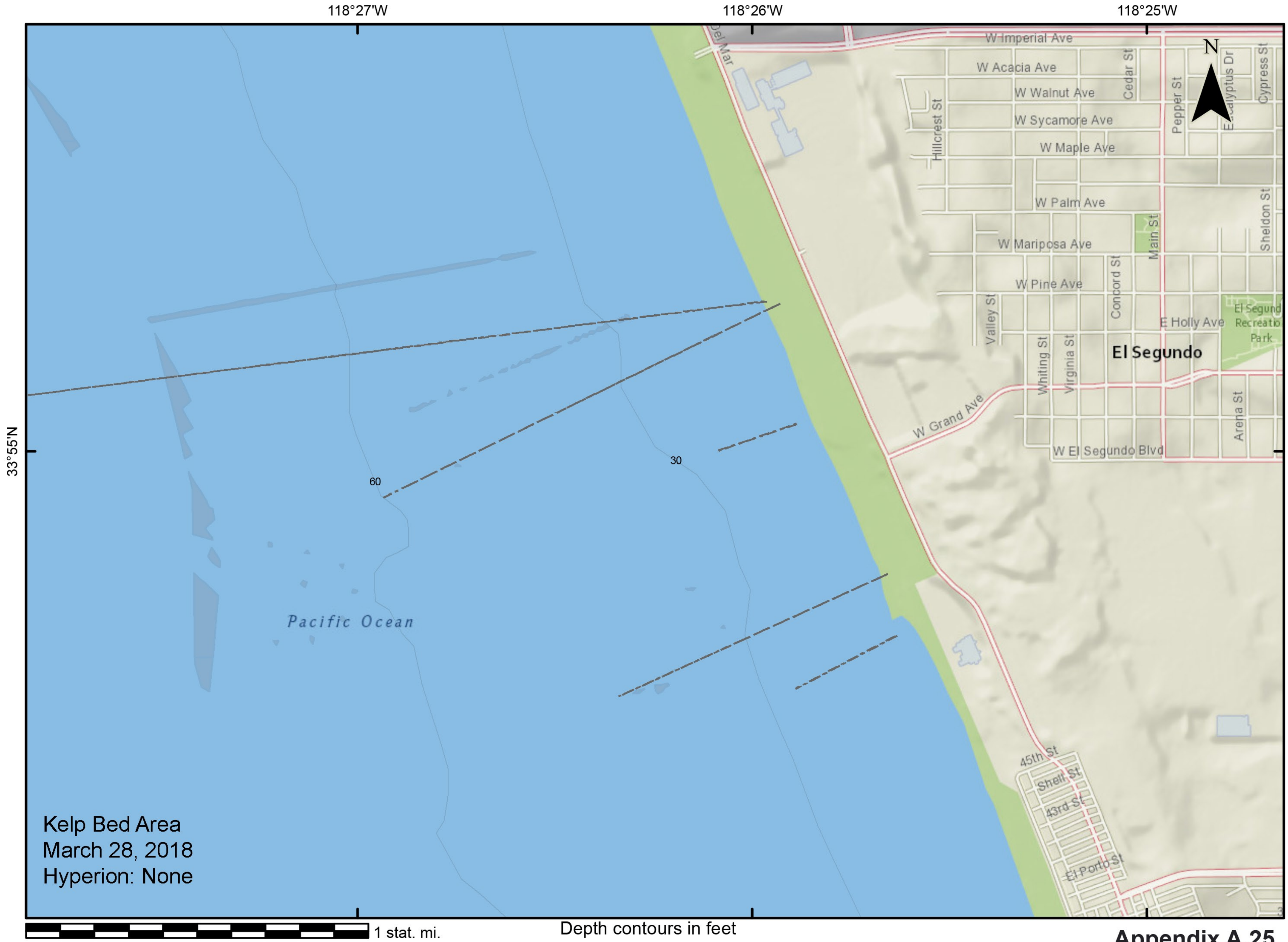
Kelp Bed Area
March 28, 2018
Dockweiler Beach: None

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

Depth contours in feet

■ Kelp 2018
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
▨ Hard Substrate

Appendix A.24
Dockweiler Beach



Kelp Bed Area
March 28, 2018
Hyperion: None

■ Kelp 2018
― Isobath
― Kelp Bed Divide
ʌʌʌ Artificial Reef
⌐ ¬ Discharge Structure
▨ Hard Substrate

Appendix A.25
Hyperion

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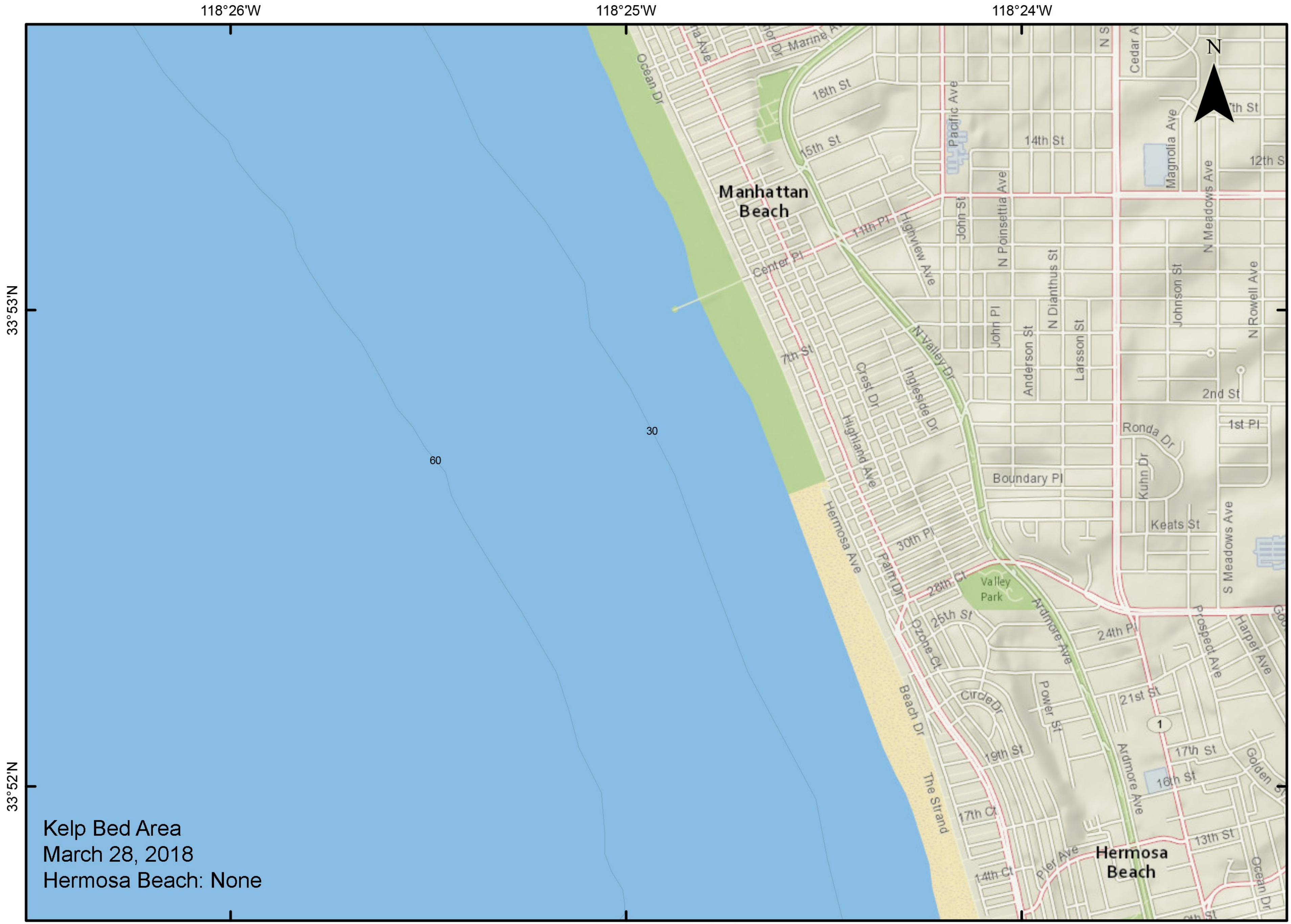


Kelp Bed Area
March 28, 2018
Hermosa Beach: None

1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

■ Kelp 2018

— Isobath

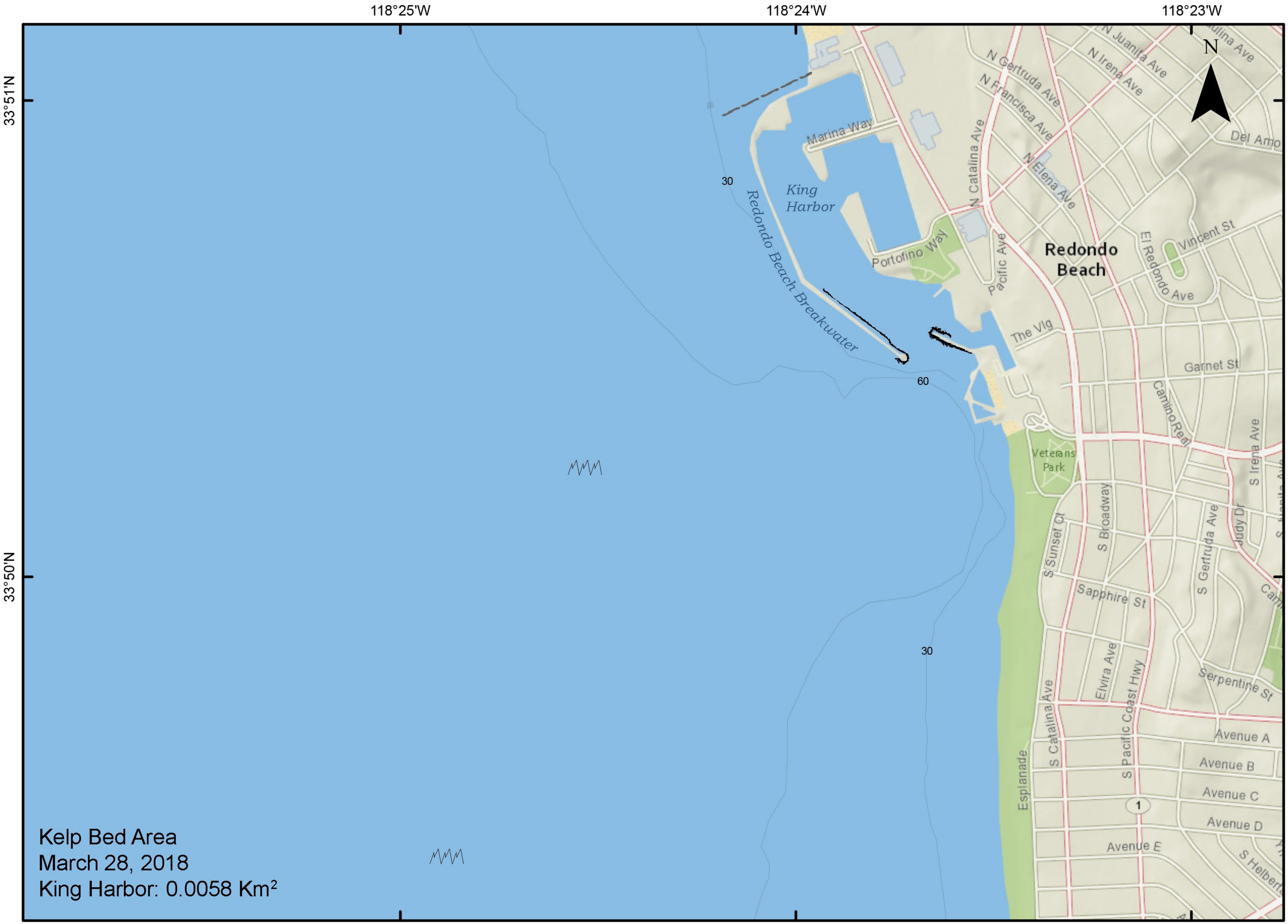
— Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.26
Hermosa Beach



Kelp Bed Area
March 28, 2018
King Harbor: 0.0058 Km^2

Depth contours in feet

■ Kelp 2018	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

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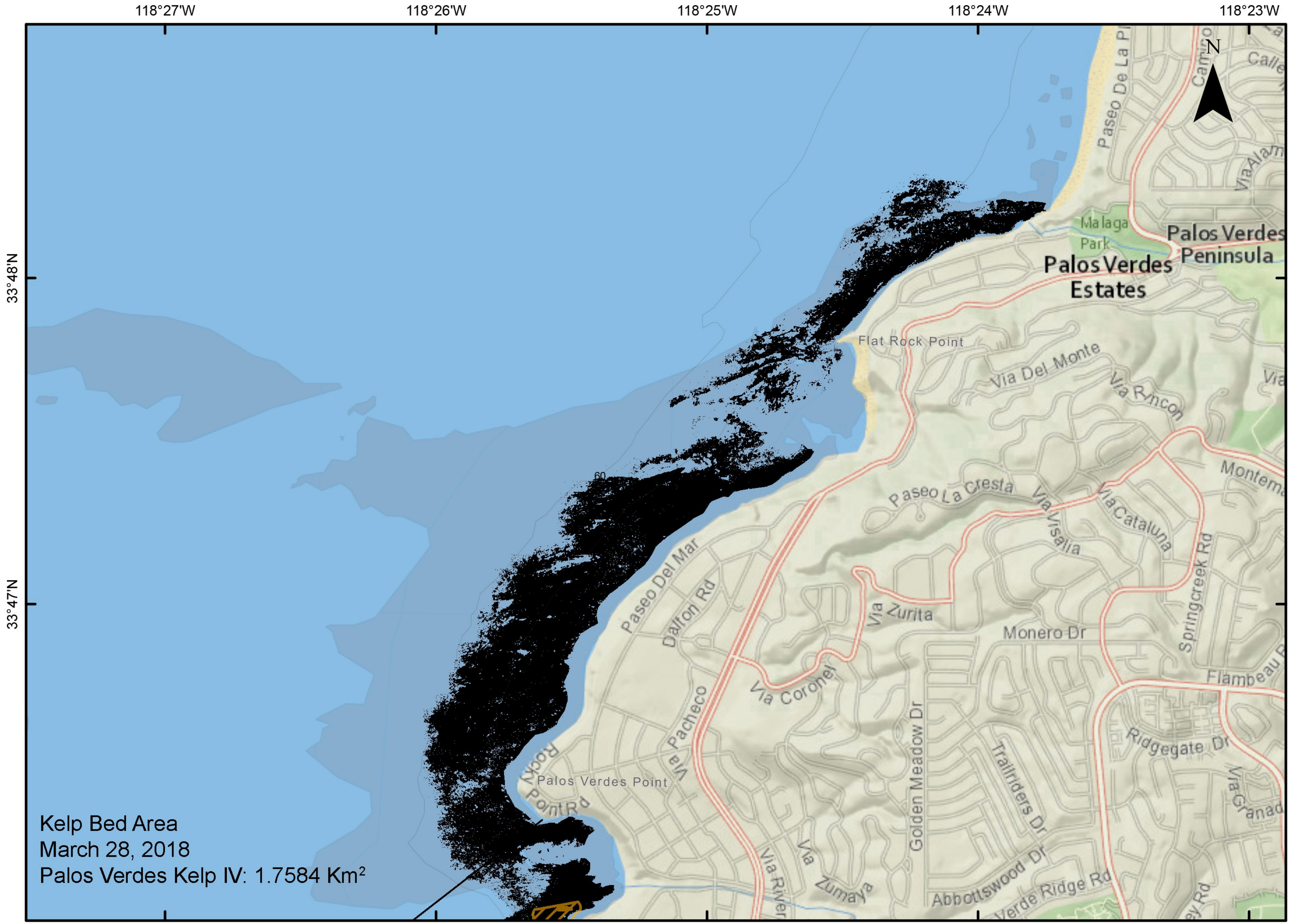
Appendix A.27
King Harbor



Kelp Bed Area
March 28, 2018
Palos Verdes Kelp IV: 1.7584 Km^2

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

Depth contours in feet

- ■ Kelp 2018
- — Isobath
- — Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

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

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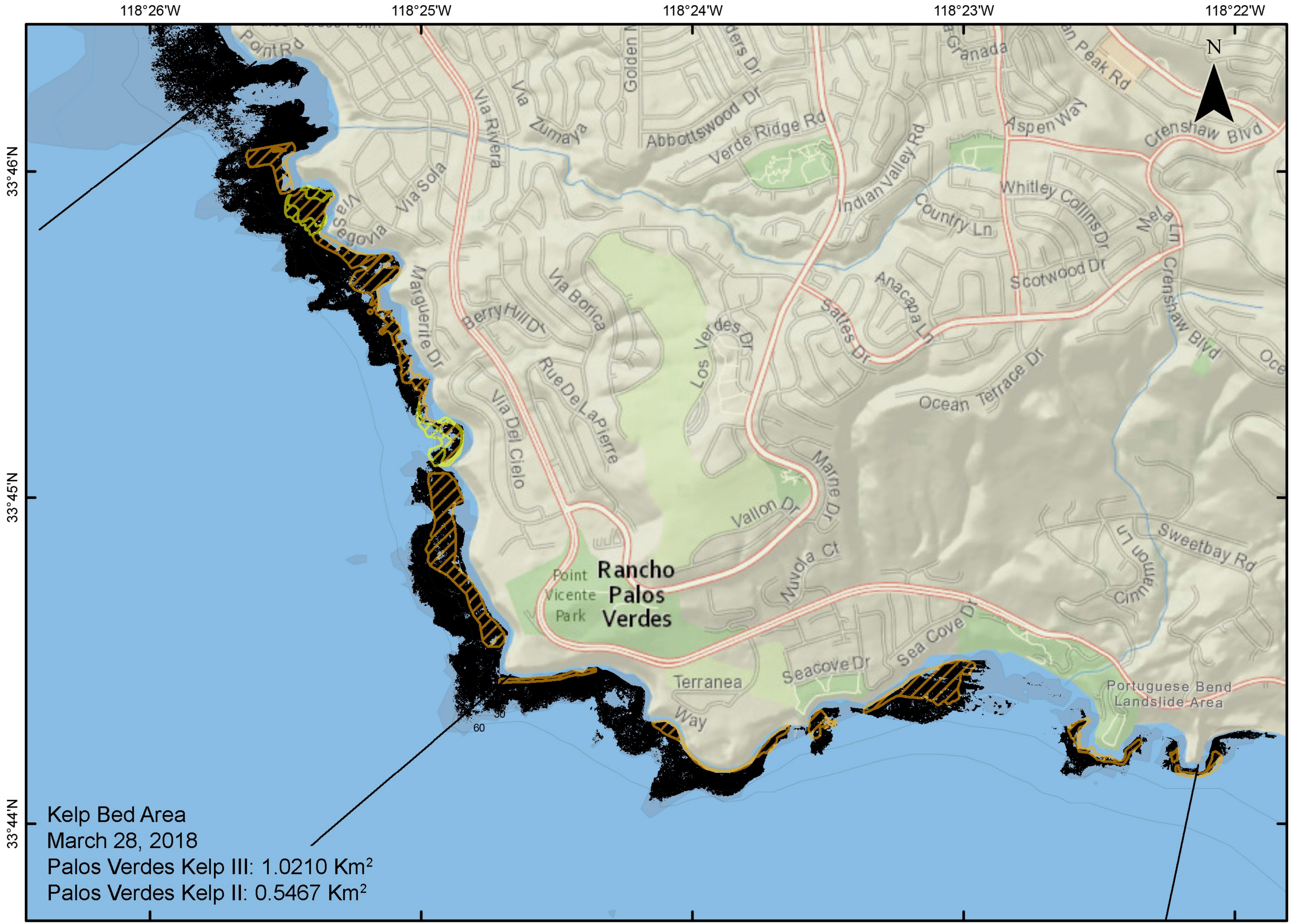
Appendix A.28
Palos Verdes Kelp IV

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



Kelp Bed Area
March 28, 2018
Palos Verdes Kelp III: 1.0210 Km²
Palos Verdes Kelp II: 0.5467 Km²

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

Depth contours in feet

■	Kelp 2018		Artificial Reef	Urchin Barrens	
—	Isobath	☐	Discharge Structure	▨	2013 extent (observed)
—	Kelp Bed Divide	■	Hard Substrate	▨	2010 extent (mapped)

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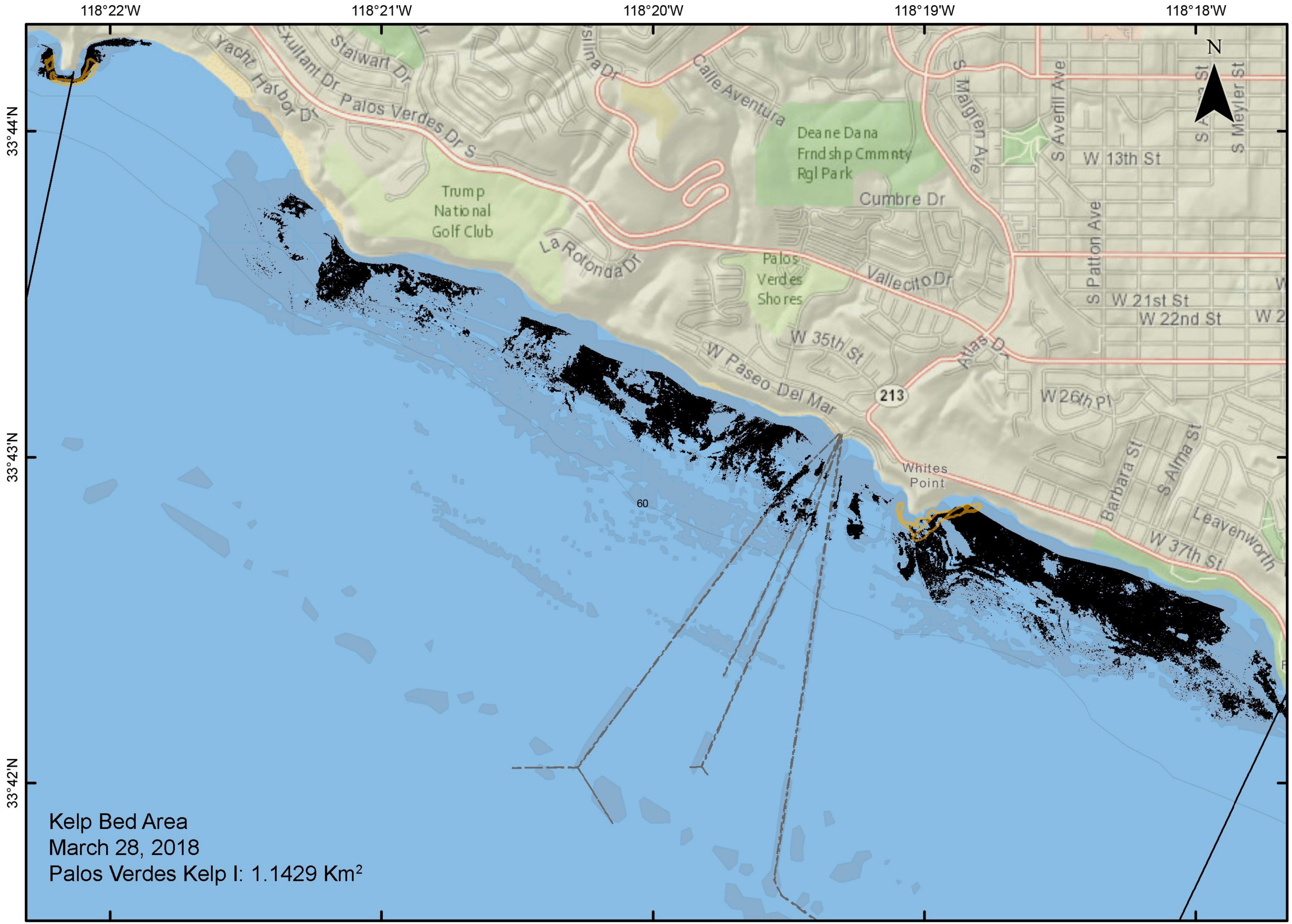

Kelp Bed Area
March 28, 2018
Palos Verdes Kelp I: 1.1429 Km^2

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

Depth contours in feet

■ Kelp 2018
Isobath
Kelp Bed Divide

Artificial Reef
Discharge Structure
Hard Substrate

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

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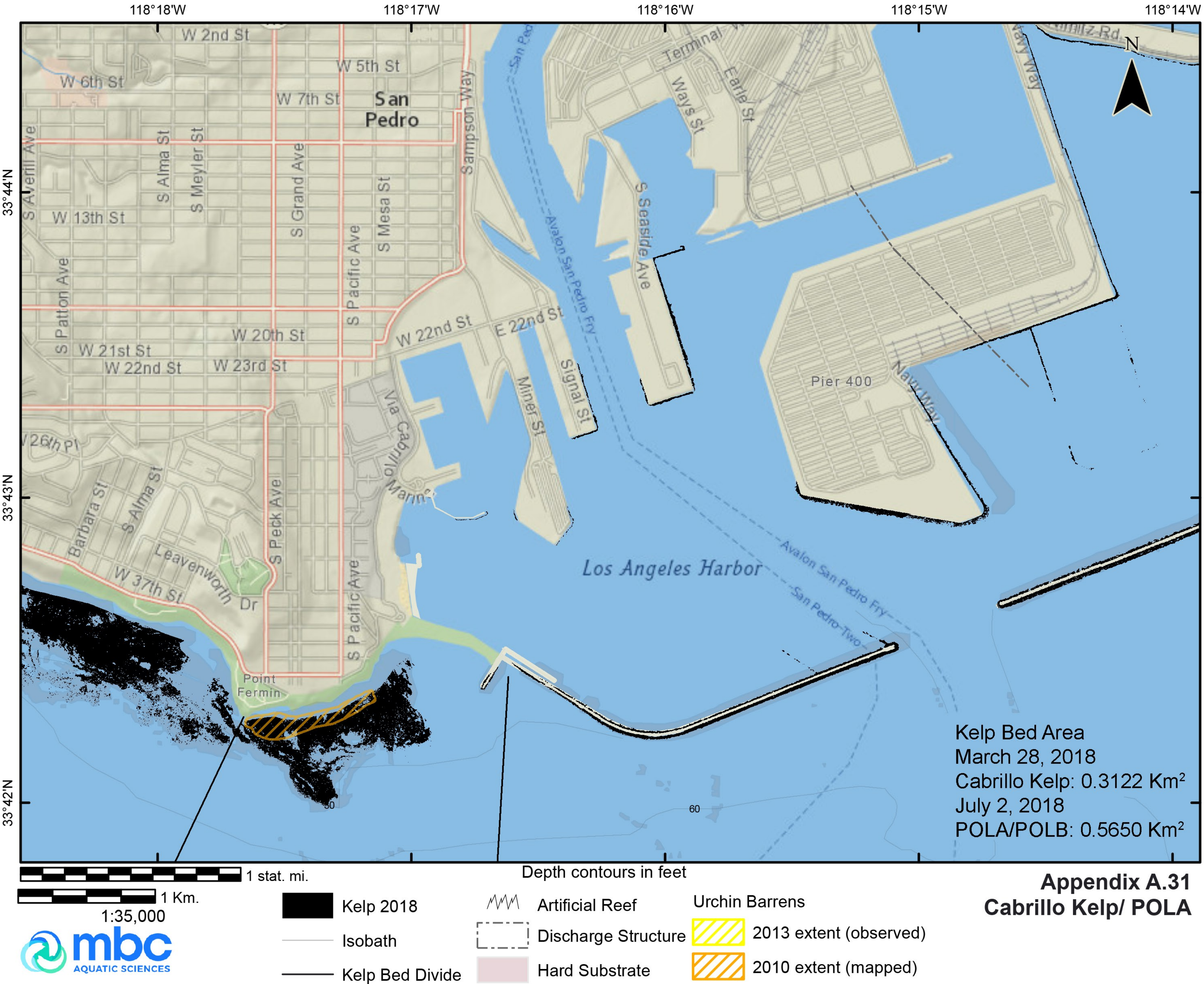
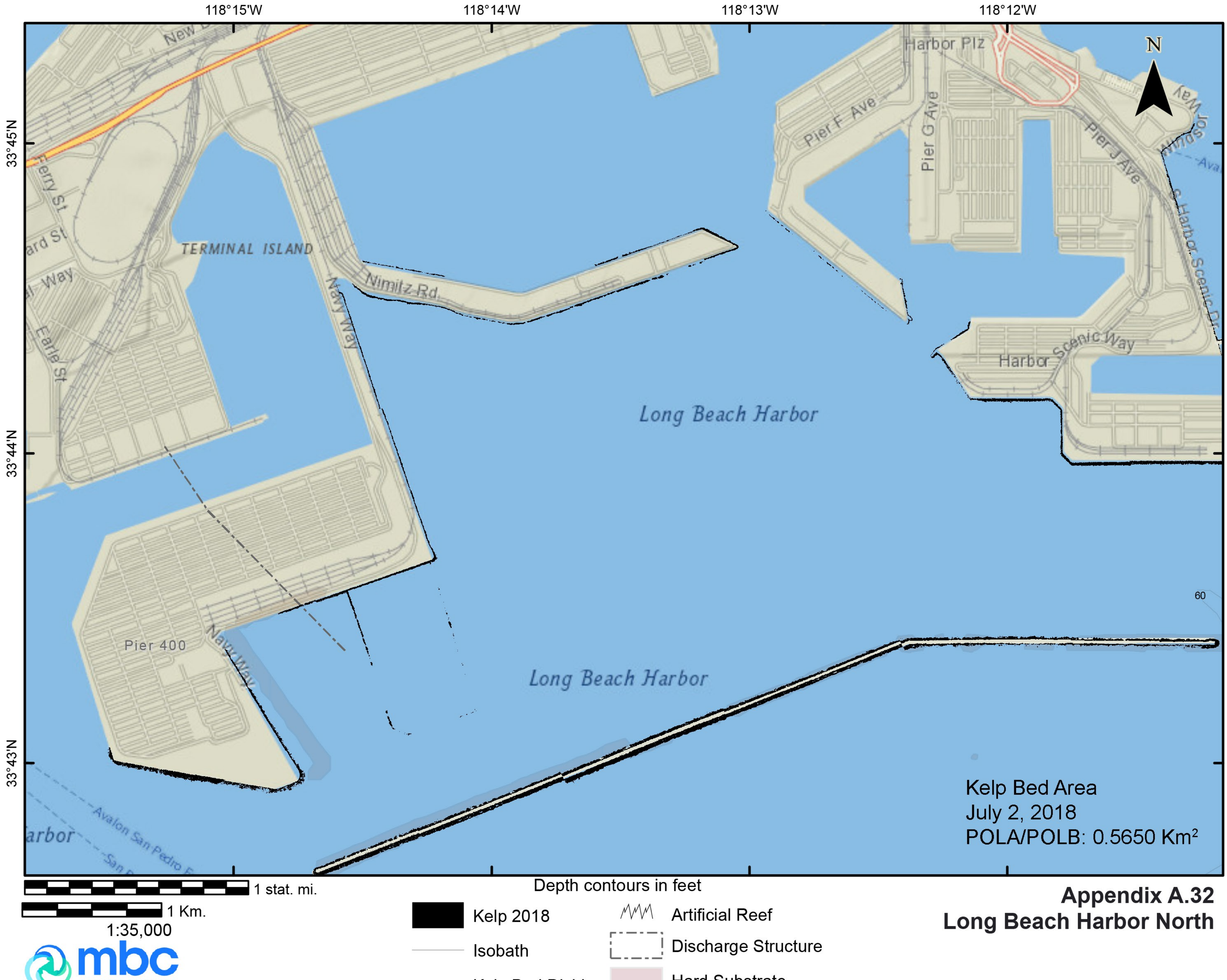
Appendix A.30
Palos Verdes I (Whites Point)



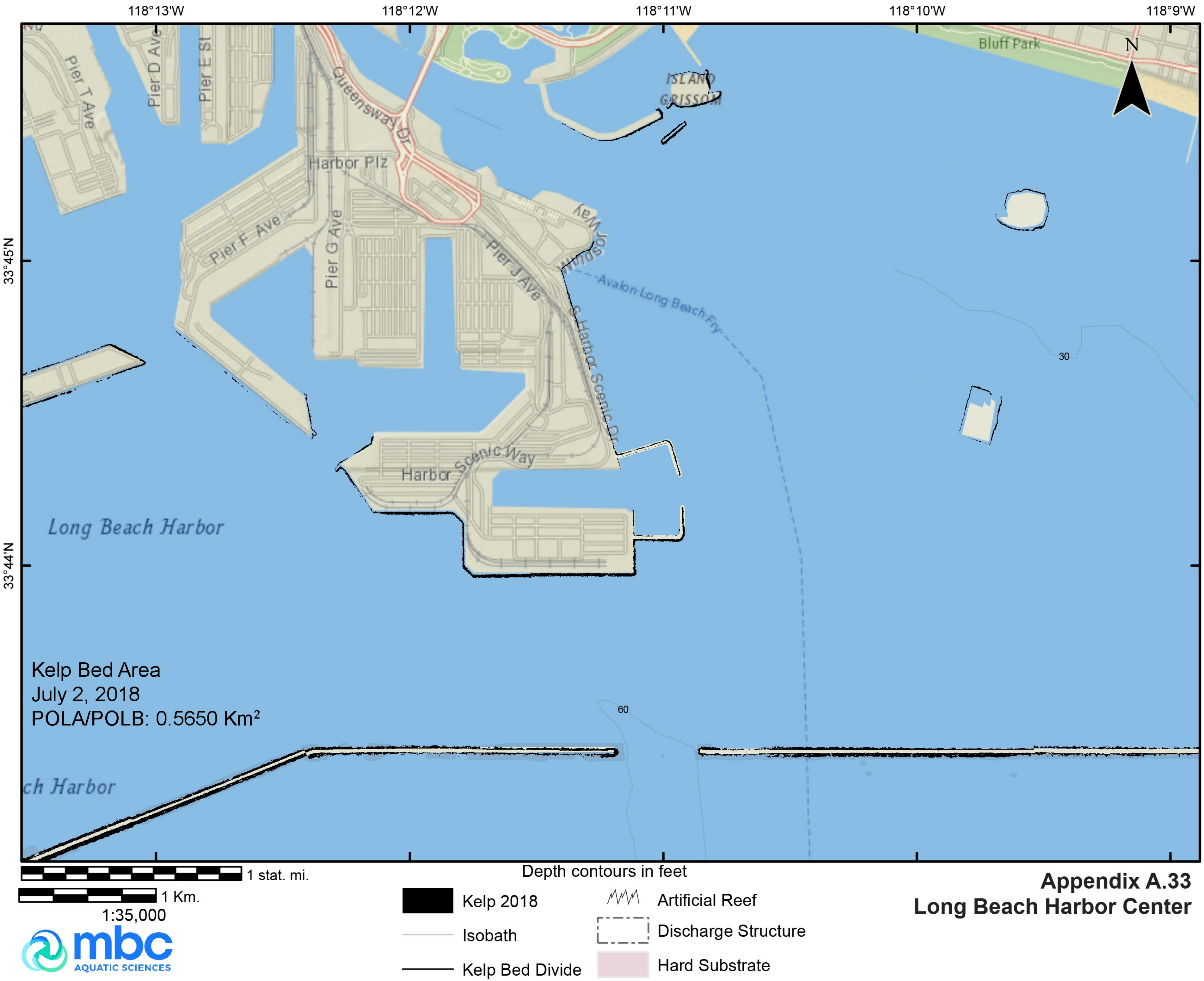
Kelp Bed Area
March 28, 2018
Cabrillo Kelp: 0.3122 Km^2
July 2, 2018
POLA/POLB: 0.5650 Km^2

Appendix A.31
Cabrillo Kelp/ POLA



Kelp Bed Area
July 2, 2018
POLA/POLB: 0.5650 Km^2

Appendix A.32
Long Beach Harbor North



Kelp Bed Area
July 2, 2018
POLA/POLB: 0.5650 Km^2

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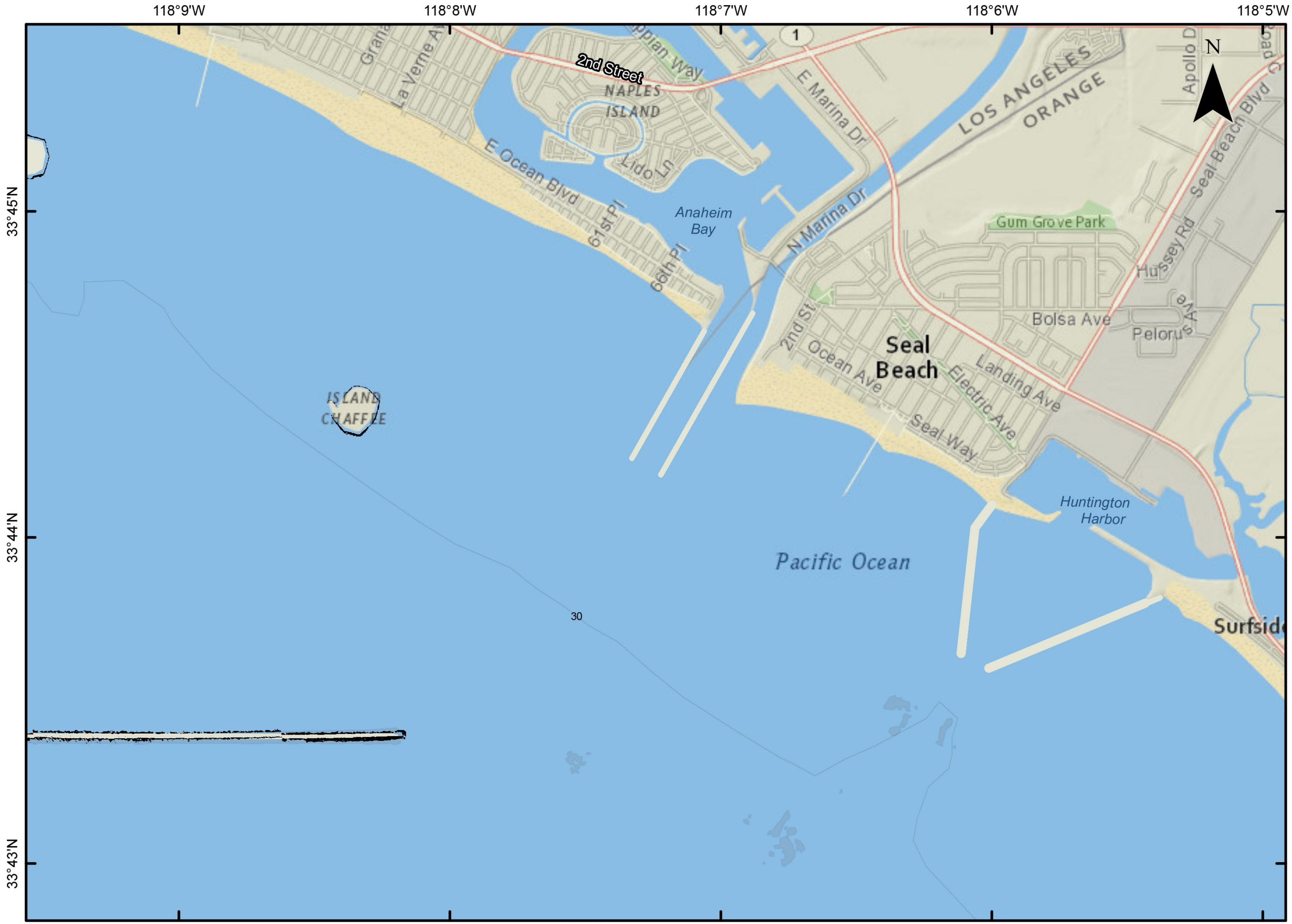
Appendix A.33
Long Beach Harbor Center



Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
/\/\/\	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

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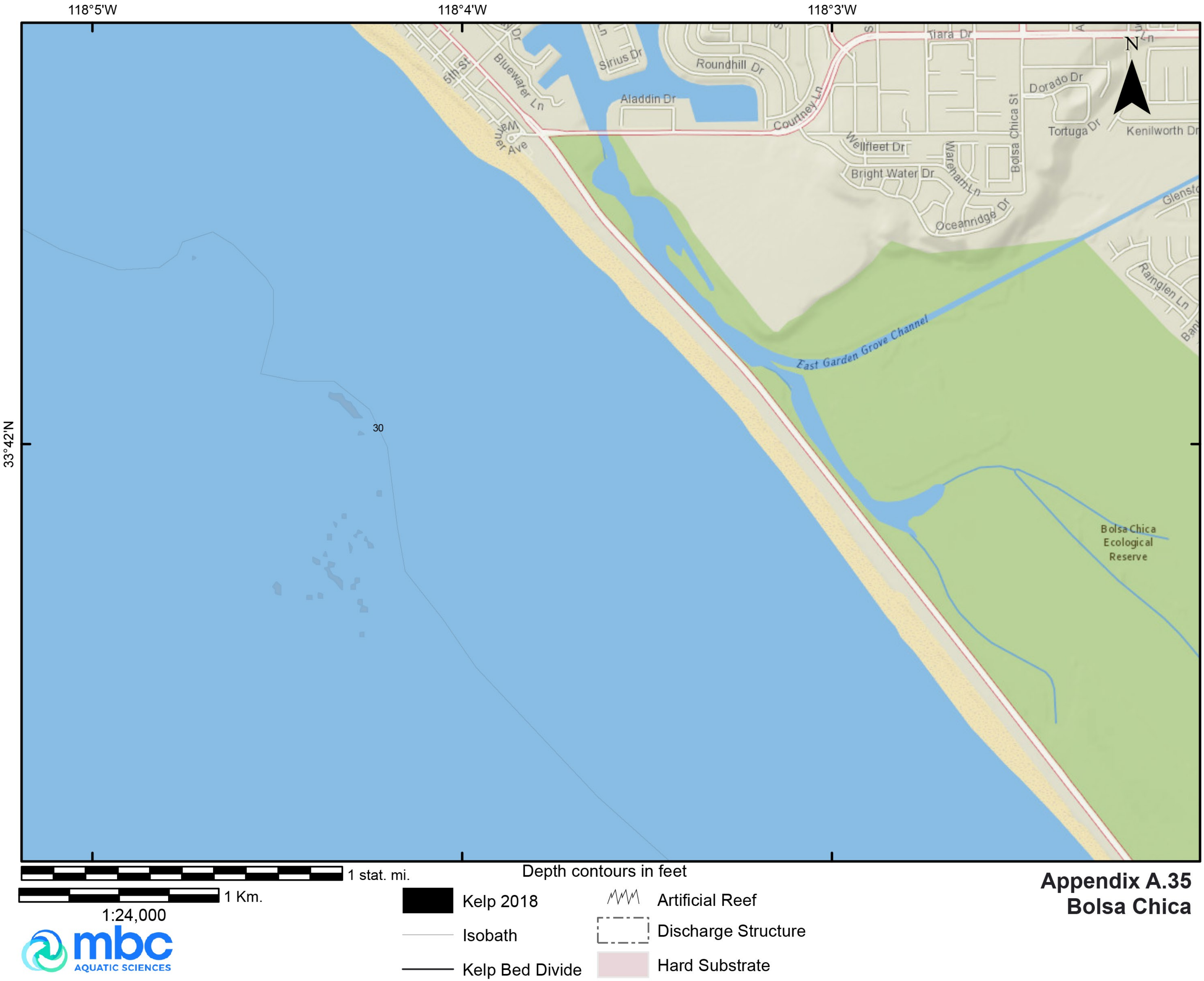
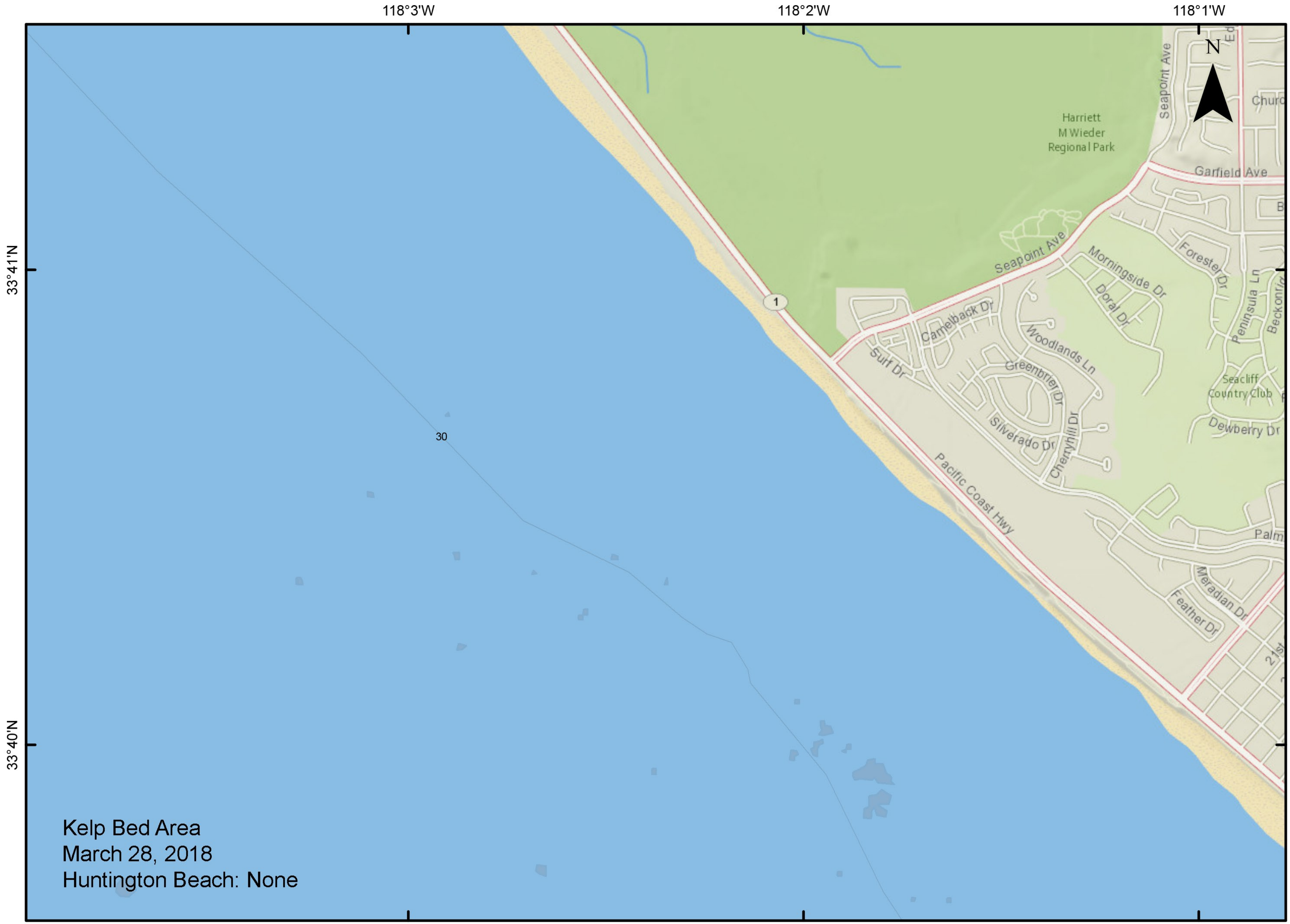
Appendix A.34
Long Beach Harbor South

Appendix A.35
Bolsa Chica





Kelp Bed Area
March 28, 2018
Huntington Beach: None

1 stat. mi.

1 Km.

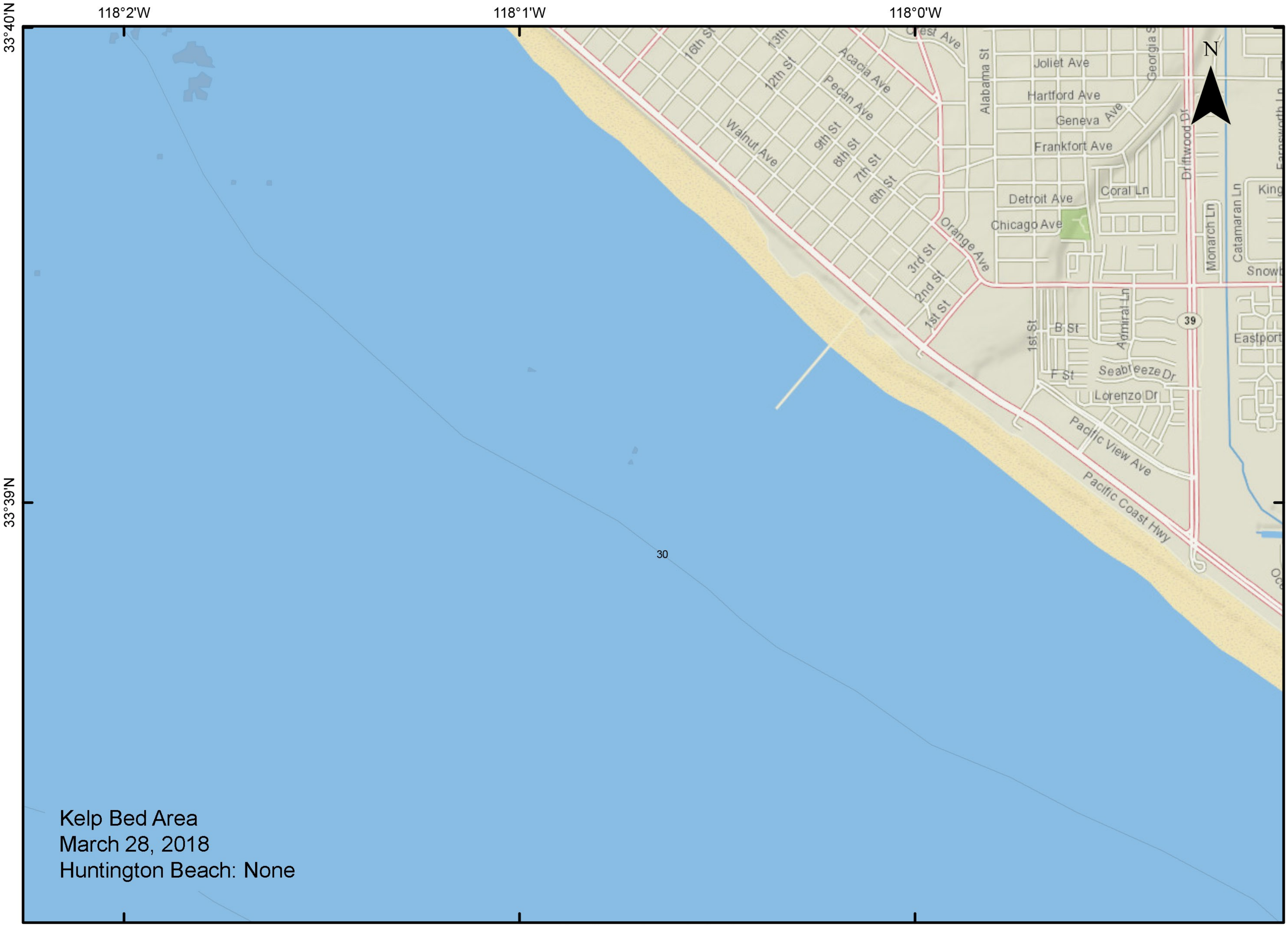
1:24,000

Depth contours in feet

■	Kelp 2018	/\/\/\	Artificial Reef
—	Isobath	┆	Discharge Structure
—	Kelp Bed Divide	▨	Hard Substrate

mbc
AQUATIC SCIENCES

Appendix A.36
Huntington Beach



1 stat. mi.

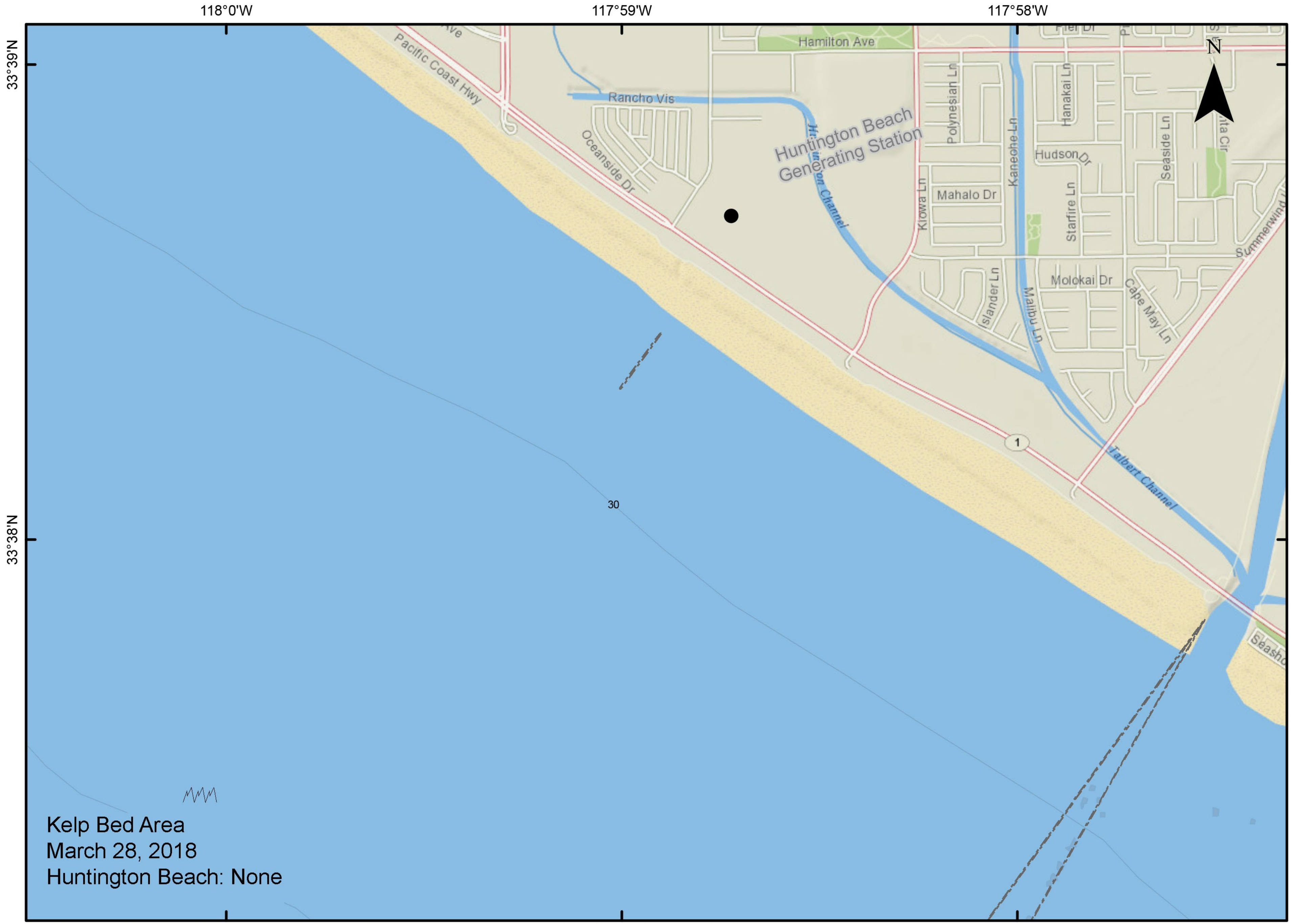
1 Km.

1:24,000

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
/\/\/\	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

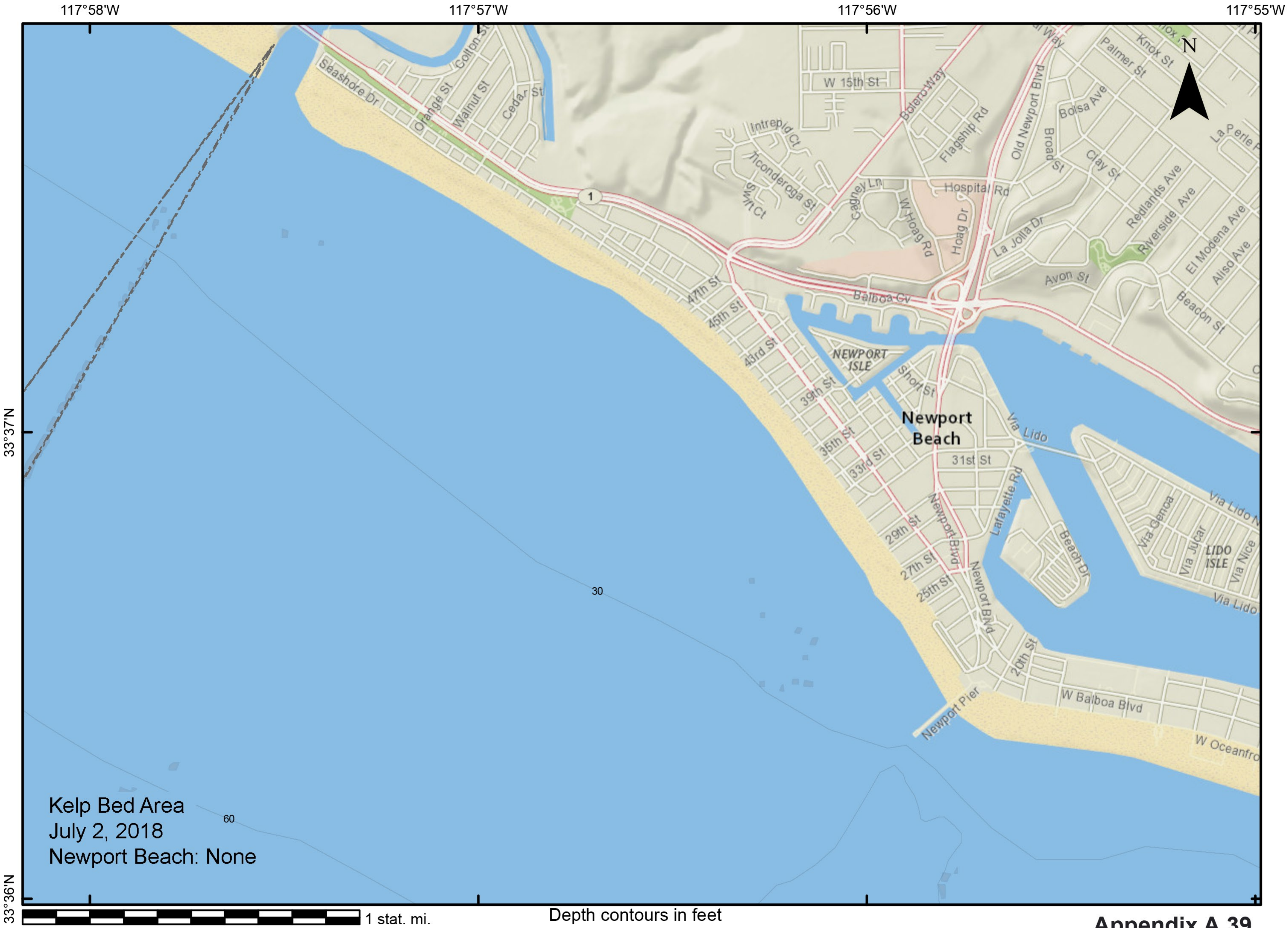
Appendix A.37
Huntington Beach Pier



Kelp Bed Area
March 28, 2018
Huntington Beach: None

Appendix A.38
Huntington Beach Generating Station

Appendix A.39
Newport Beach



Kelp Bed Area
July 2, 2018
Newport Beach: None

1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

■ Kelp 2018

Isobath

Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

mbc
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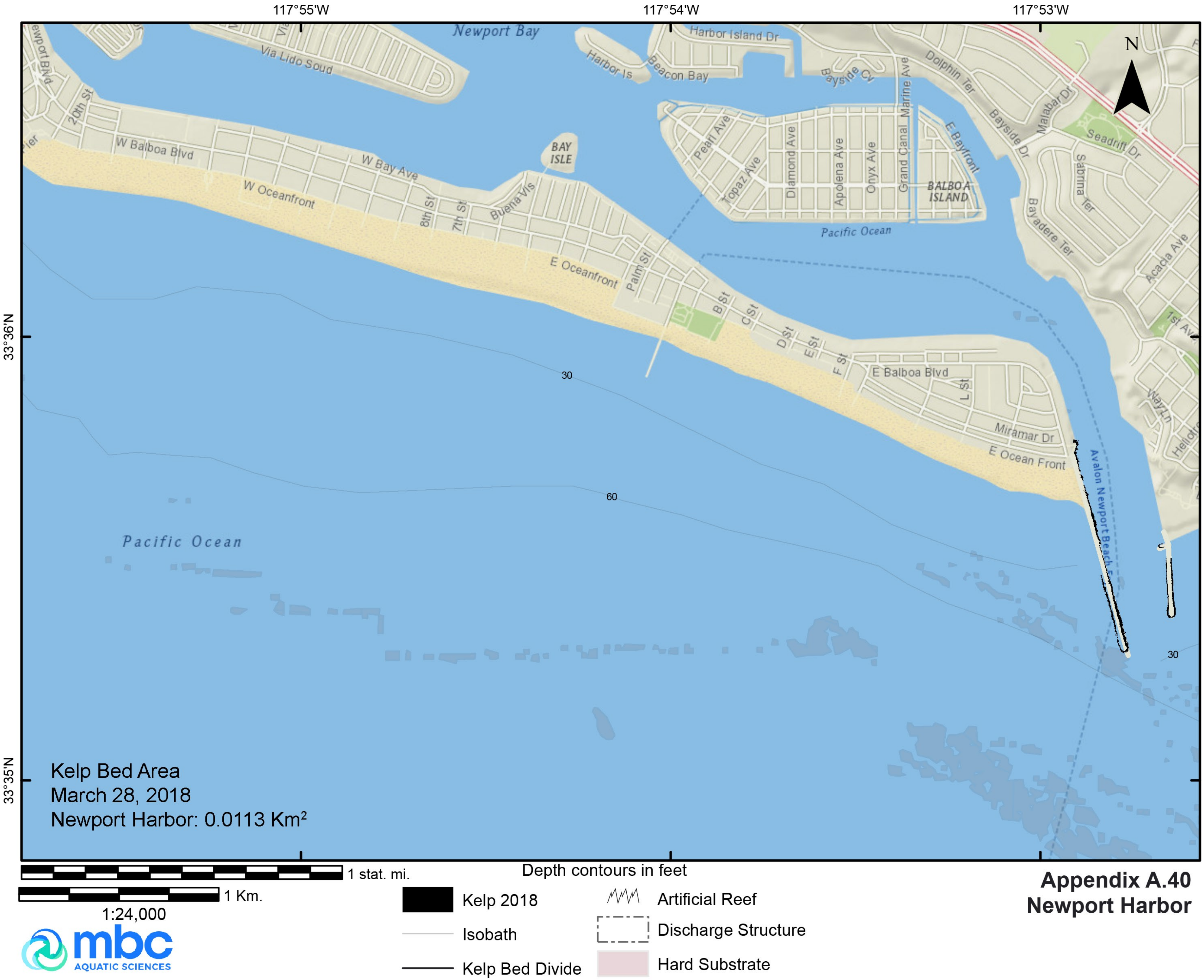
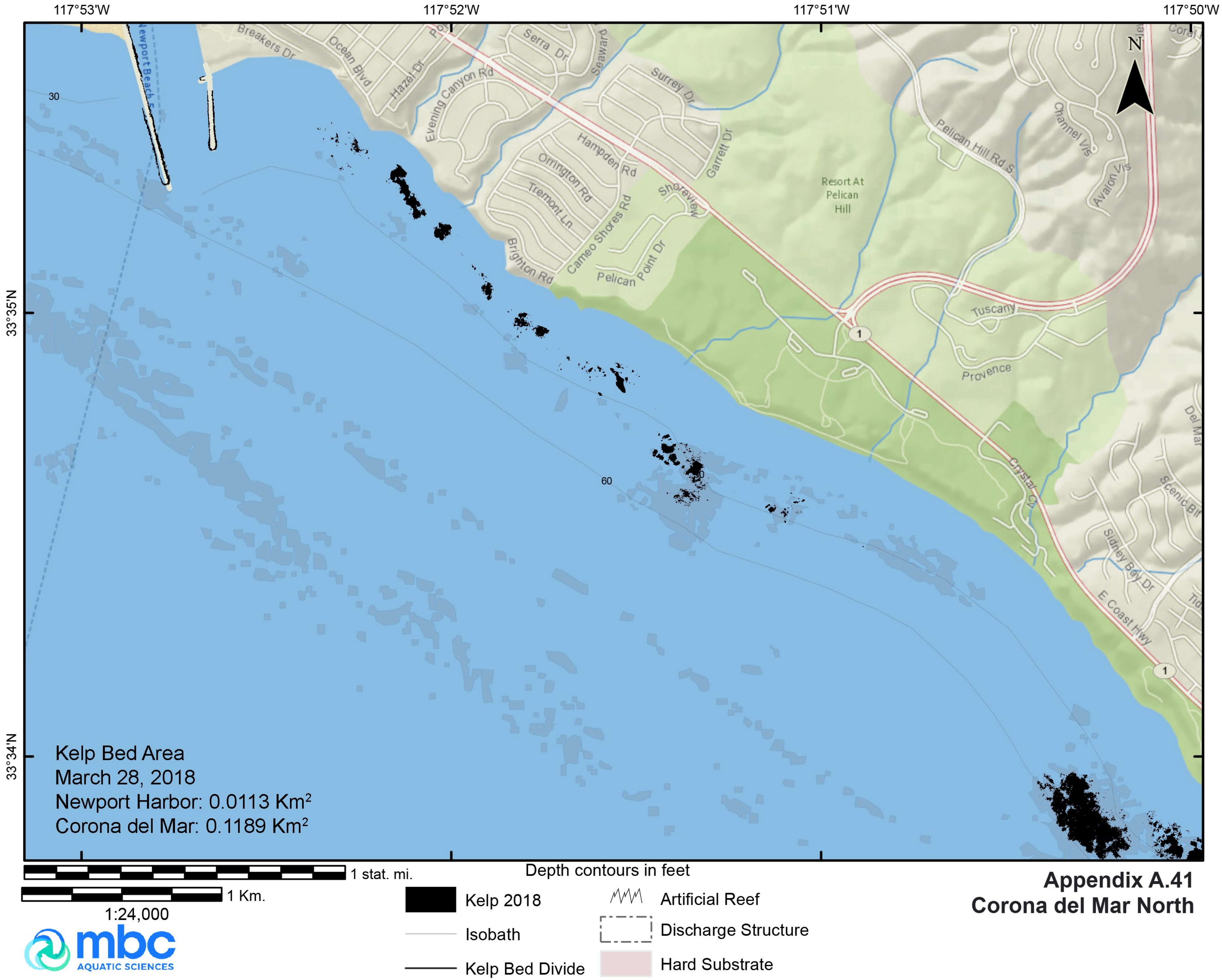
Appendix A.40
Newport Harbor

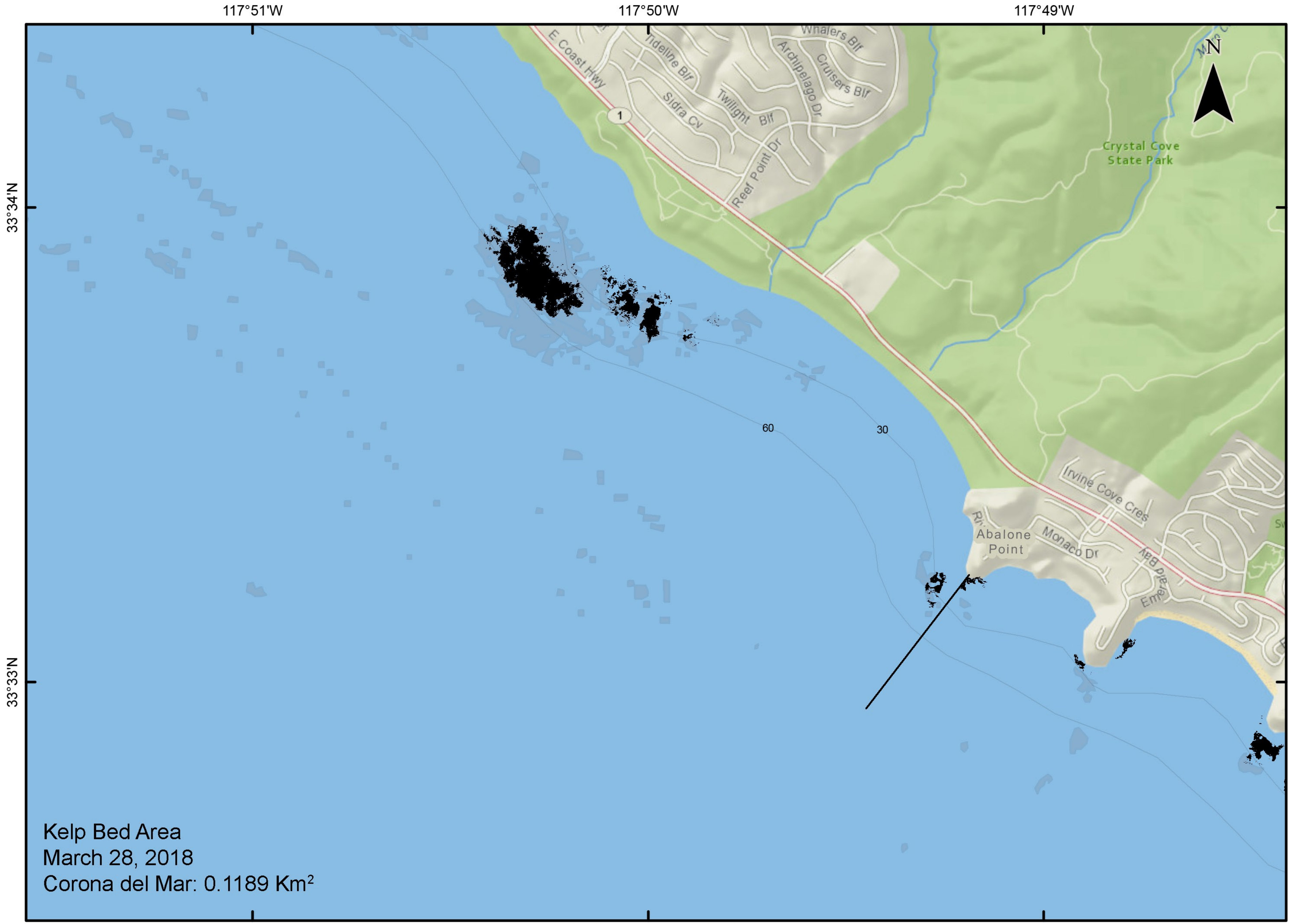


Kelp Bed Area
March 28, 2018
Newport Harbor: 0.0113 Km²



Kelp Bed Area
March 28, 2018
Newport Harbor: 0.0113 Km²
Corona del Mar: 0.1189 Km²

Appendix A.41
Corona del Mar North



Appendix A.42
Corona del Mar South

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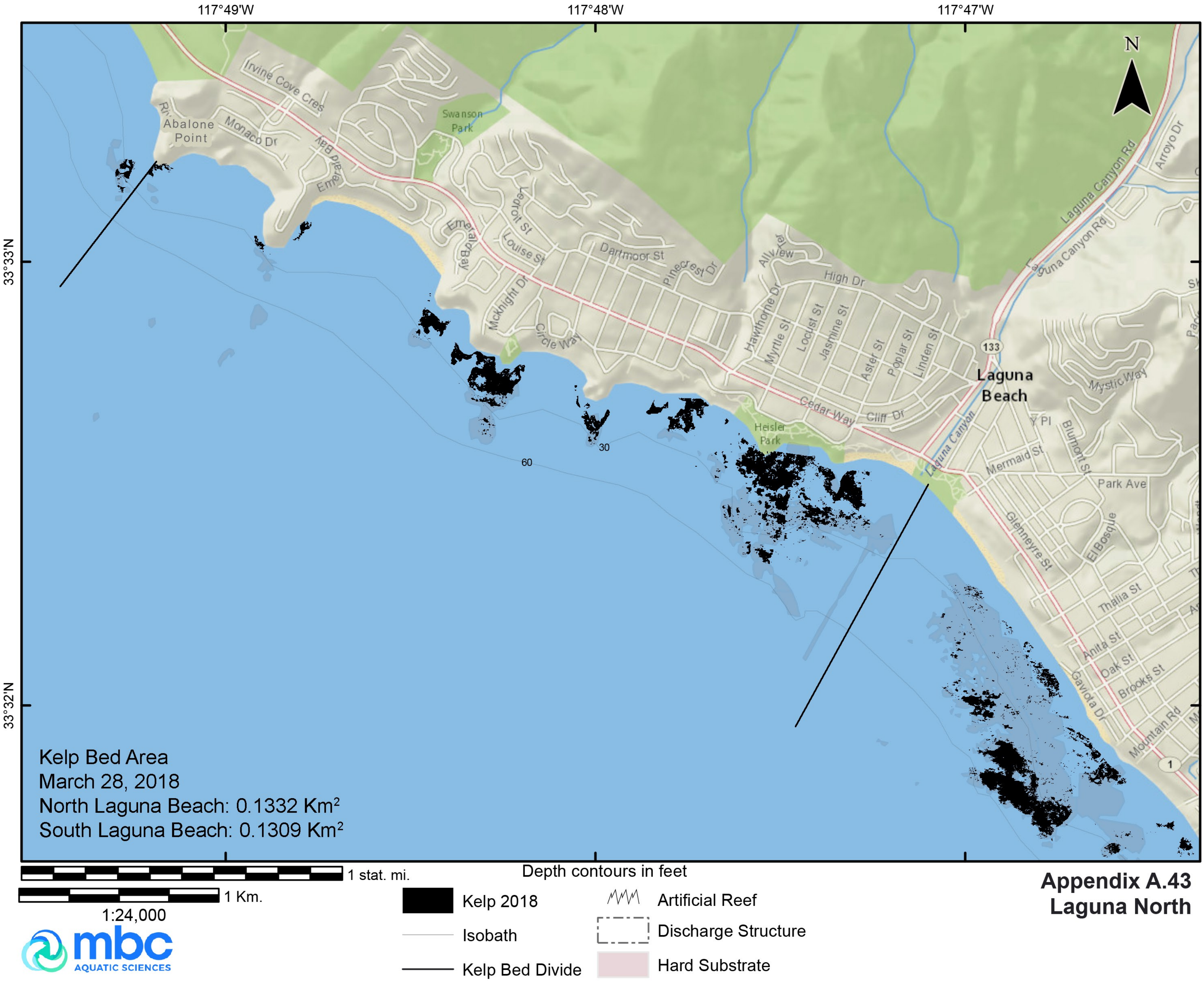
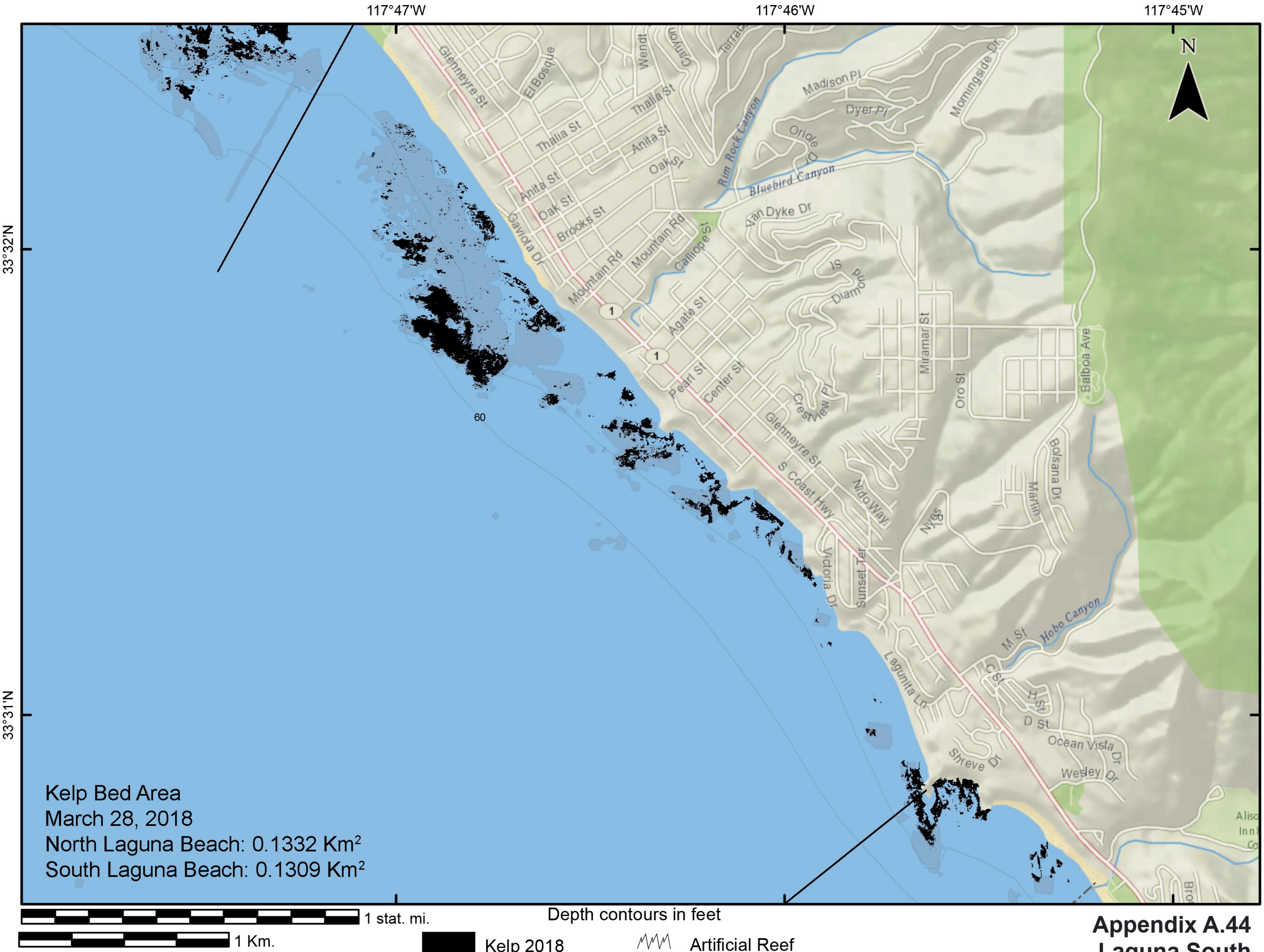
Appendix A.43
Laguna North



Kelp Bed Area
March 28, 2018
North Laguna Beach: 0.1332 Km^2
South Laguna Beach: 0.1309 Km^2



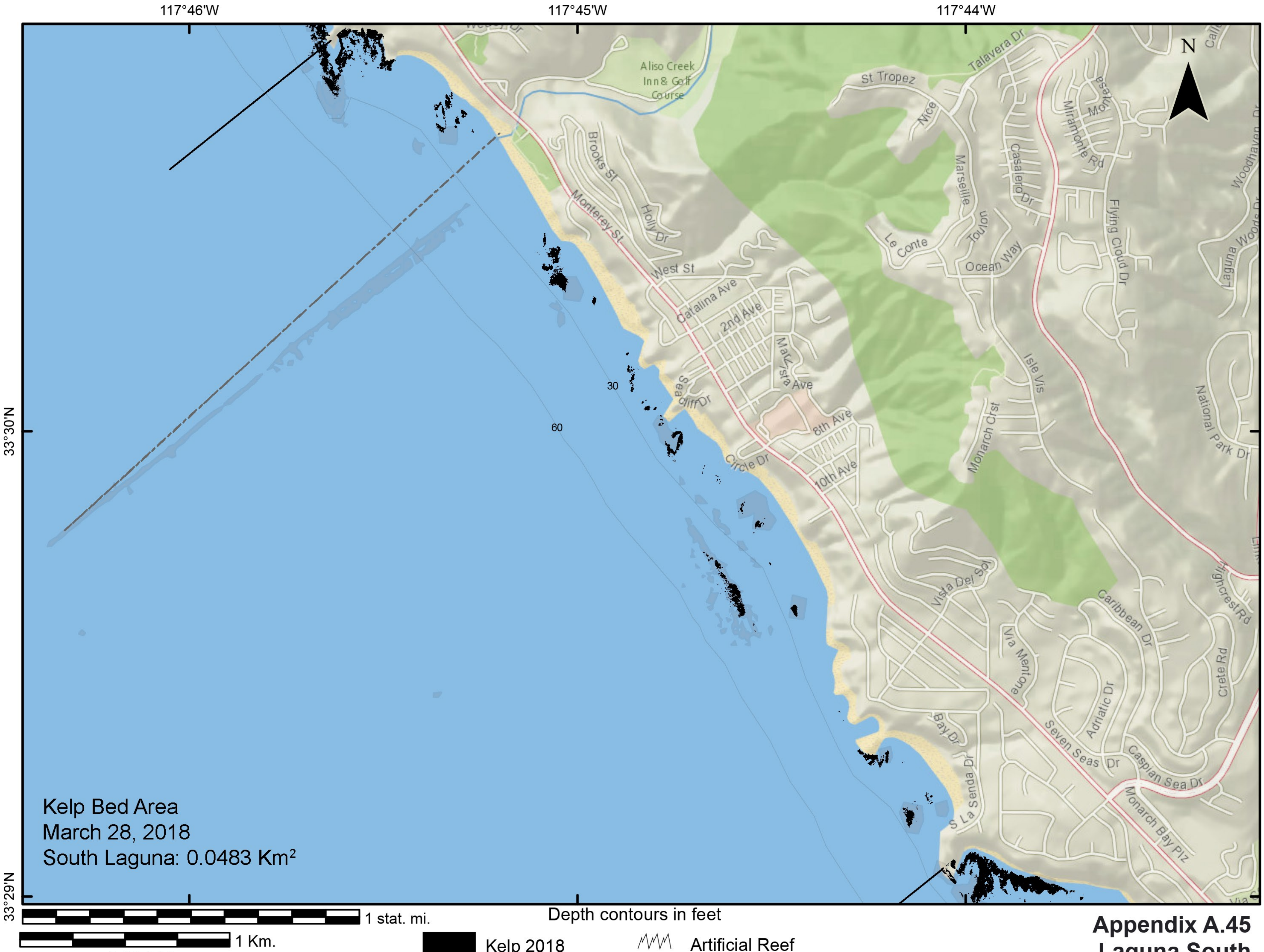
Kelp Bed Area
March 28, 2018
North Laguna Beach: 0.1332 Km²
South Laguna Beach: 0.1309 Km²

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
ᴧᴧᴧ	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

Appendix A.44
Laguna South

mbc AQUATIC SCIENCES



Kelp Bed Area
March 28, 2018
South Laguna: 0.0483 Km^2

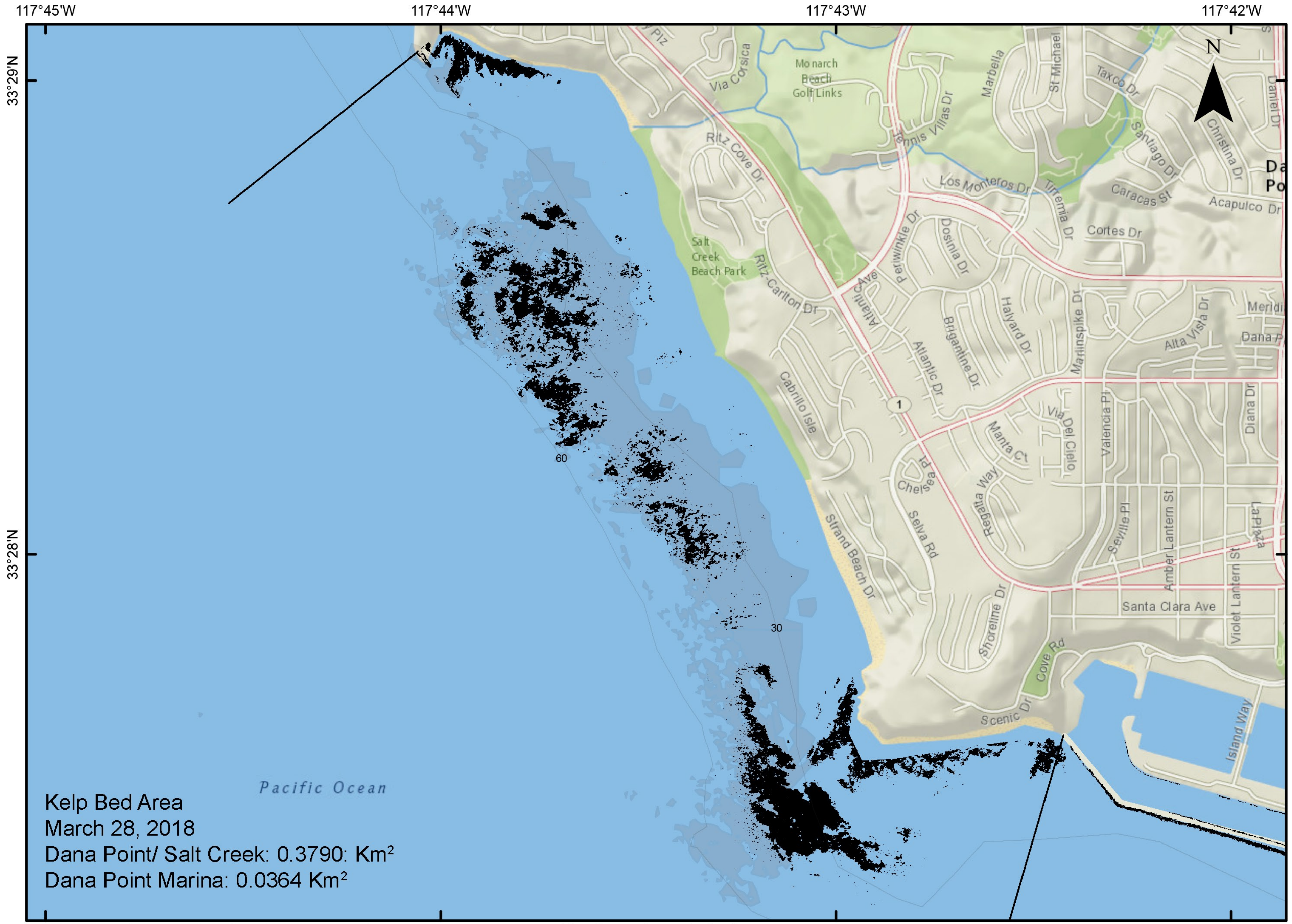
Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
⋀⋀⋀	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.45
Laguna South

Appendix A.46
Dana Point/Salt Creek



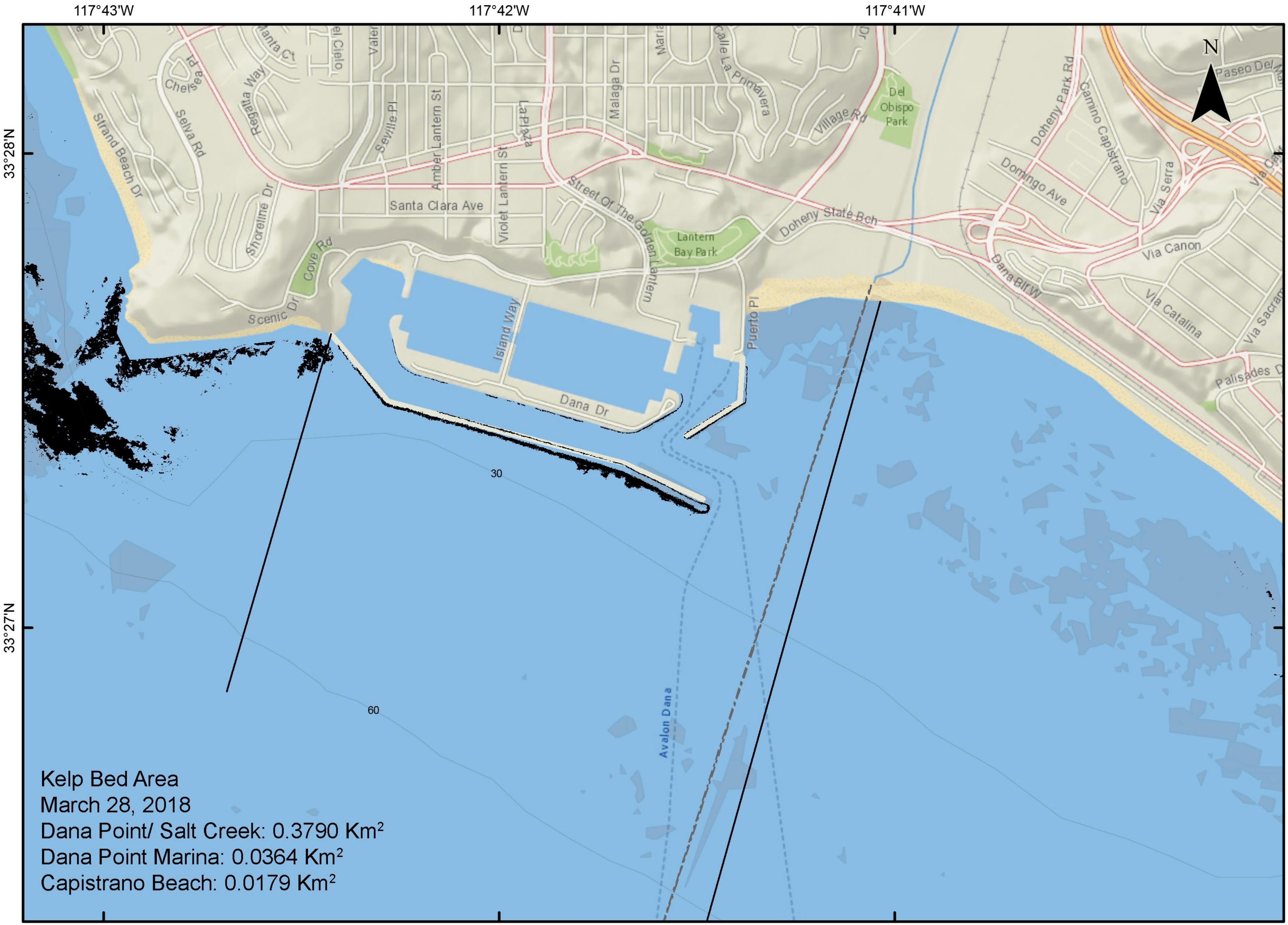
Kelp Bed Area
March 28, 2018
Dana Point/ Salt Creek: 0.3790: Km²
Dana Point Marina: 0.0364 Km²

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

Depth contours in feet

■	Kelp 2018
─	Isobath
━	Kelp Bed Divide
⩘	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

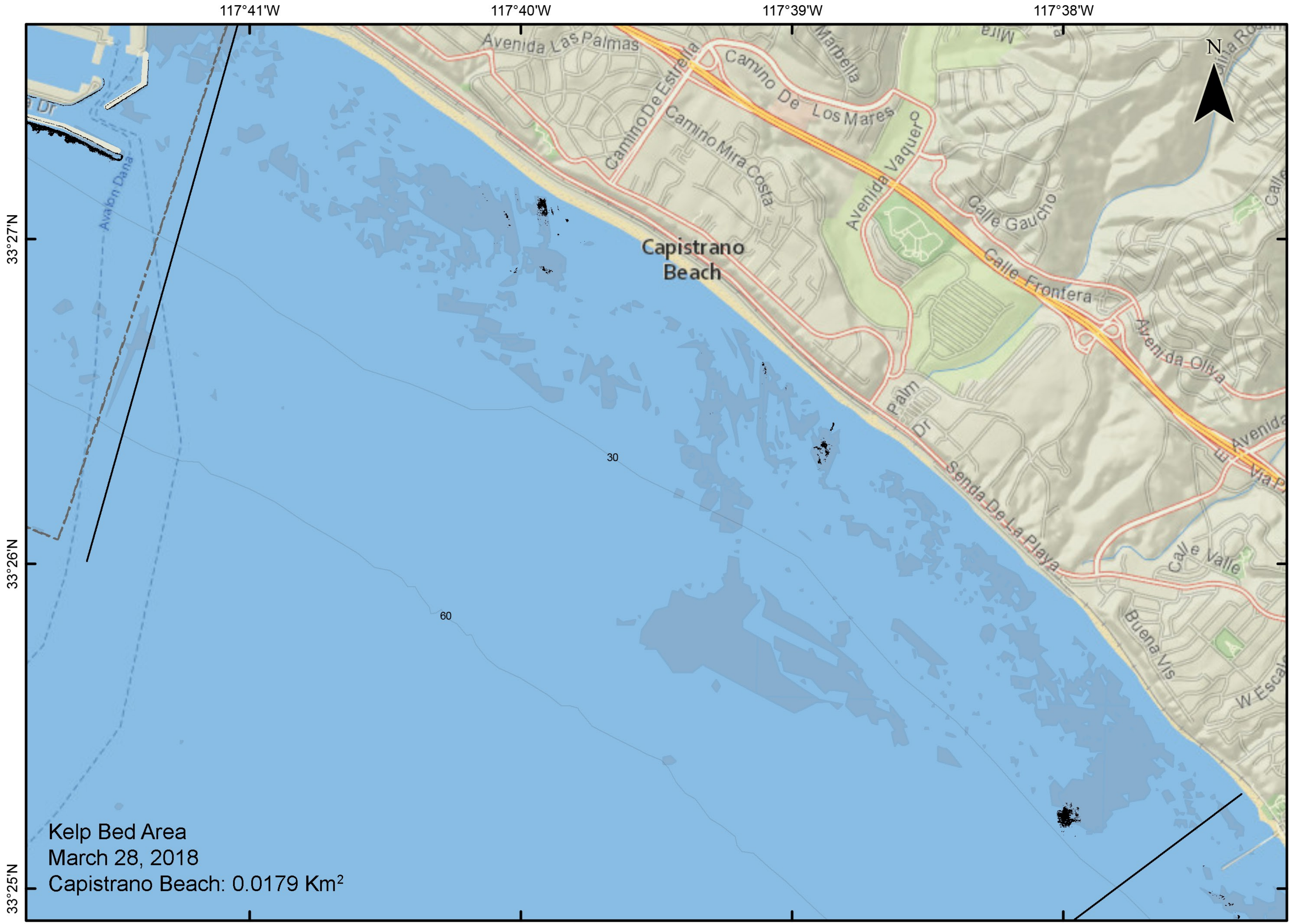
mbc AQUATIC SCIENCES



Kelp Bed Area
March 28, 2018
Dana Point/ Salt Creek: 0.3790 Km²
Dana Point Marina: 0.0364 Km²
Capistrano Beach: 0.0179 Km²

mbc AQUATIC SCIENCES

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



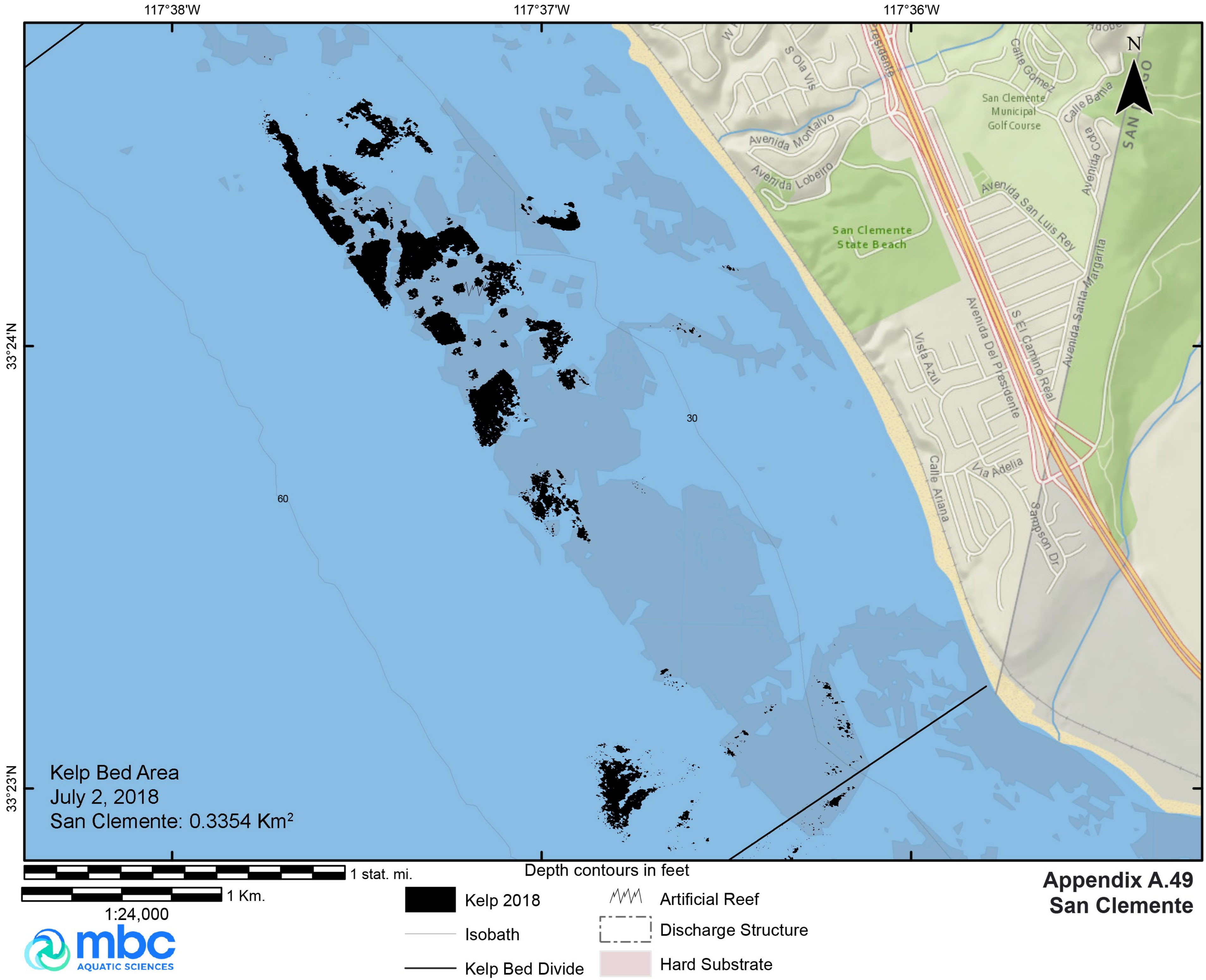
Kelp Bed Area
March 28, 2018
Capistrano Beach: 0.0179 Km^2

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

Depth contours in feet

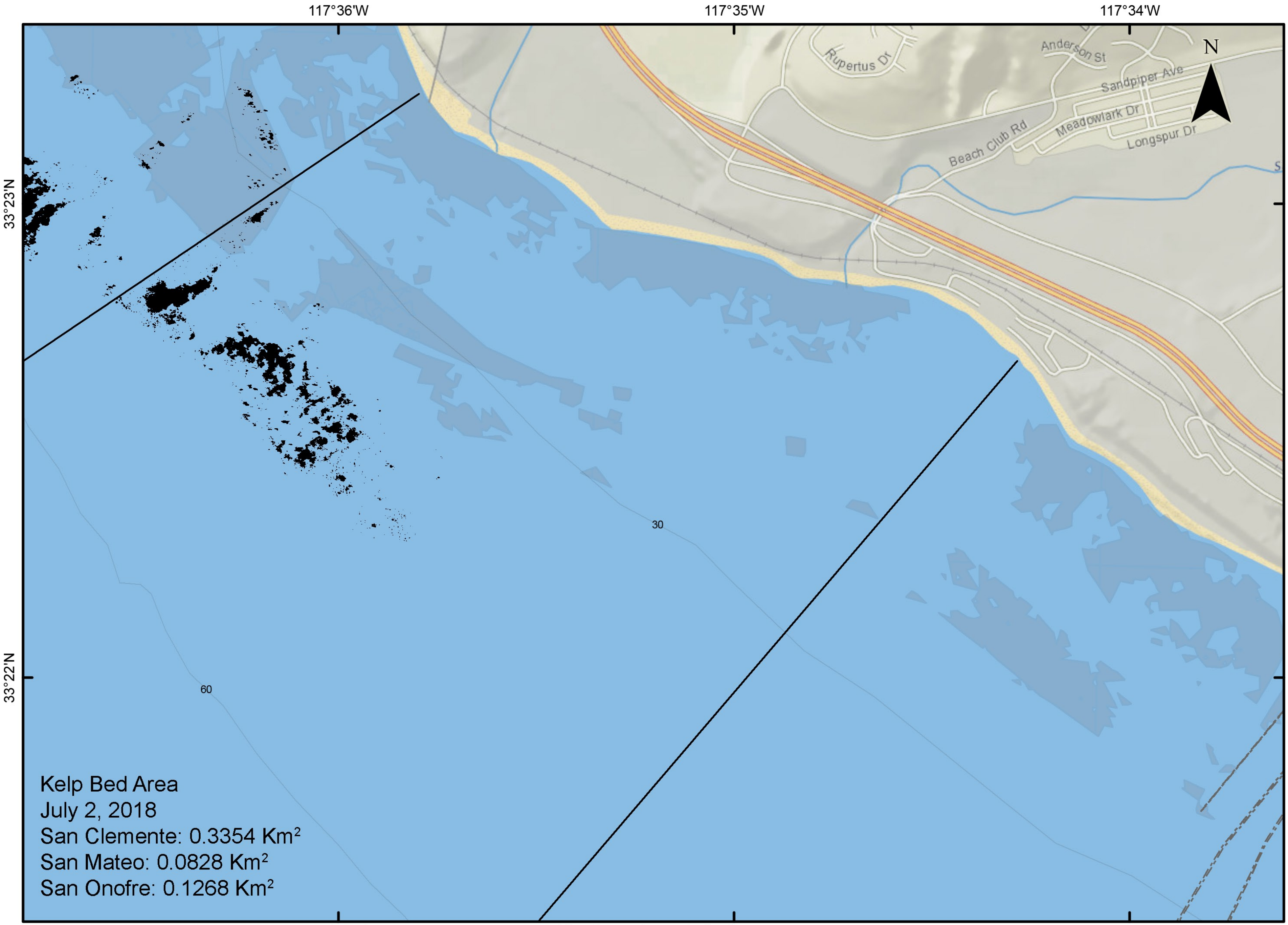
- ■ Kelp 2018
- — Isobath
- — Kelp Bed Divide
- Artificial Reef
- Discharge Structure
- Hard Substrate

Appendix A.48
Capistrano Beach

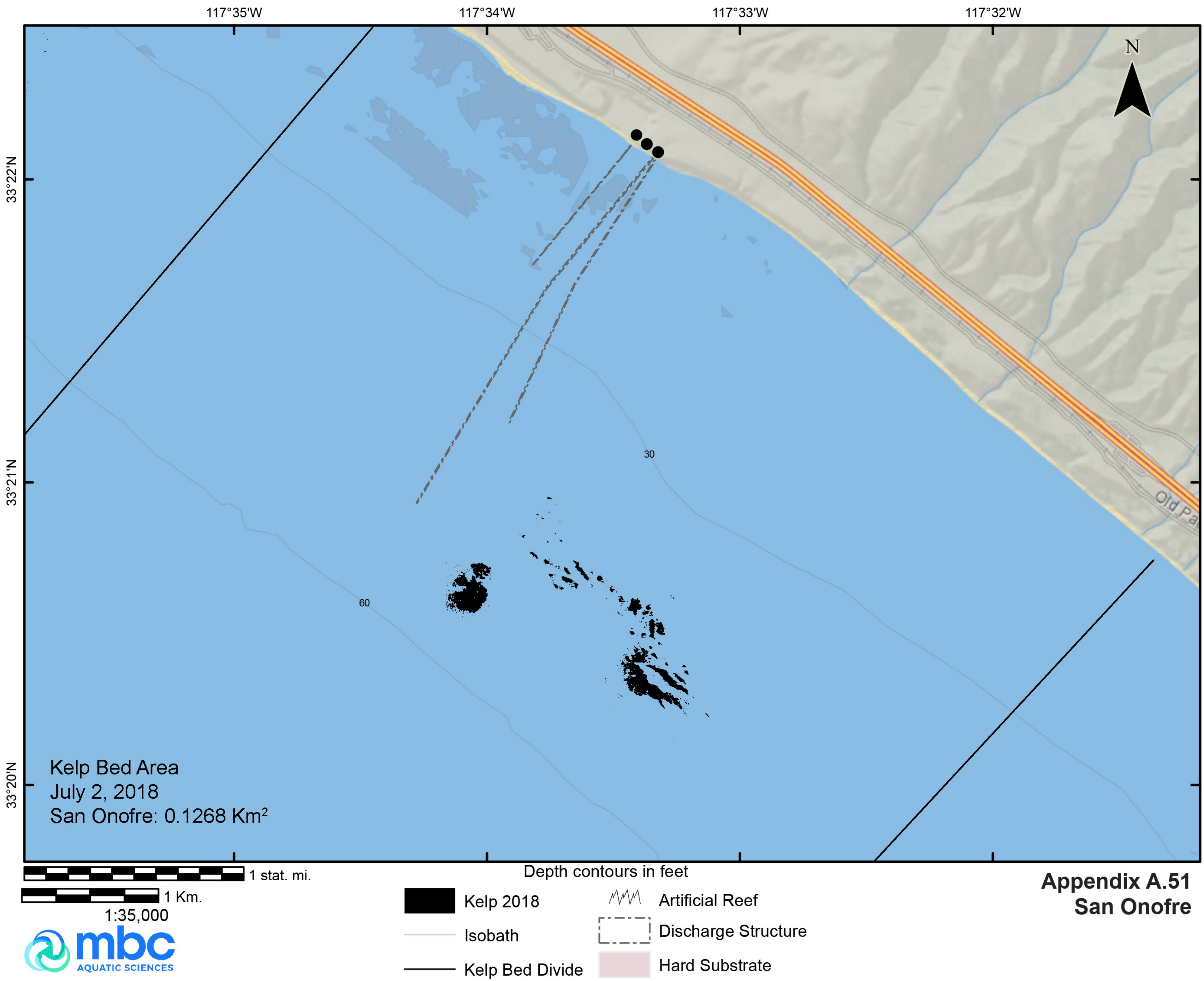


Appendix A.49
San Clemente

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

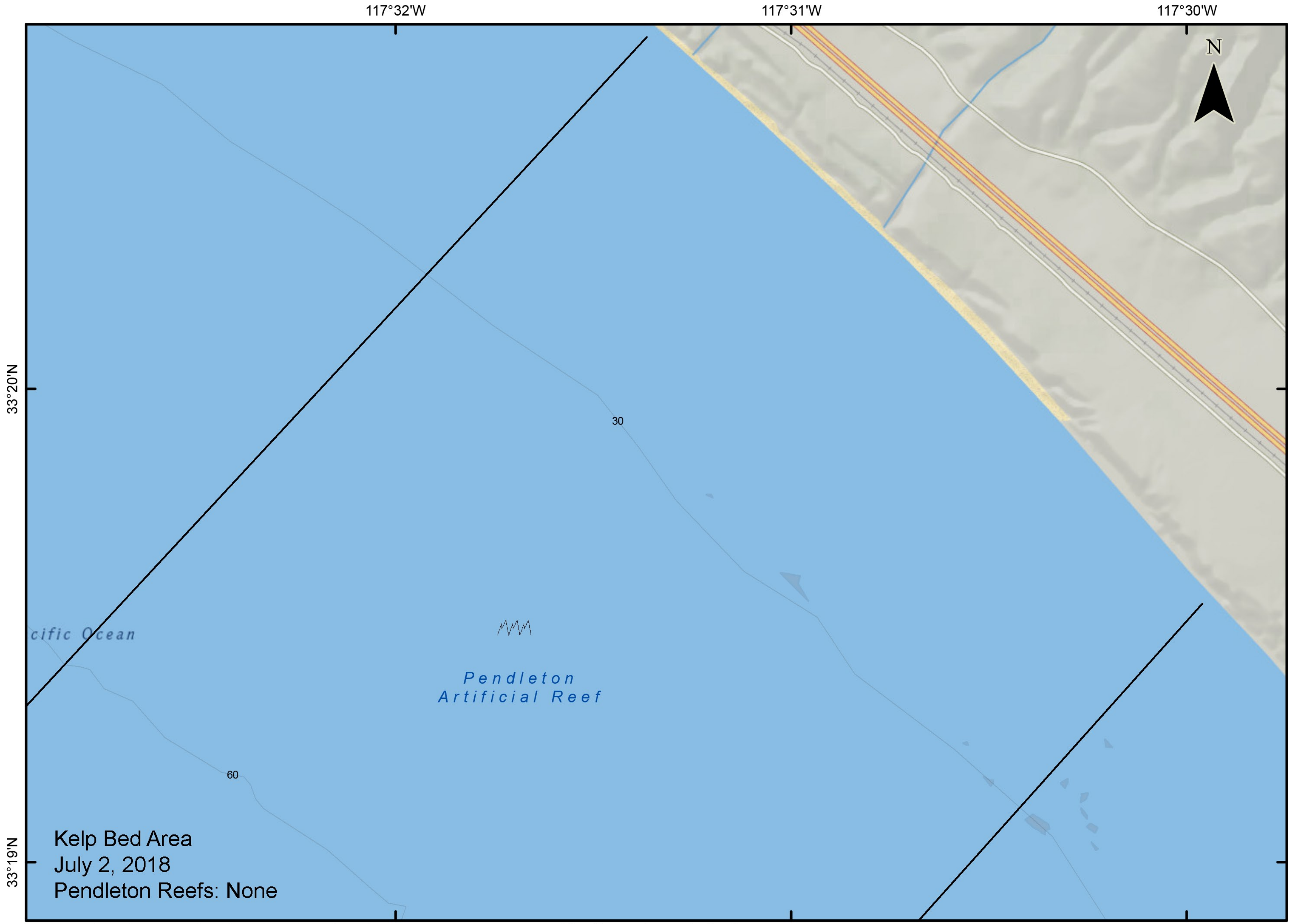


Kelp Bed Area
July 2, 2018
San Clemente: 0.3354 Km^2
San Mateo: 0.0828 Km^2
San Onofre: 0.1268 Km^2



Appendix A.51
San Onofre

Appendix A.52
Pendleton Reef



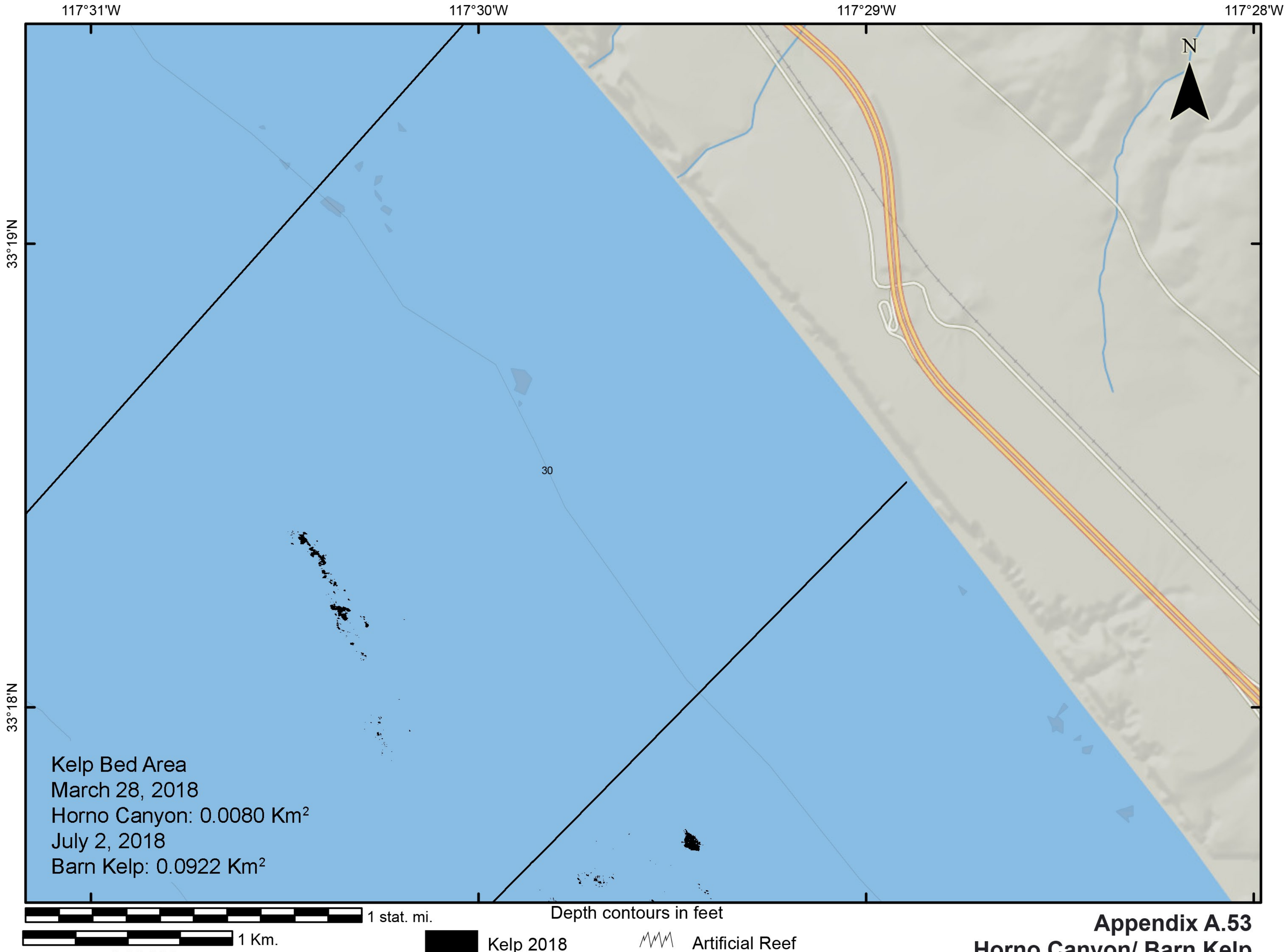
Kelp Bed Area
July 2, 2018
Pendleton Reefs: None

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

Depth contours in feet

■ Kelp 2018
— Isobath
— Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

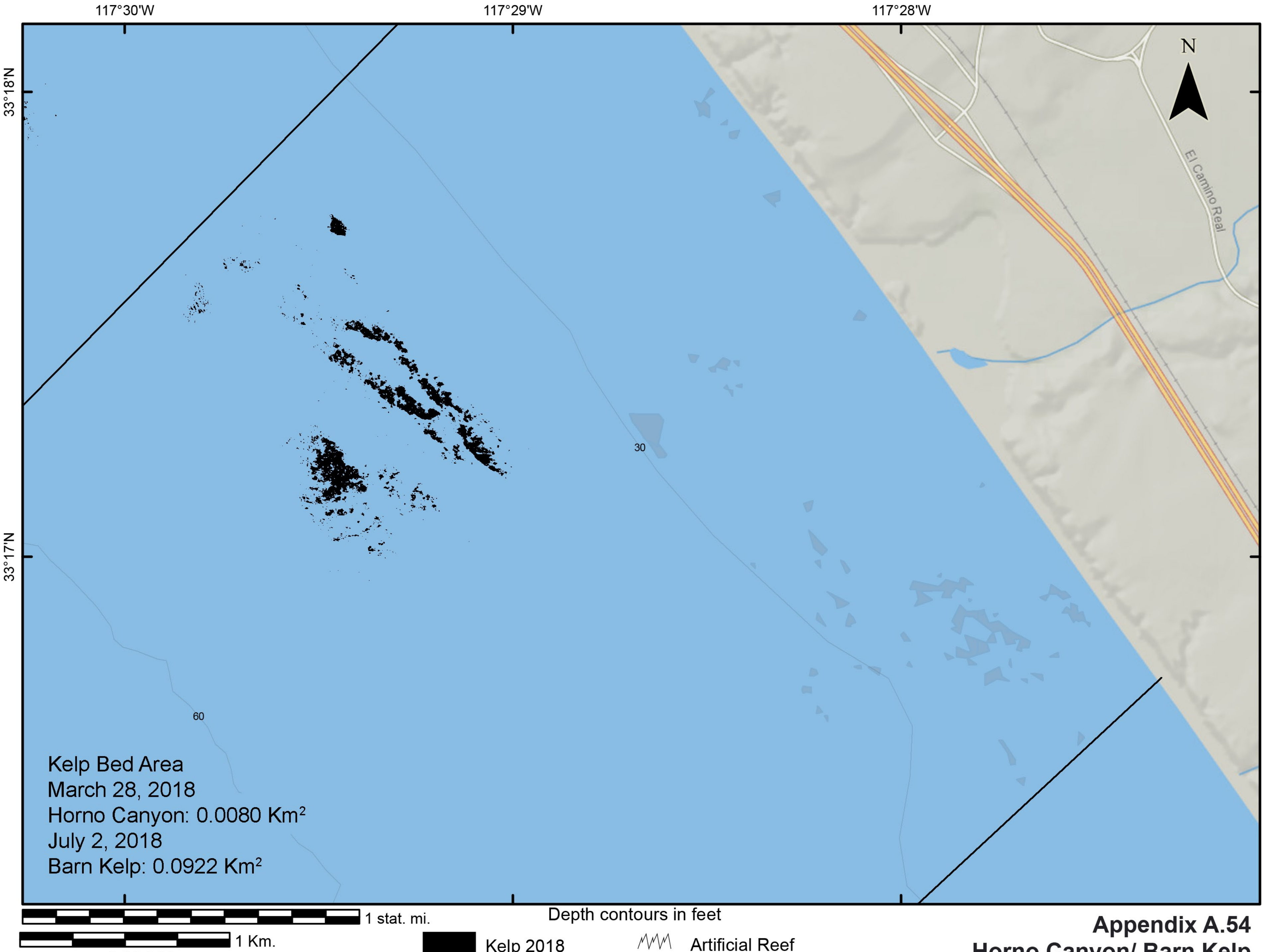


Kelp Bed Area
March 28, 2018
Horno Canyon: 0.0080 Km²
July 2, 2018
Barn Kelp: 0.0922 Km²

Depth contours in feet

■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
/\/\/\	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate

Appendix A.53
Horno Canyon/ Barn Kelp

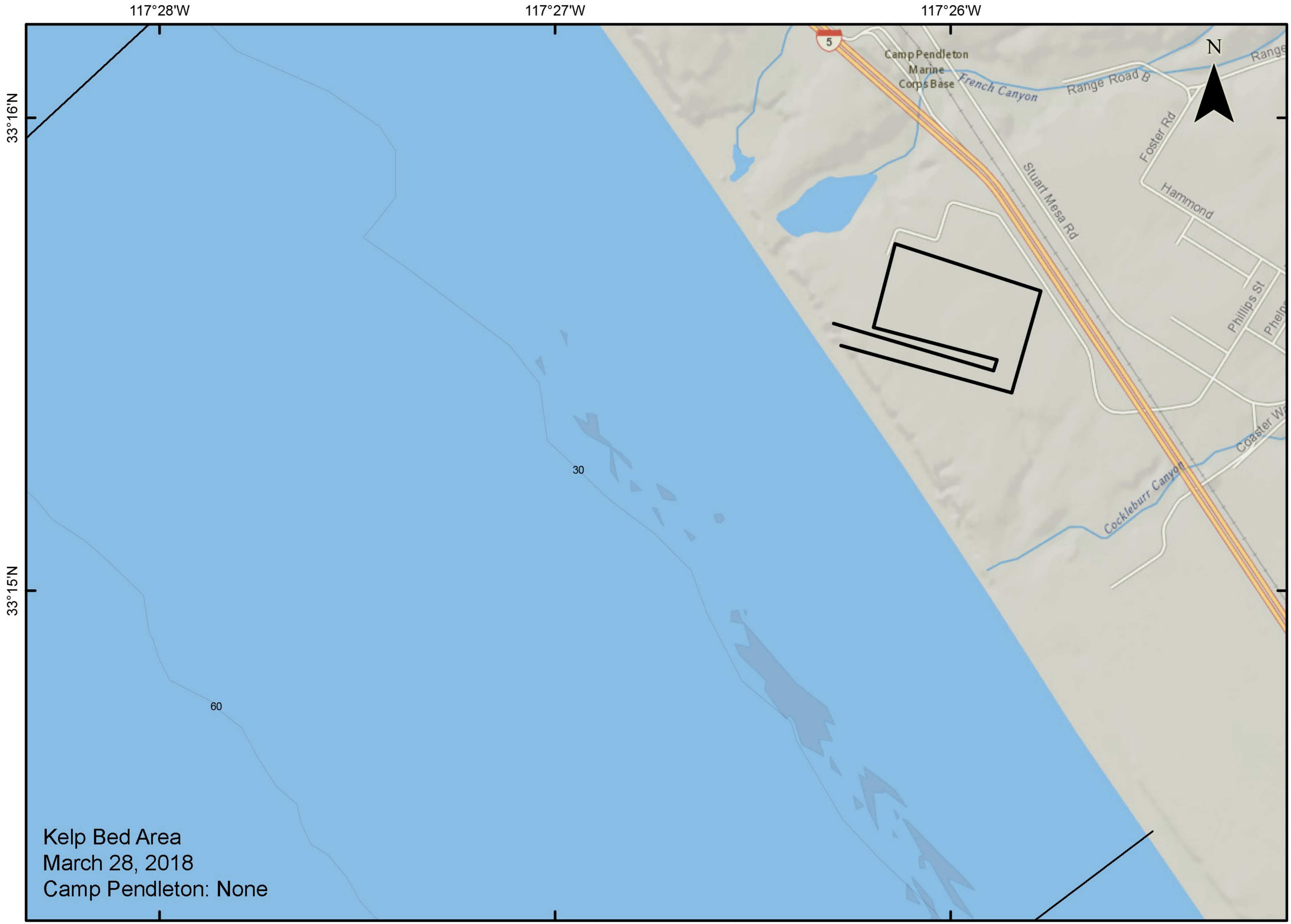


Kelp Bed Area
March 28, 2018
Horno Canyon: 0.0080 Km²
July 2, 2018
Barn Kelp: 0.0922 Km²

Depth contours in feet

■ Kelp 2018
— Isobath
— Kelp Bed Divide
⋀⋀⋀ Artificial Reef
▭ Discharge Structure
▨ Hard Substrate

Appendix A.54
Horno Canyon/ Barn Kelp



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

■ Kelp 2018

Isobath

Kelp Bed Divide

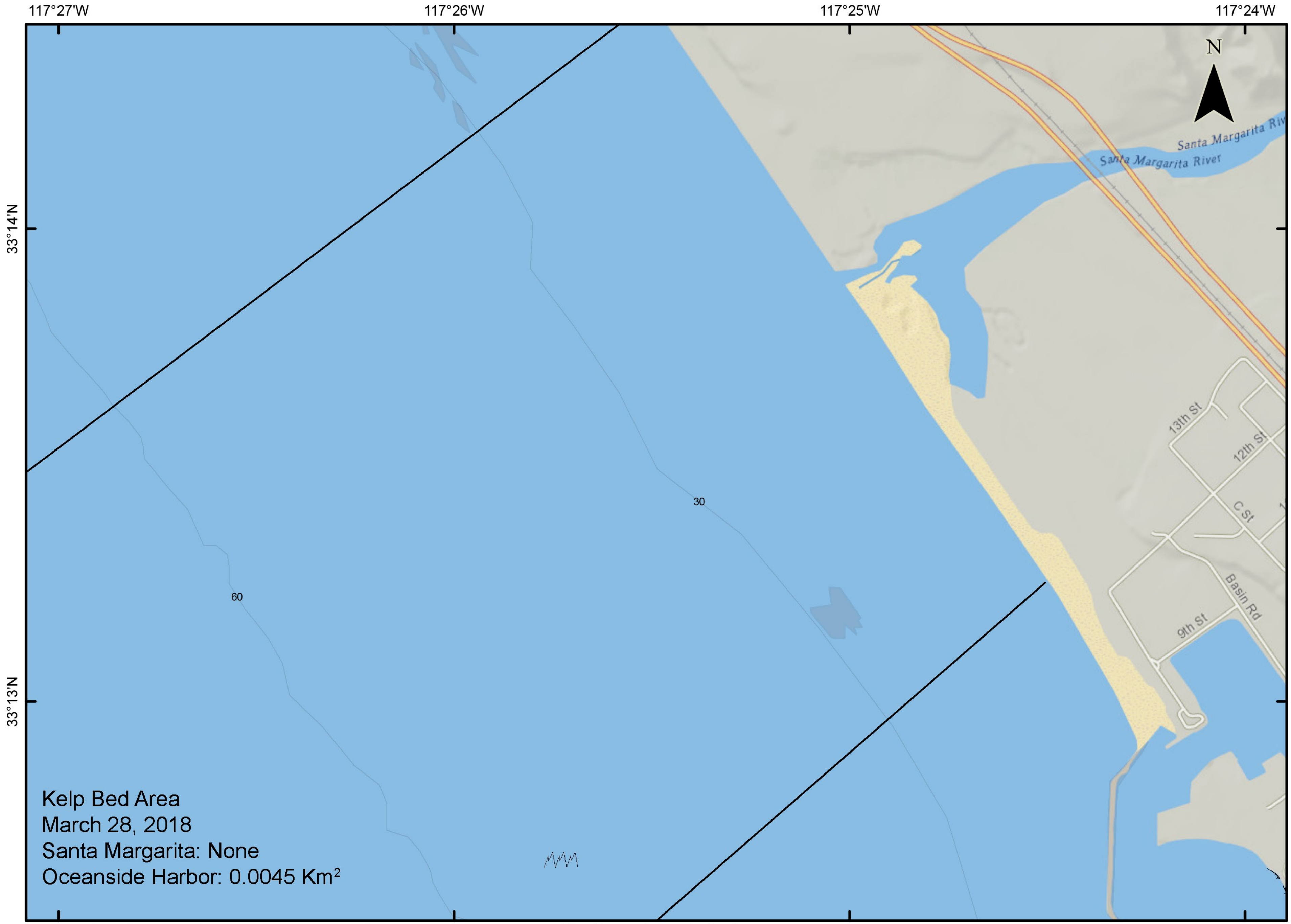
Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.55
Camp Pendleton

Appendix A.56
Santa Margarita/ Oceanside Harbor



Kelp Bed Area
March 28, 2018
Santa Margarita: None
Oceanside Harbor: 0.0045 Km²

1 stat. mi.

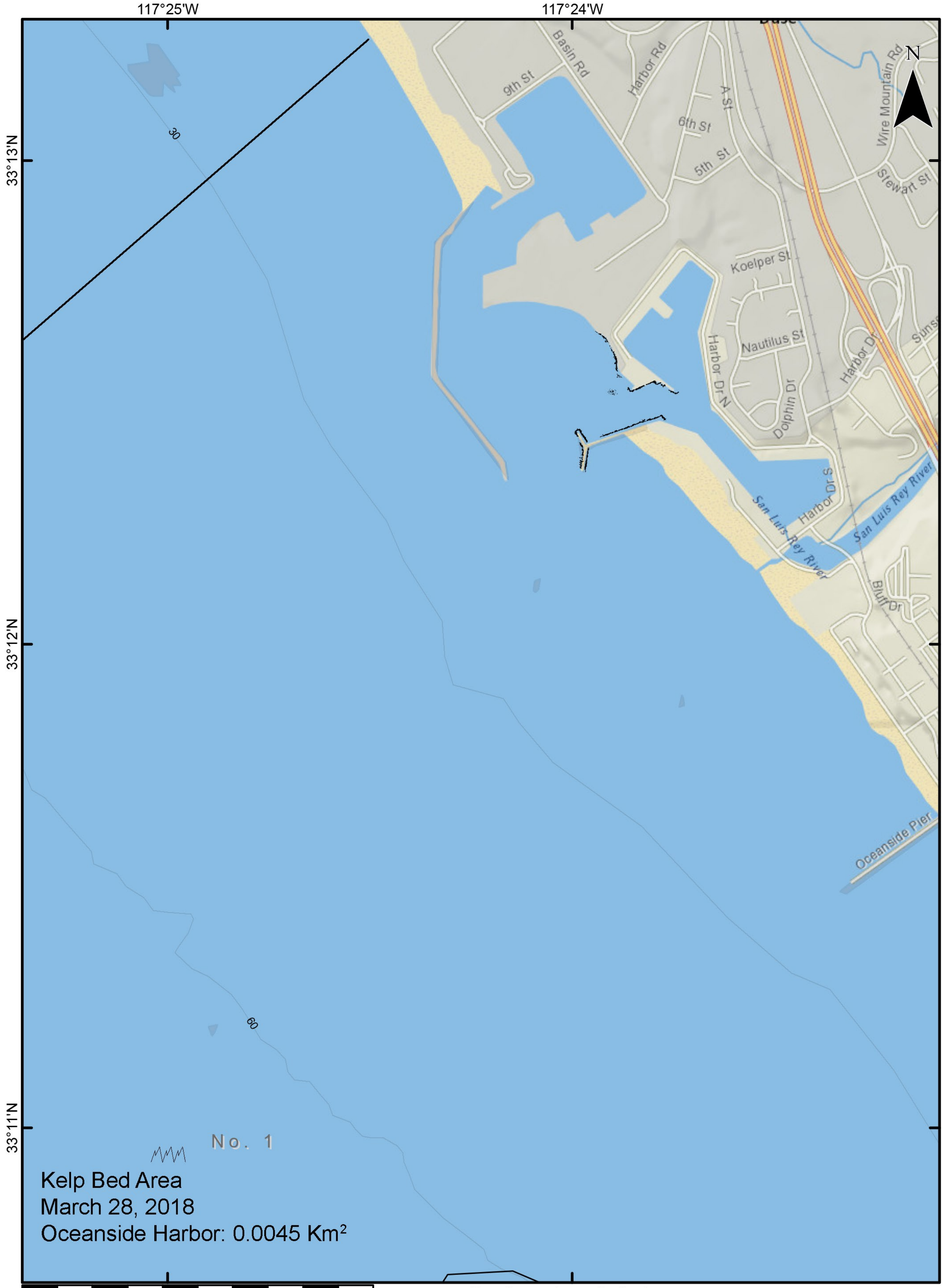
1 Km.

1:24,000

Depth contours in feet

- ■ Kelp 2018
- ― Isobath
- ― Kelp Bed Divide
- ⋀⋀⋀ Artificial Reef
- ▭ Discharge Structure
- ▨ Hard Substrate

mbc
AQUATIC SCIENCES



1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.57
Oceanside Harbor and Pier

■ Kelp 2018

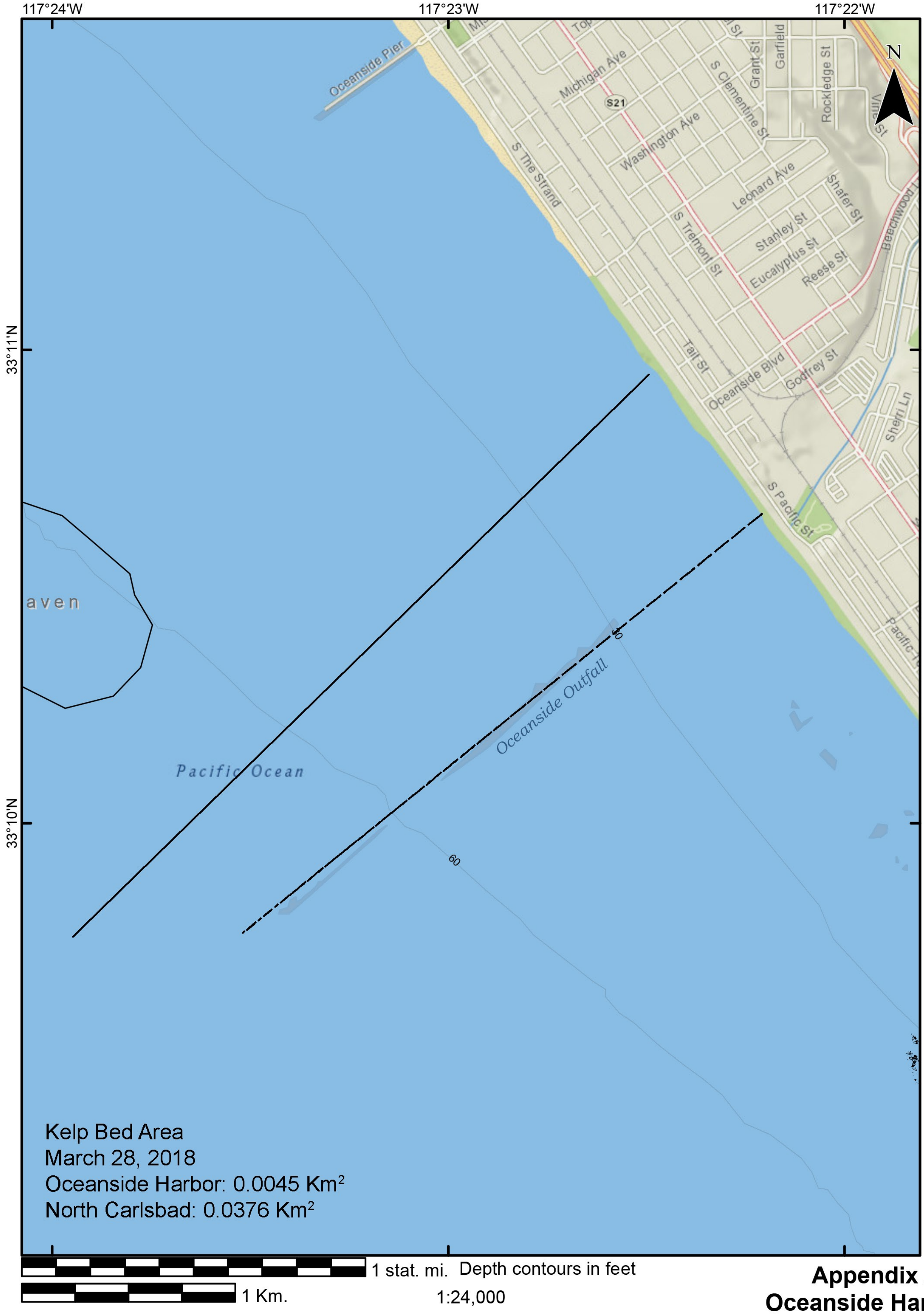
⋀⋀⋀ Artificial Reef

⬚ Discharge Structure

— Isobath

— Kelp Bed Divide

▨ Hard Substrate



Kelp Bed Area
March 28, 2018
Oceanside Harbor: 0.0045 Km^2
North Carlsbad: 0.0376 Km^2

Depth contours in feet

1:24,000

Appendix A.58
Oceanside Harbor/
Pier/ North Carlsbad

mbc AQUATIC SCIENCES

■ Kelp 2018

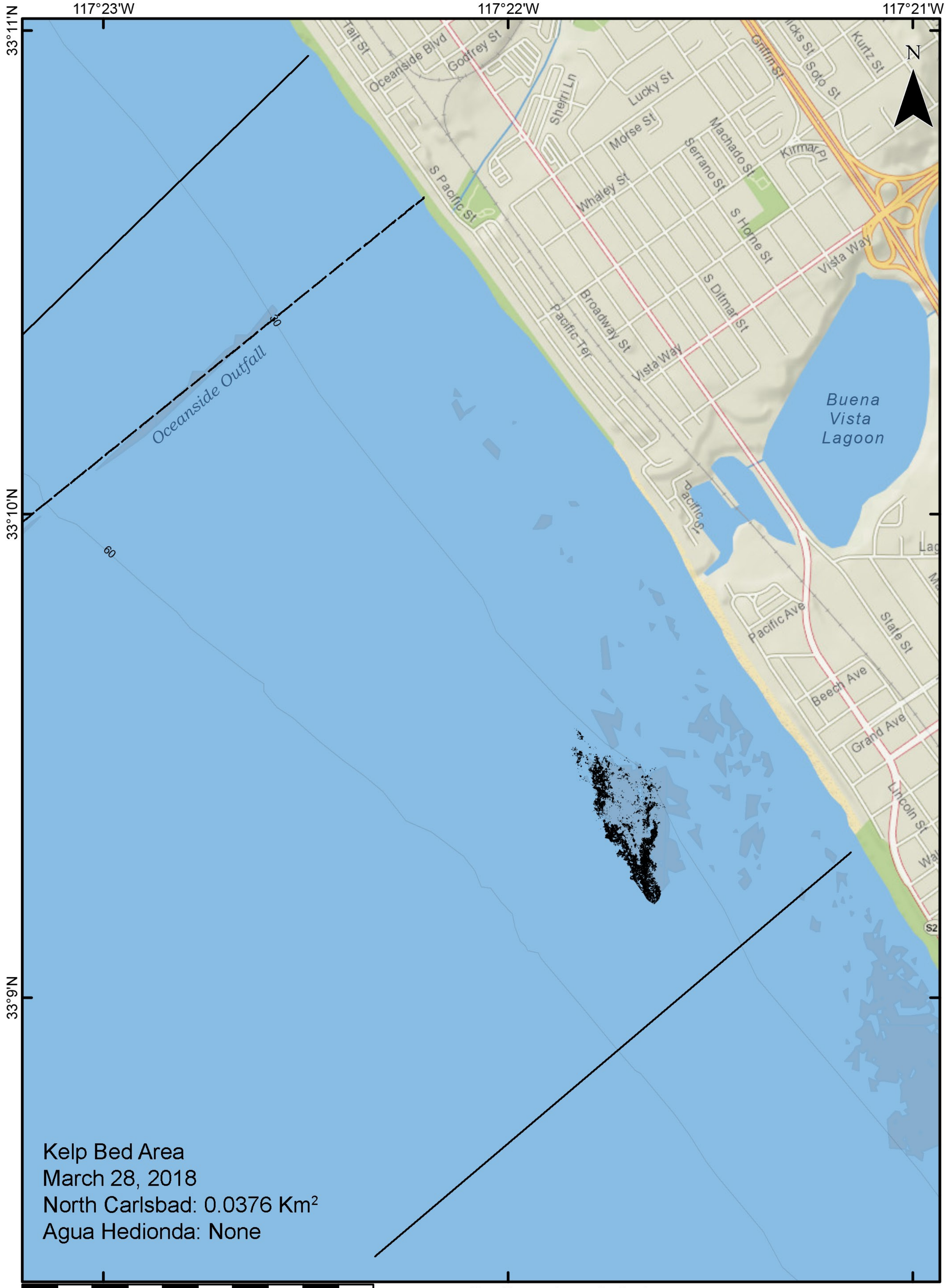
Artificial Reef

Discharge Structure

Isobath

Kelp Bed Divide

Hard Substrate

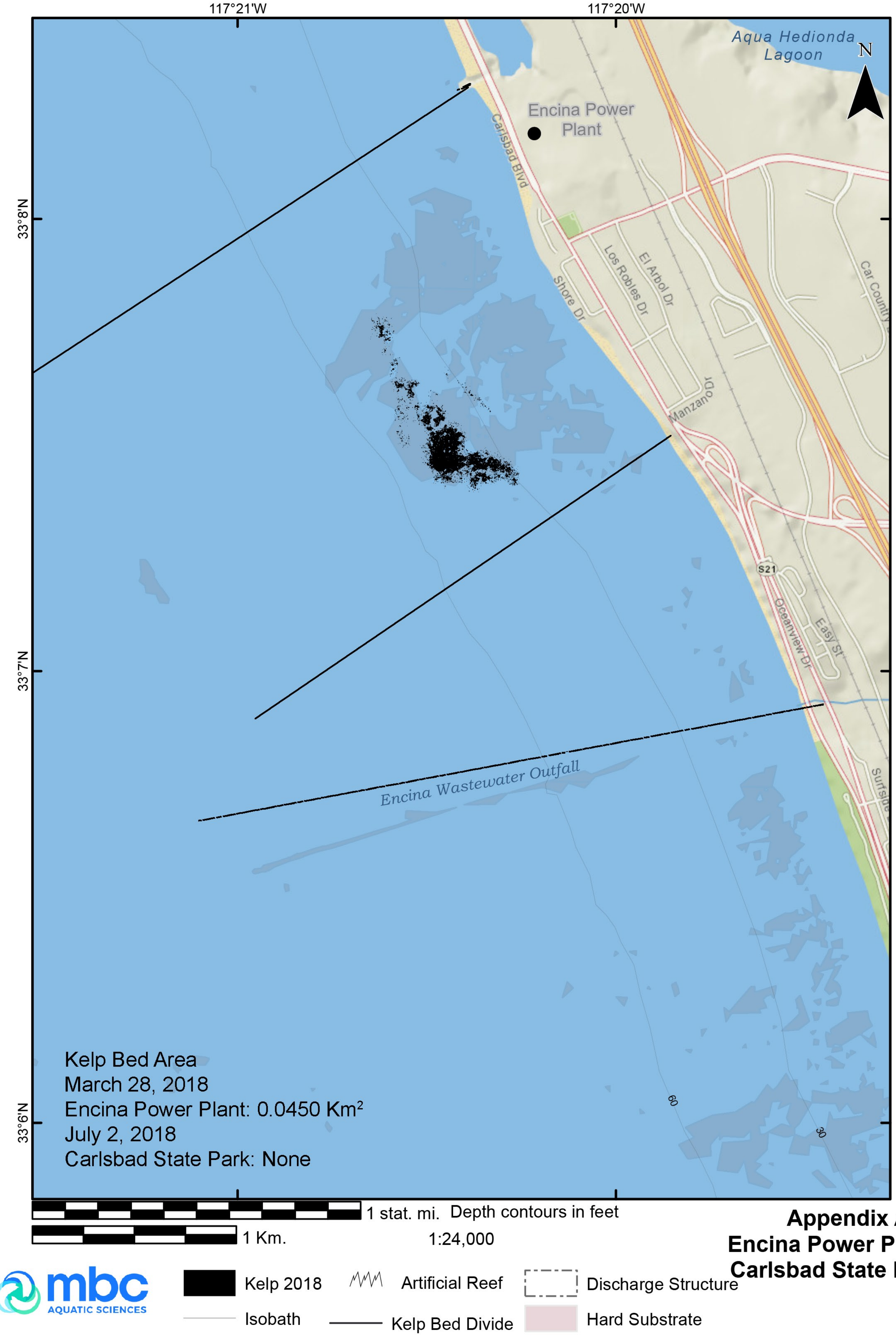


Kelp Bed Area
March 28, 2018
North Carlsbad: 0.0376 Km^2
Agua Hedionda: None

1 stat. mi.
Depth contours in feet
1 Km.
1:24,000

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

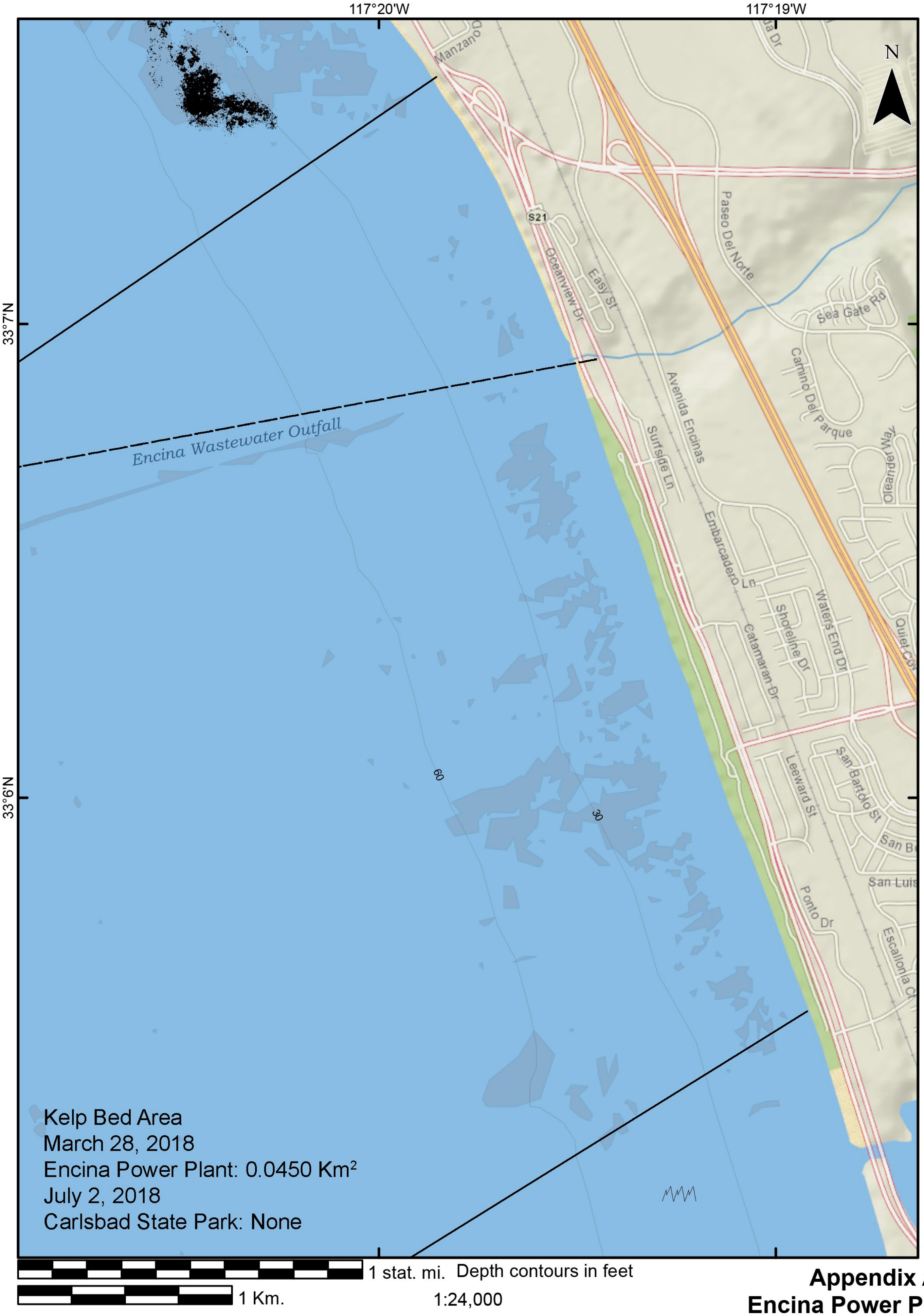
■ Kelp 2018	Artificial Reef	Discharge Structure
Isobath	Kelp Bed Divide	Hard Substrate



Kelp Bed Area
March 28, 2018
Encina Power Plant: 0.0450 Km^2
July 2, 2018
Carlsbad State Park: None

Appendix A.60
Encina Power Plant/
Carlsbad State Park

mbc
AQUATIC SCIENCES



Kelp Bed Area
March 28, 2018
Encina Power Plant: 0.0450 Km^2
July 2, 2018
Carlsbad State Park: None

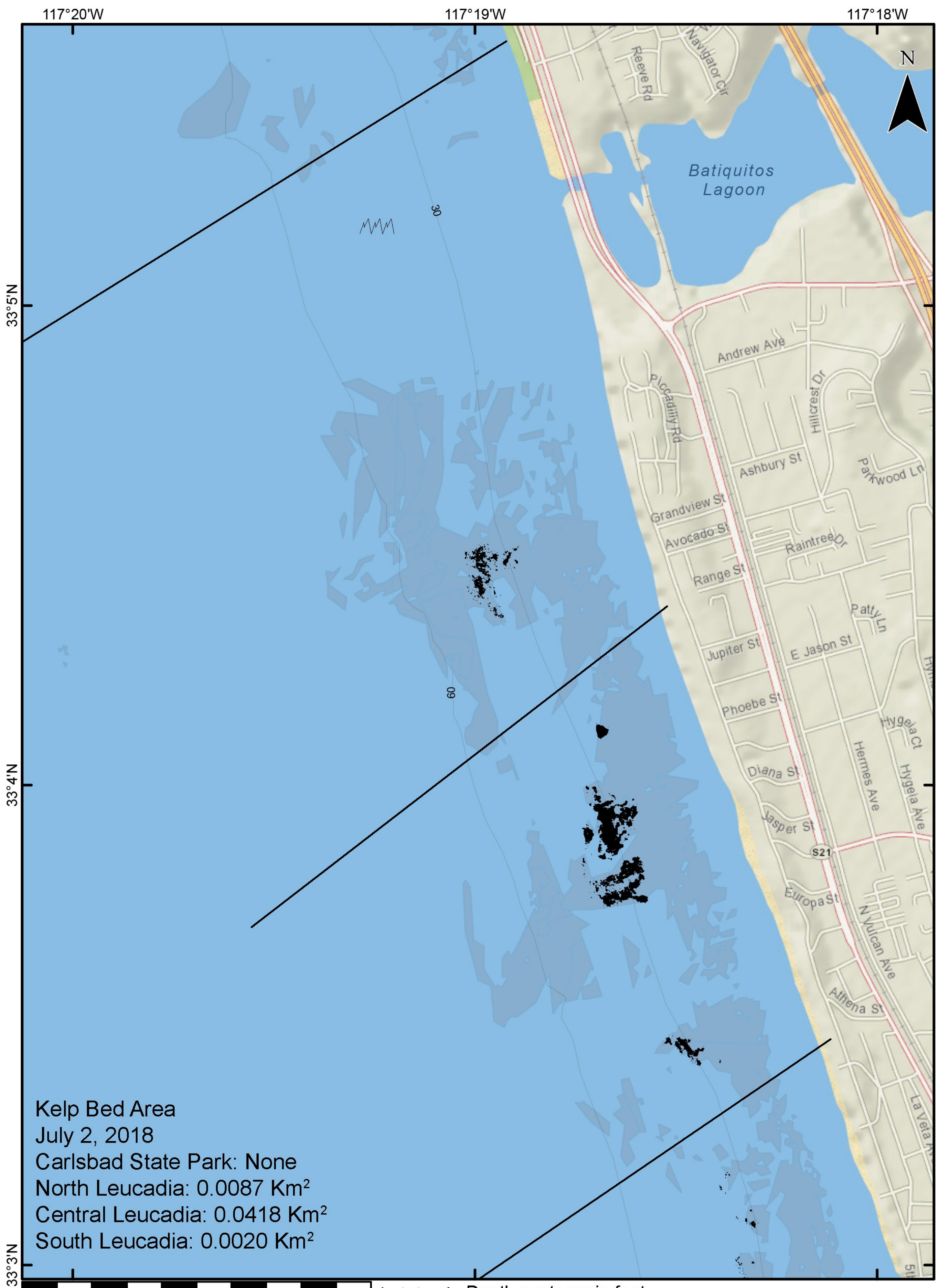
Depth contours in feet

1:24,000

Appendix A.61
Encina Power Plant/ Carlsbad State Park

mbc
AQUATIC SCIENCES

■	Kelp 2018	⩘⩘⩘	Artificial Reef	▭	Discharge Structure
—	Isobath	—	Kelp Bed Divide	▨	Hard Substrate



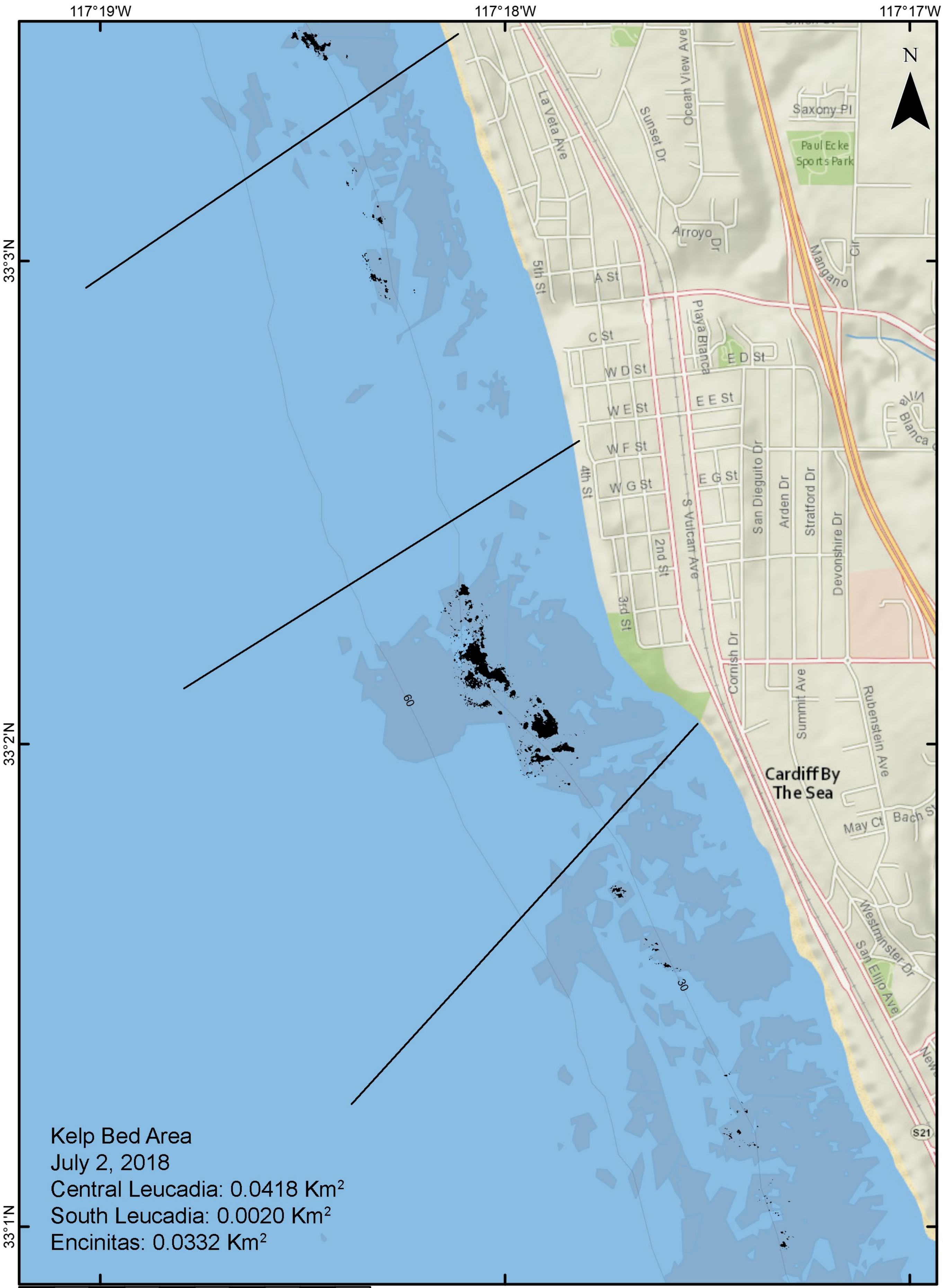
Kelp Bed Area
July 2, 2018
Carlsbad State Park: None
North Leucadia: 0.0087 Km^2
Central Leucadia: 0.0418 Km^2
South Leucadia: 0.0020 Km^2

1 stat. mi. Depth contours in feet
1 Km.
1:24,000

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

MBC AQUATIC SCIENCES

■ Kelp 2018
Artificial Reef
Discharge Structure
Isobath
Kelp Bed Divide
Hard Substrate



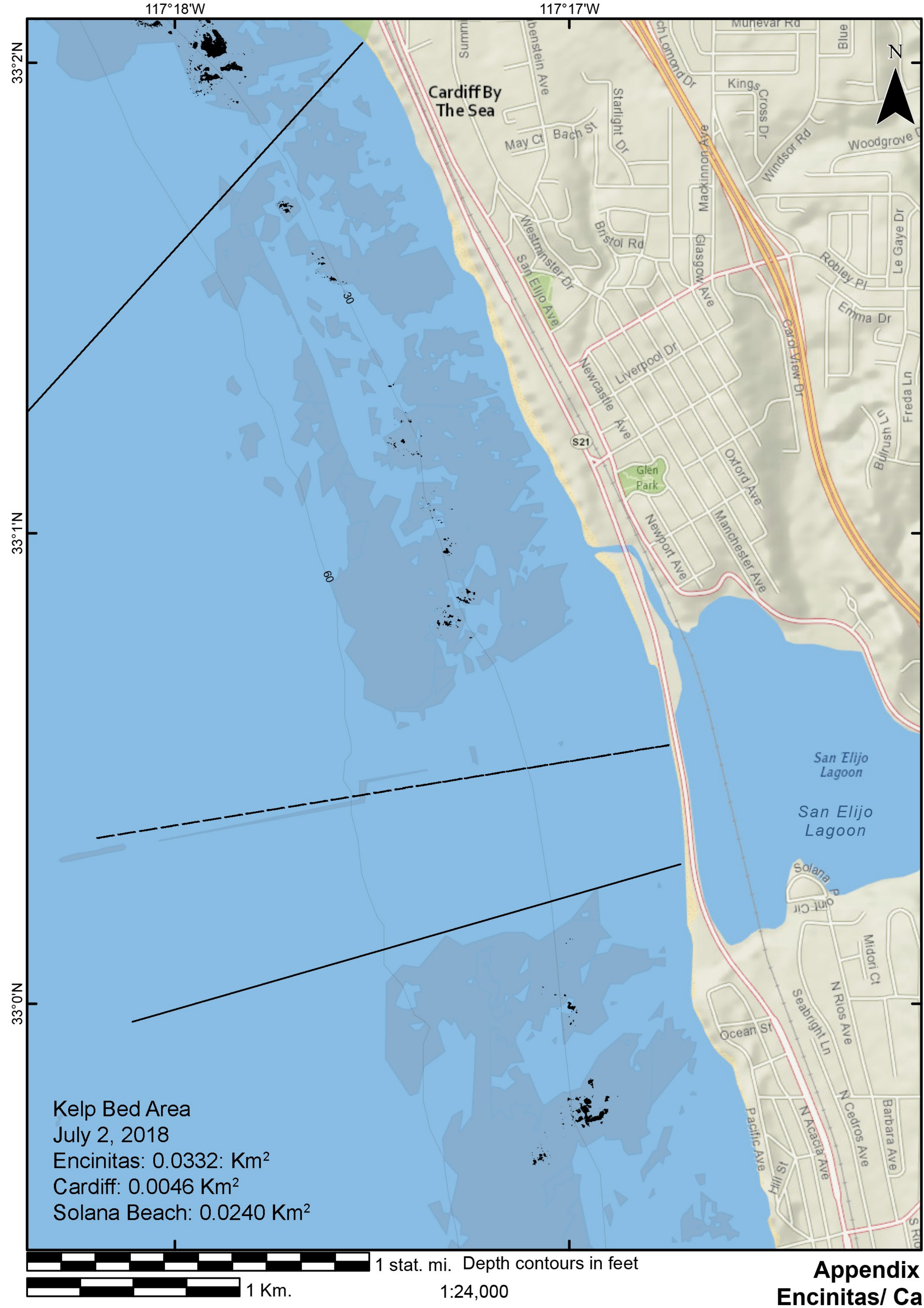
Kelp Bed Area
July 2, 2018
Central Leucadia: 0.0418 Km^2
South Leucadia: 0.0020 Km^2
Encinitas: 0.0332 Km^2

1 stat. mi. Depth contours in feet

1 Km. 1:24,000

■ Kelp 2018
Isobath
Artificial Reef
Kelp Bed Divide
Discharge Structure
Hard Substrate

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



Kelp Bed Area
July 2, 2018
Encinitas: 0.0332: Km²
Cardiff: 0.0046 Km²
Solana Beach: 0.0240 Km²

Appendix A.64
Encinitas/ Cardiff/ Solana Beach

■ Kelp 2018

Isobath

Artificial Reef

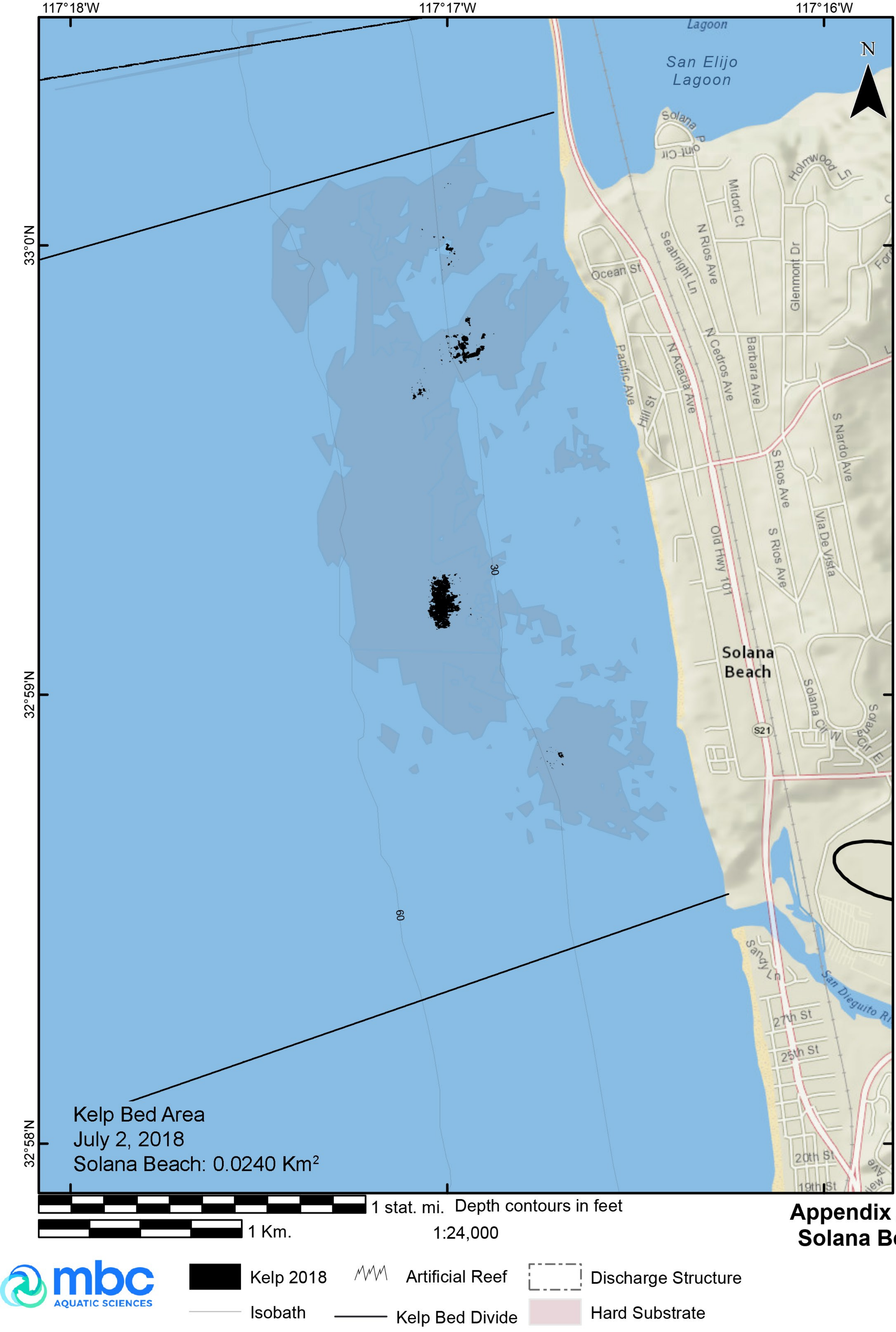
Kelp Bed Divide

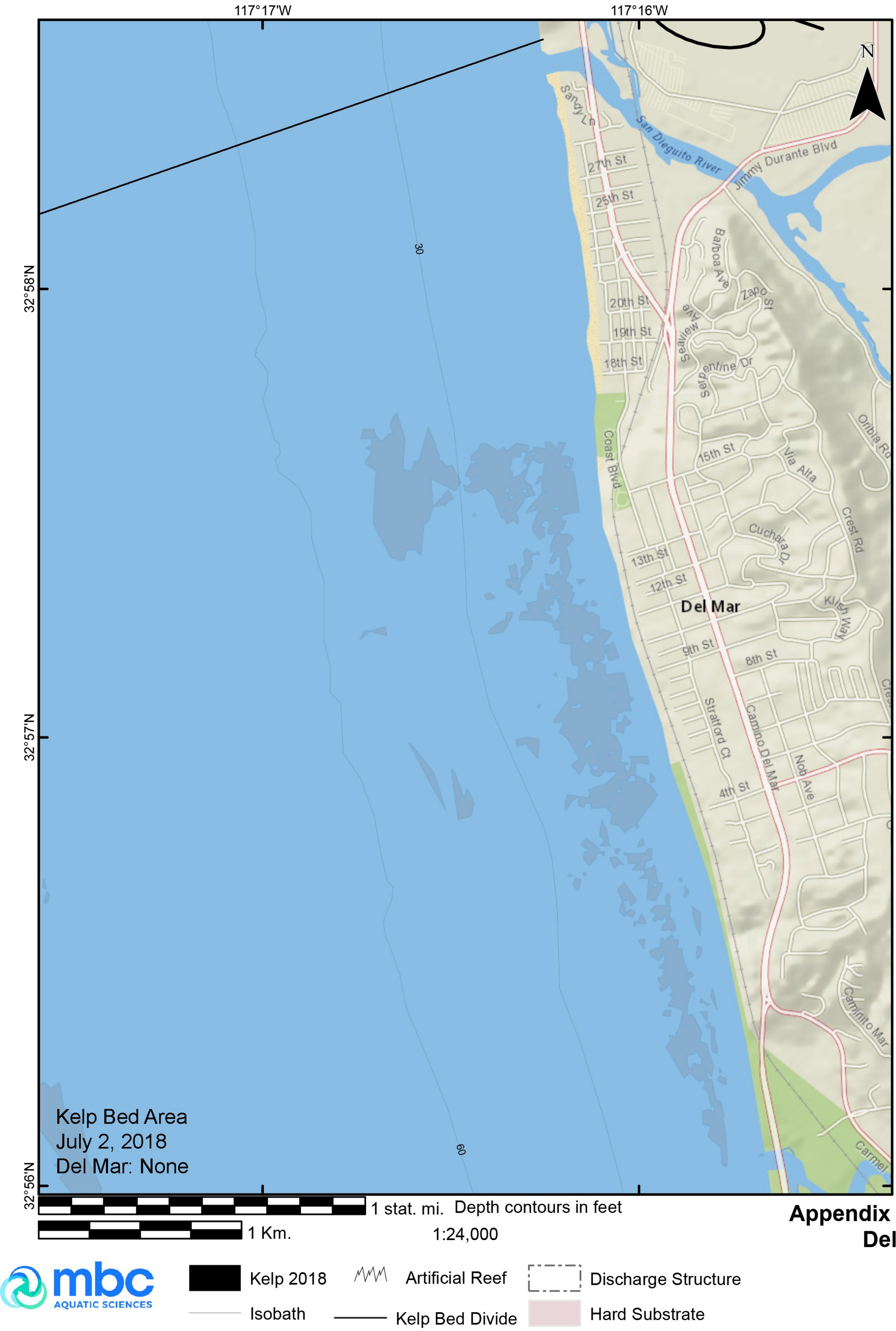
Discharge Structure

Hard Substrate

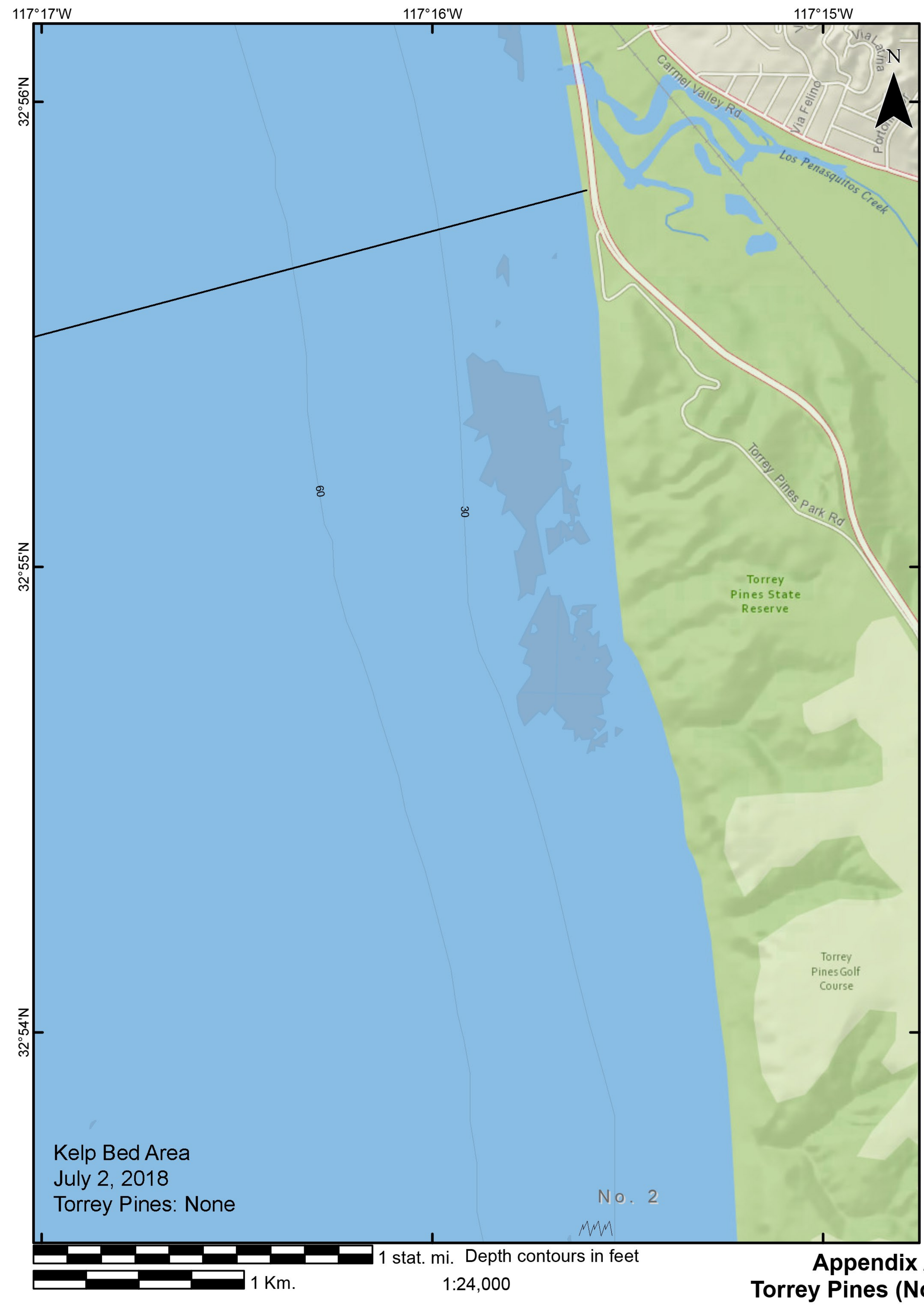
mbc AQUATIC SCIENCES

Appendix A.65
Solana Beach

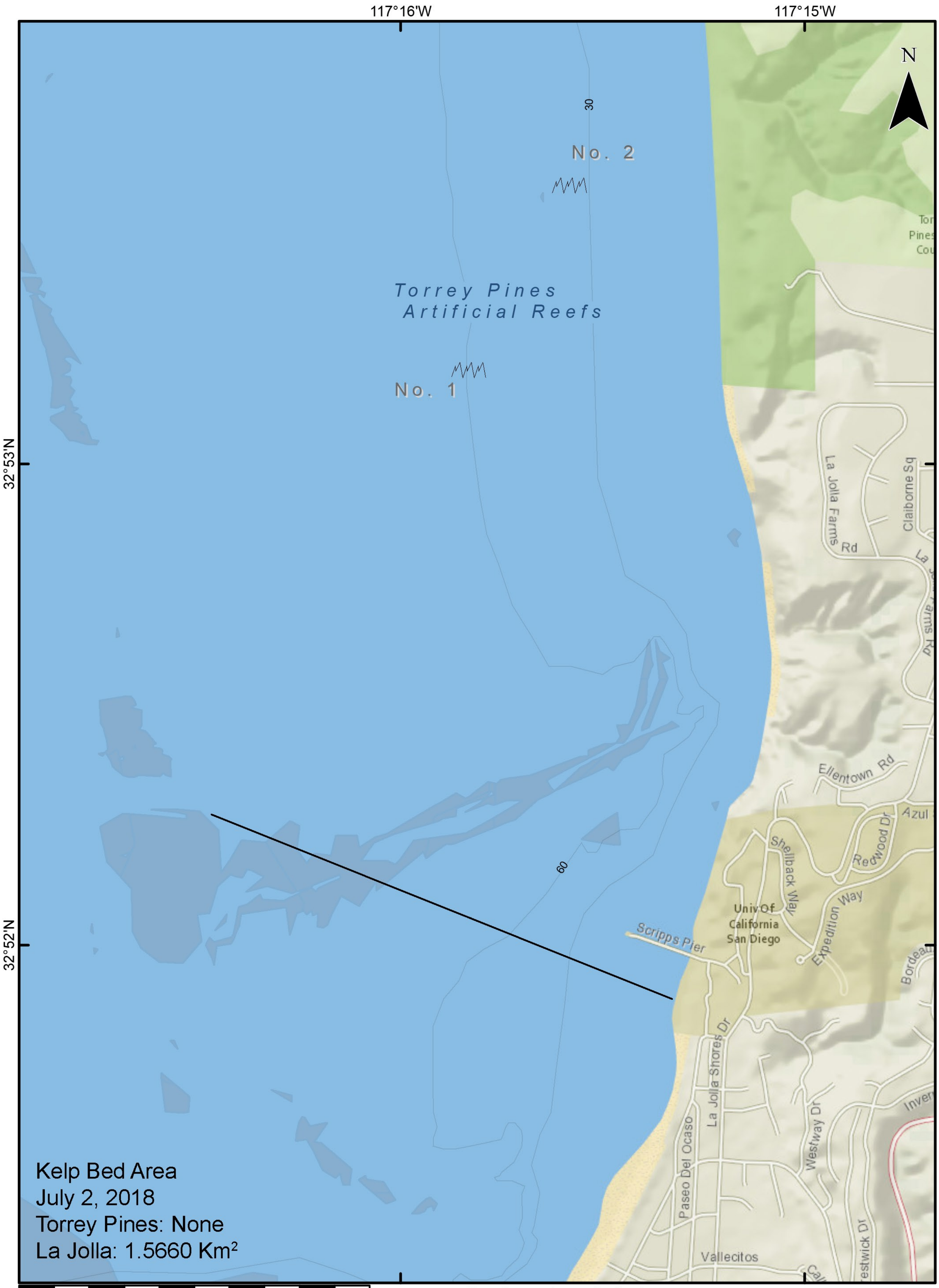




Appendix A.66
Del Mar



Appendix A.67
Torrey Pines (North)



Kelp Bed Area
July 2, 2018
Torrey Pines: None
La Jolla: 1.5660 Km²

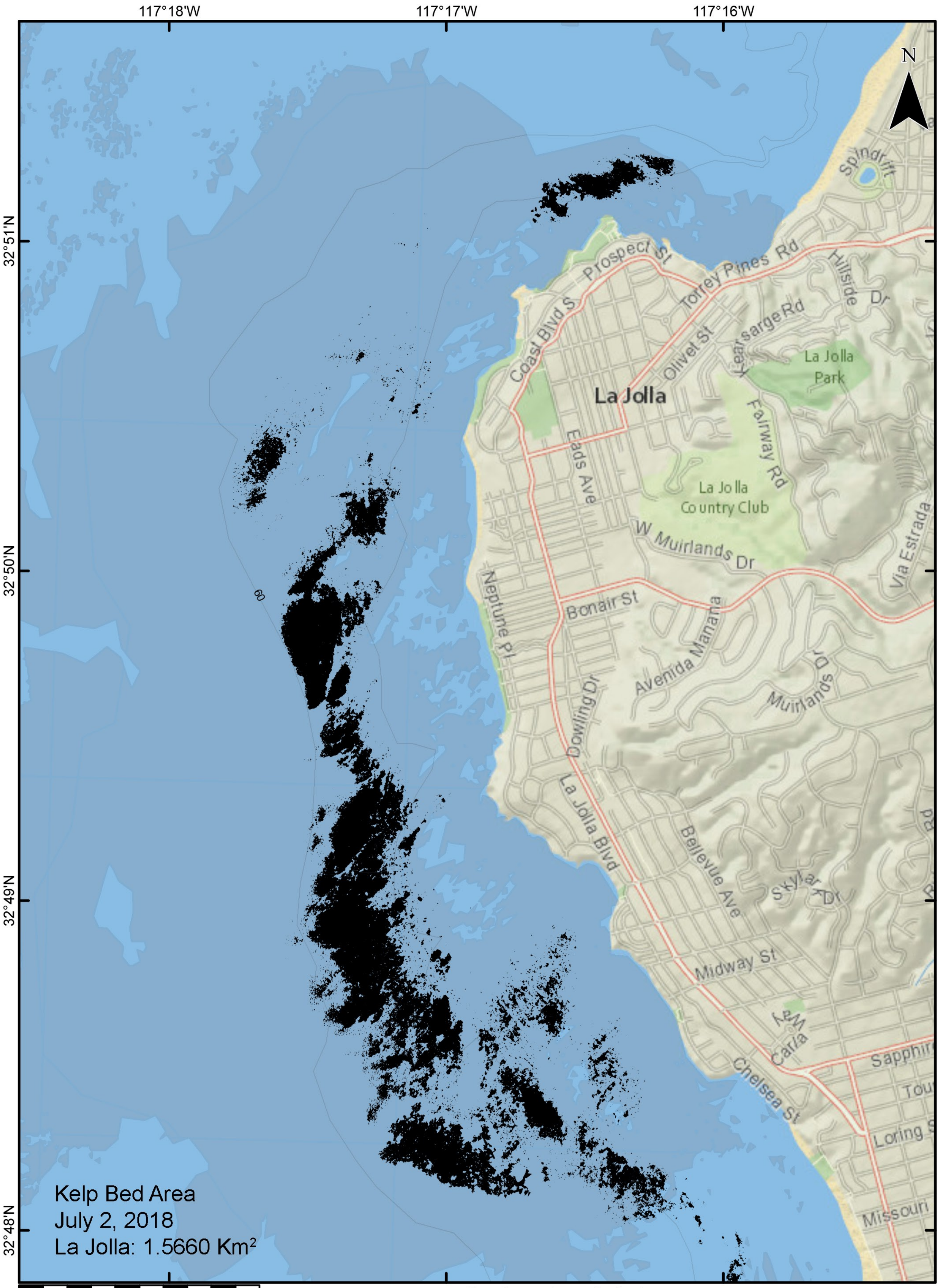
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.68
Torrey Pines Reef (South)

mbc AQUATIC SCIENCES

■ Kelp 2018
Isobath
Artificial Reef
Kelp Bed Divide
Discharge Structure
Hard Substrate



Kelp Bed Area
July 2, 2018
La Jolla: 1.5660 Km^2

1 stat. mi.

1 Km.

Depth contours in feet

1:35,000

Appendix A.69
La Jolla

■ Kelp 2018

Artificial Reef

Discharge Structure

Isobath

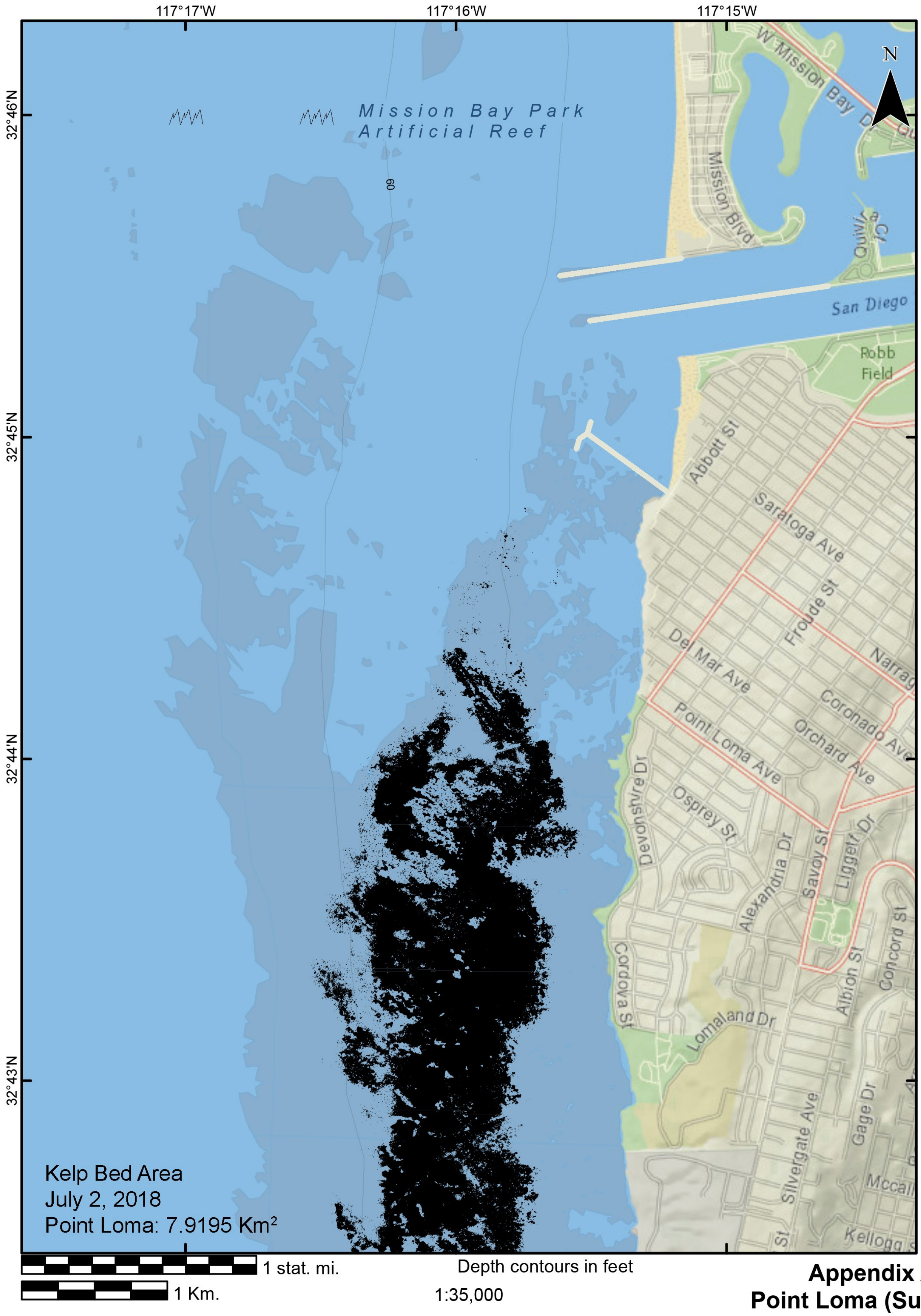
Kelp Bed Divide

Hard Substrate

Appendix A.70
La Jolla/ Mission Bay

mbc AQUATIC SCIENCES

■ Kelp 2018	Artificial Reef
Discharge Structure	Isobath
Kelp Bed Divide	Hard Substrate

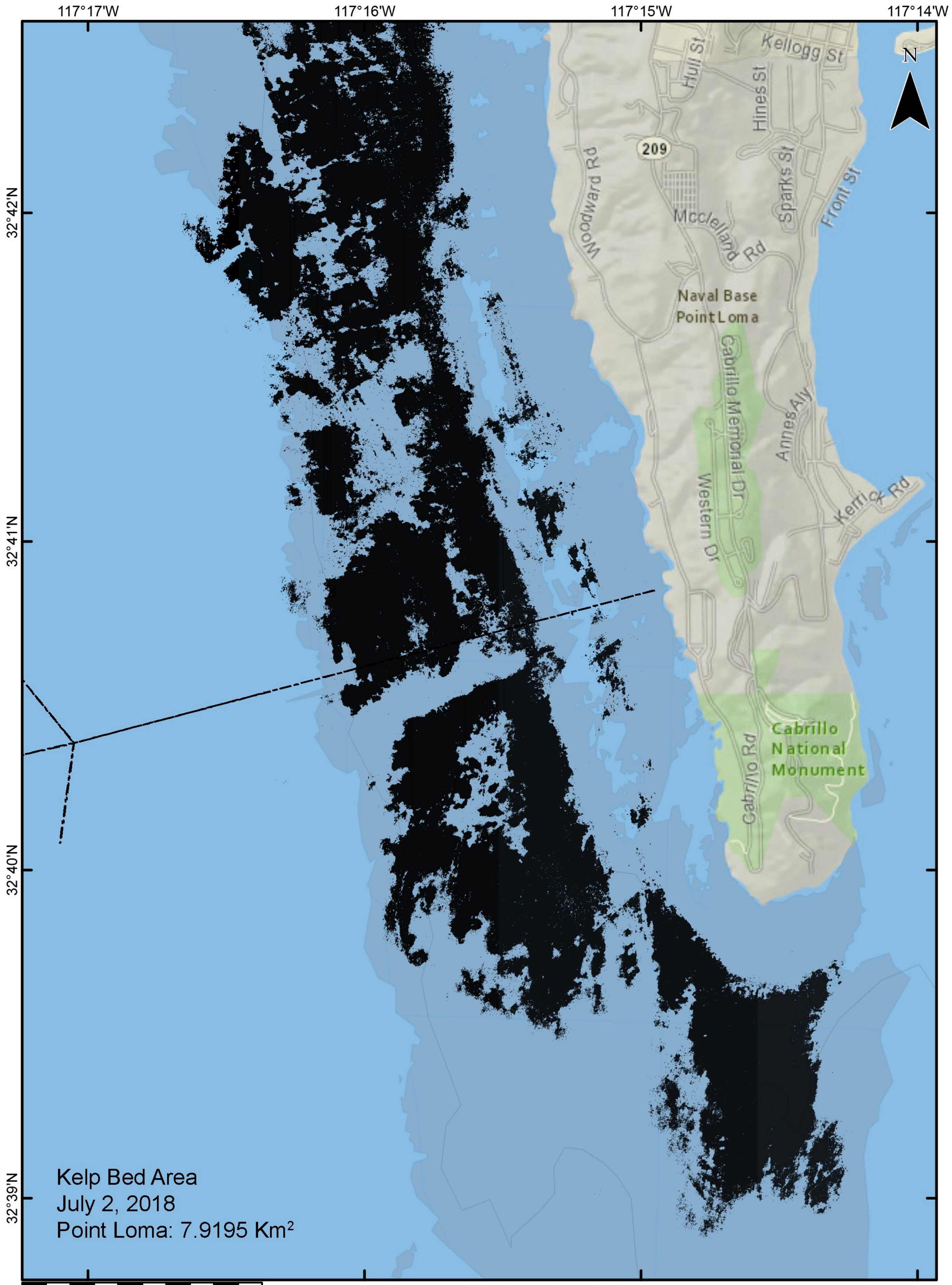


Kelp Bed Area
July 2, 2018
Point Loma: 7.9195 Km²

Appendix A.71
Point Loma (Sunset Cliffs)

mbc AQUATIC SCIENCES

■ Kelp 2018
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)

■ Kelp 2018

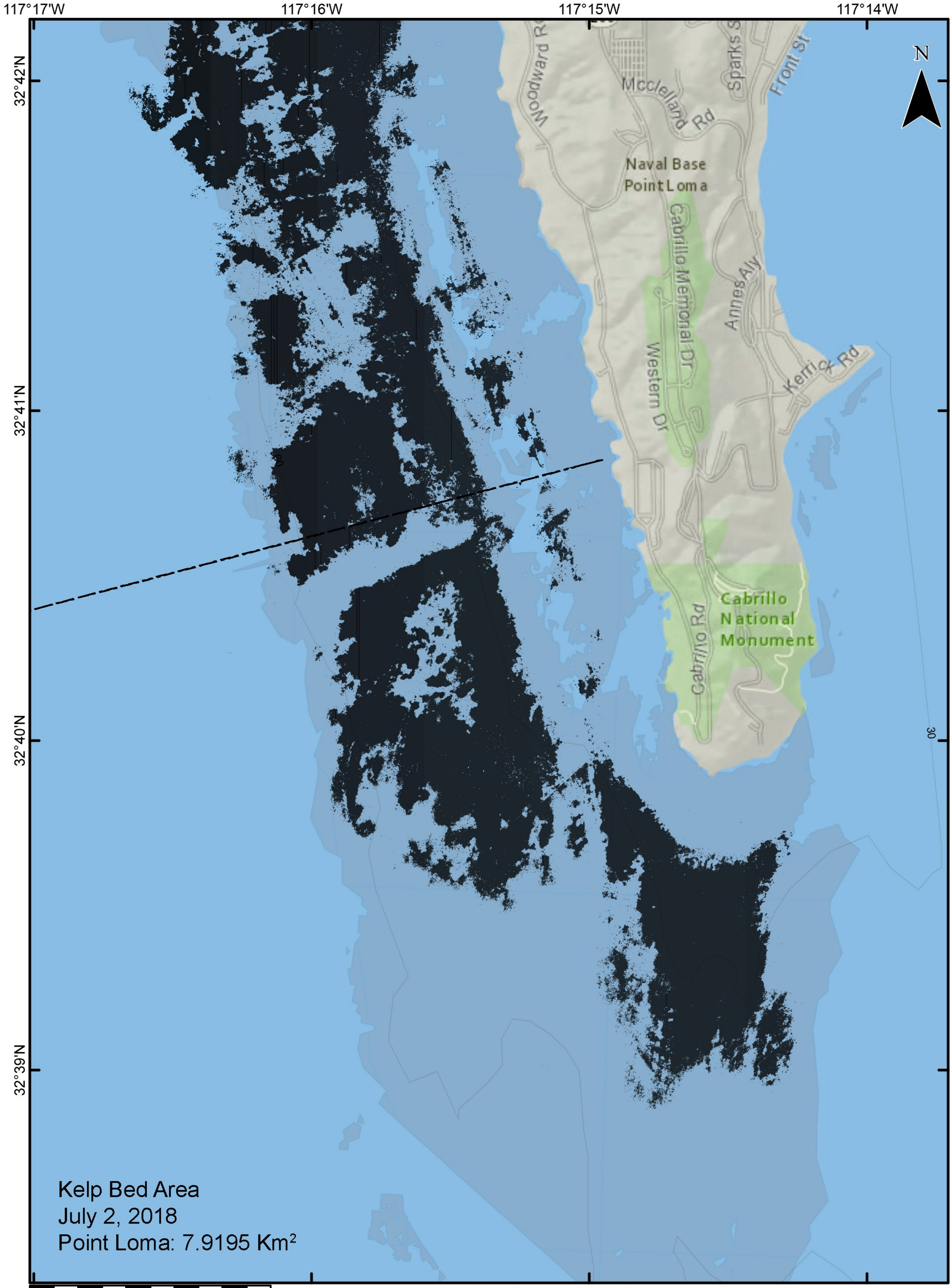
Artificial Reef

Discharge Structure

Isobath

Kelp Bed Divide

Hard Substrate



Kelp Bed Area
July 2, 2018
Point Loma: 7.9195 Km^2

1 stat. mi.

1 Km.

Depth contours in feet

1:35,000

Appendix A.73
Point Loma (bay entrance)

■ Kelp 2018

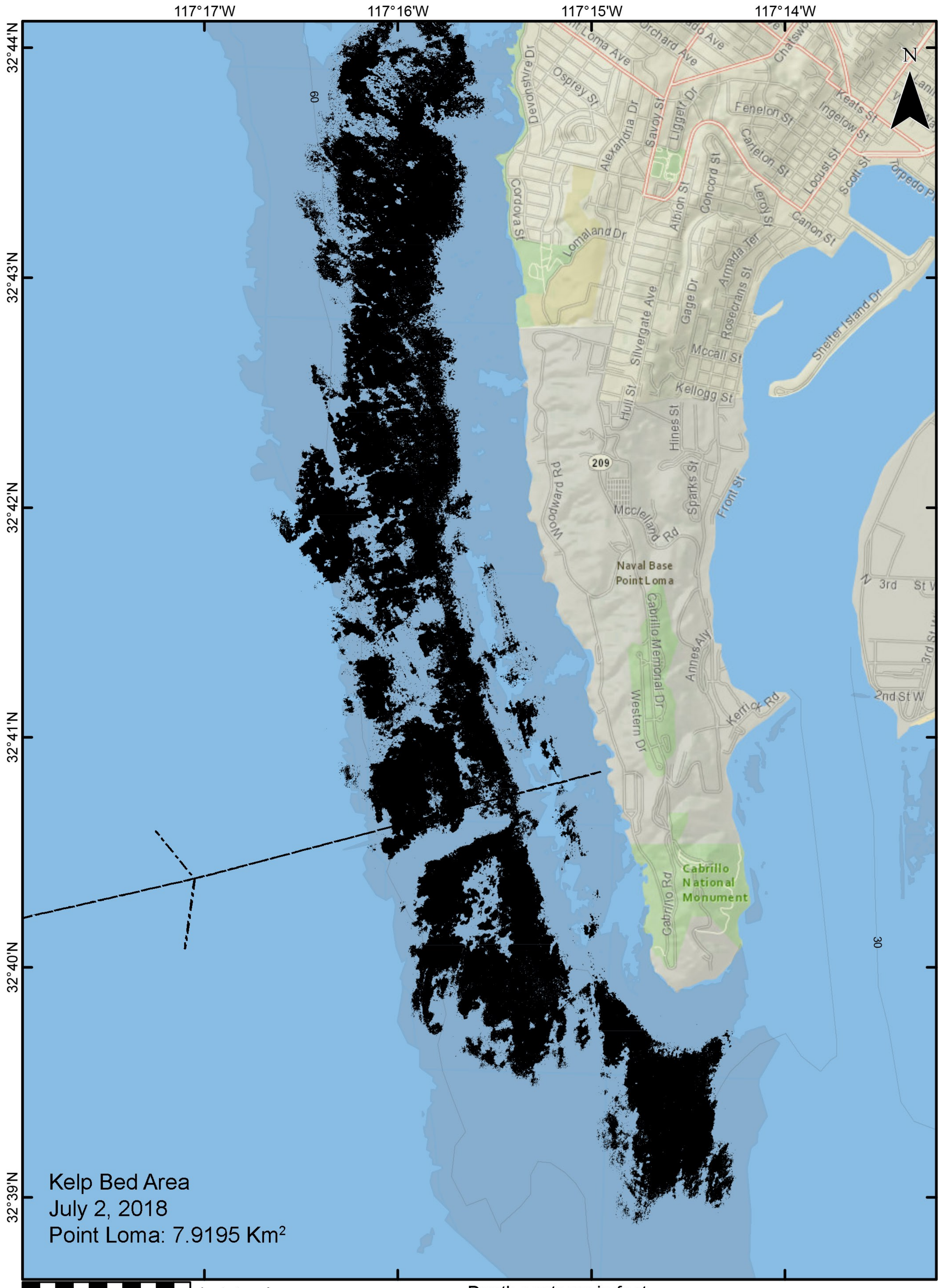
Artificial Reef

Discharge Structure

Isobath

Kelp Bed Divide

Hard Substrate



Kelp Bed Area
July 2, 2018
Point Loma: 7.9195 Km^2

1 stat. mi.

1 Km.

Depth contours in feet

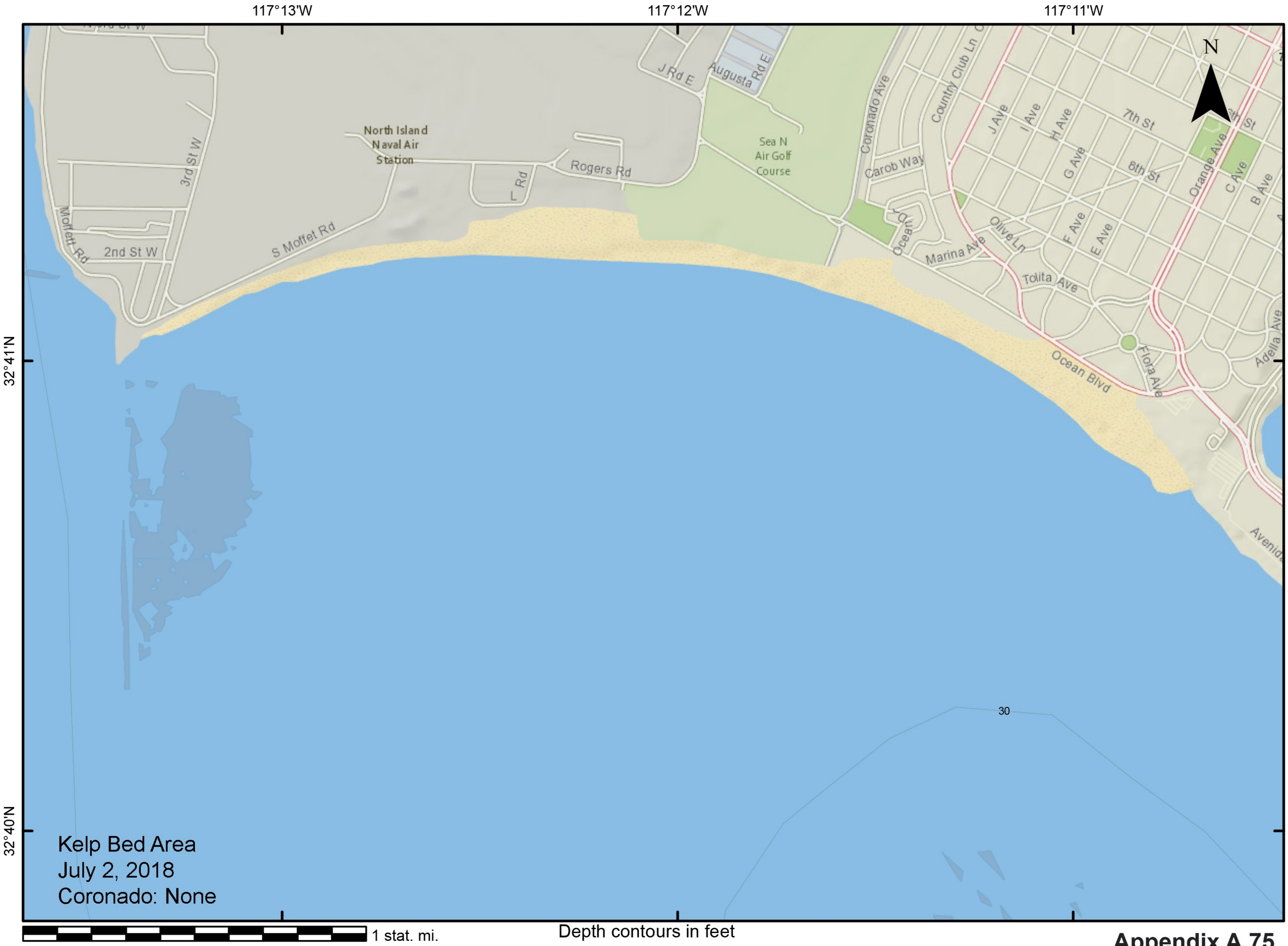
1:50,000

Appendix A.74
Point Loma

mbc AQUATIC SCIENCES

■ Kelp 2018	Isobath
Artificial Reef	Kelp Bed Divide
Discharge Structure	Hard Substrate

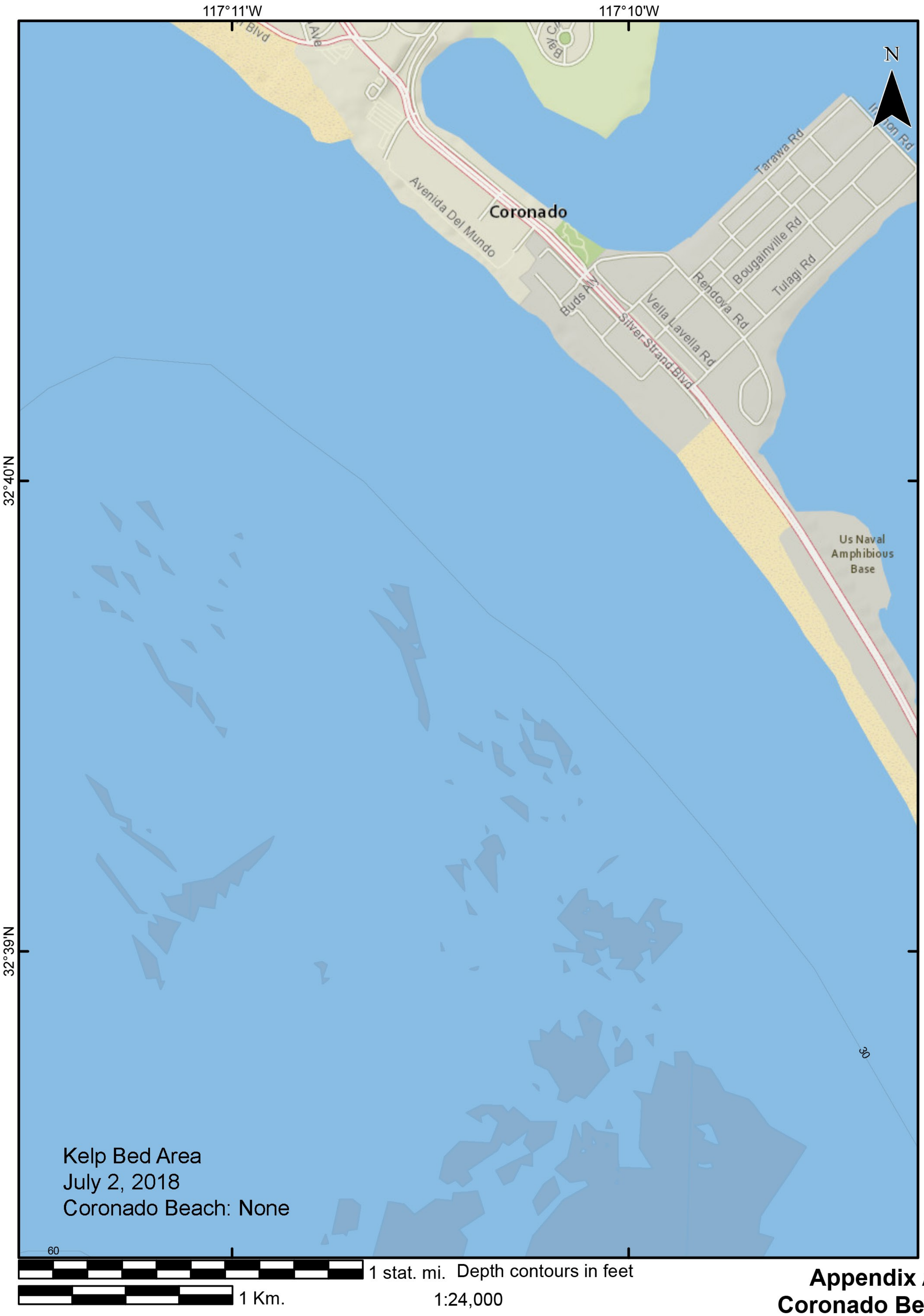
Appendix A.75
Coronado (North Island Naval Air Station)



Kelp Bed Area
July 2, 2018
Coronado: None

Depth contours in feet

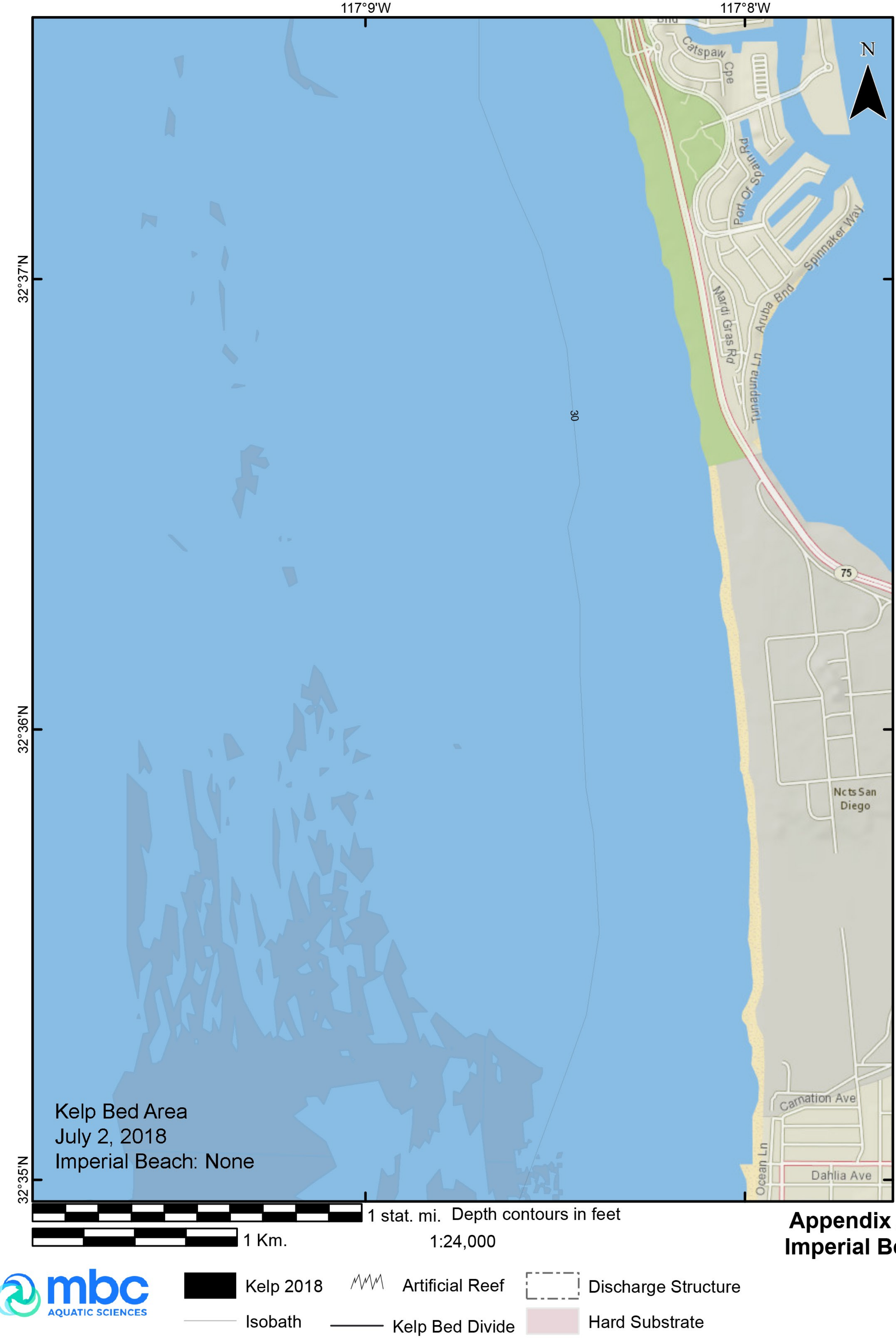
■	Kelp 2018
—	Isobath
—	Kelp Bed Divide
⋀⋀⋀	Artificial Reef
▭	Discharge Structure
▨	Hard Substrate



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

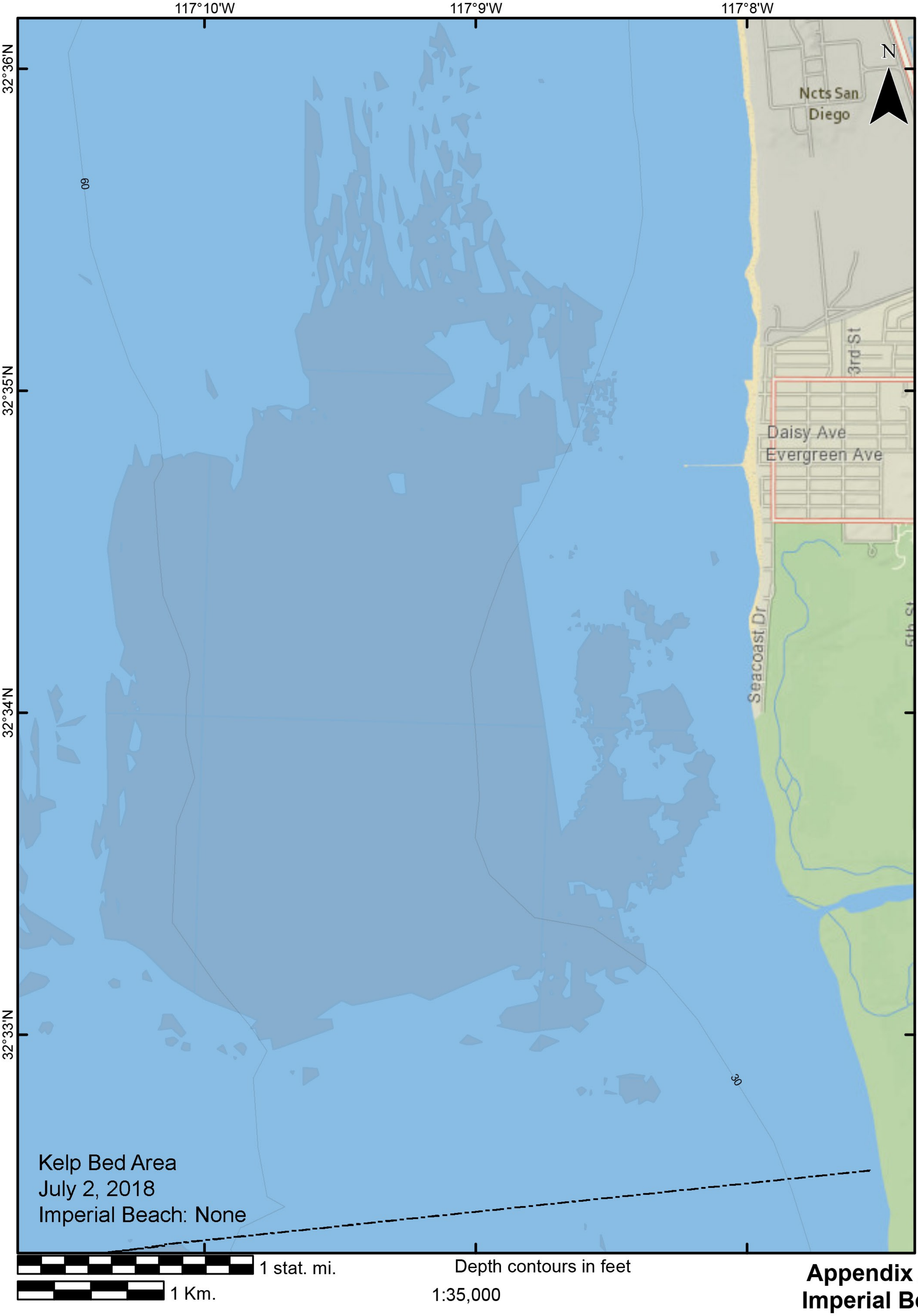
■	Kelp 2018
―	Isobath
/\/\/\/\	Artificial Reef
―	Kelp Bed Divide
▭	Discharge Structure
▨	Hard Substrate

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



Appendix A.78
Imperial Beach

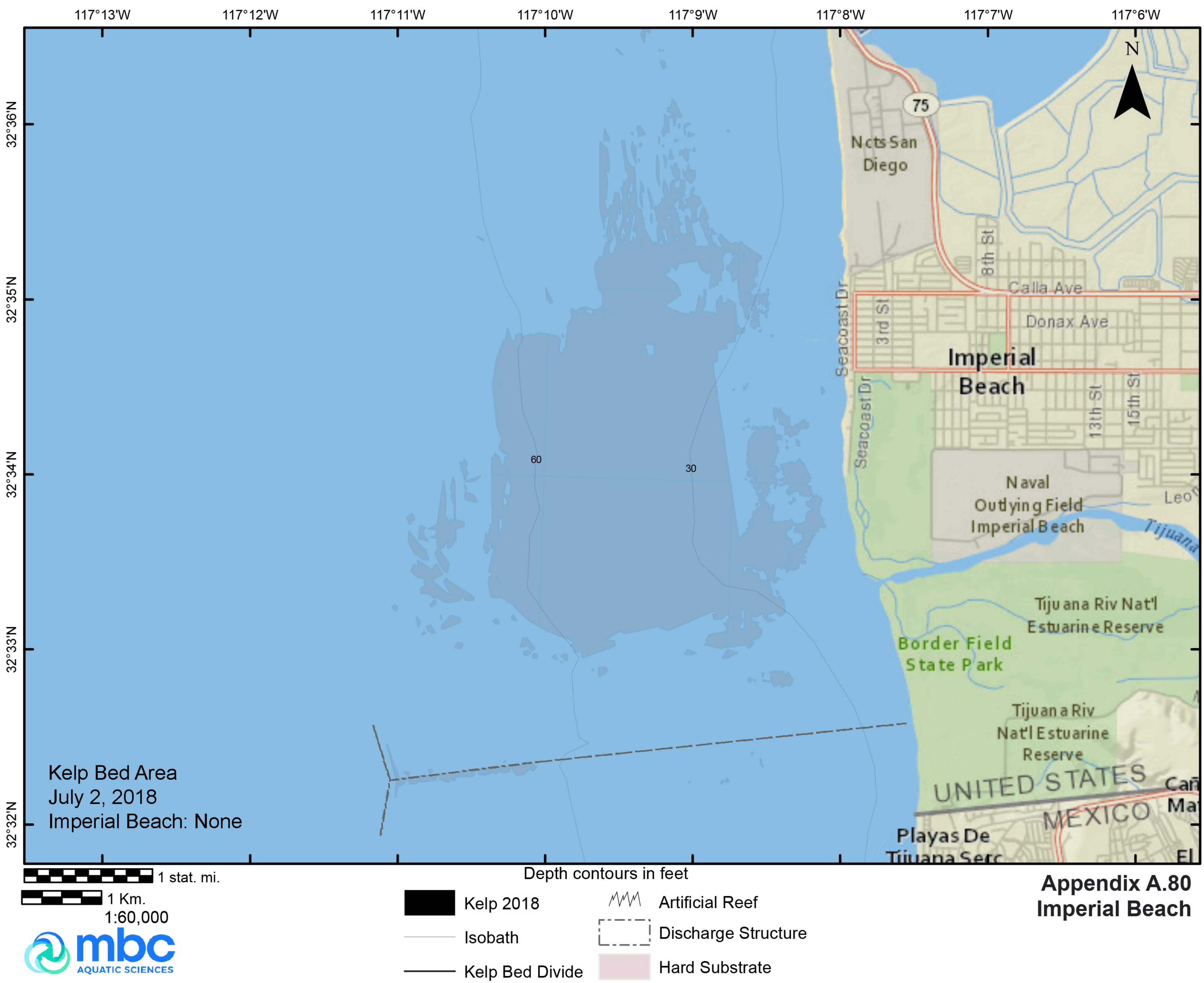
Appendix A.79
Imperial Beach



Kelp Bed Area
July 2, 2018
Imperial Beach: None

■	Kelp 2018	⩘⩘	Artificial Reef	⬚	Discharge Structure
—	Isobath	—	Kelp Bed Divide	▨	Hard Substrate

mbc
AQUATIC SCIENCES



Kelp Bed Area
July 2, 2018
Imperial Beach: None

Depth contours in feet

Appendix A.80
Imperial Beach

APPENDIX B

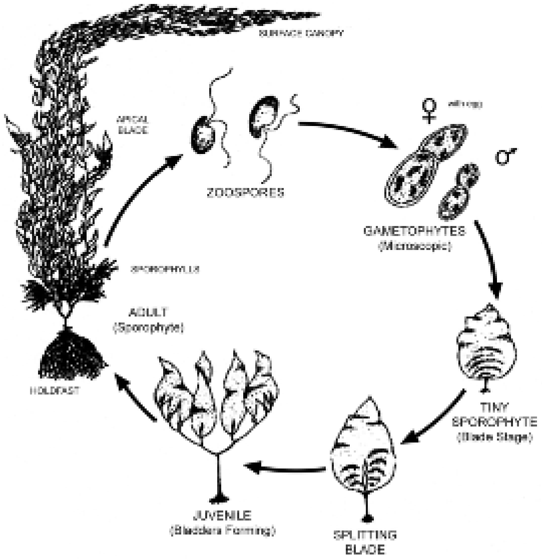
Life History of Giant Kelp
Historical Kelp Surveys
Crandall's Maps

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.

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



Appendix B.1 Life cycle for giant kelp.

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 2018. 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.).

	Canopy Area (km^2)									
Kelp Bed	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	2018
Deer Creek	0.074	0.105	0.062	0.055	0.041	0.104	0.103	0.124	0.087	0.105	0.145
Leo Carillo	0.207	0.255	0.232	0.226	0.337	0.366	0.261	0.408	0.326	0.426	0.633
Nicolas Canyon	0.268	0.433	0.291	0.130	0.240	0.369	0.288	0.347	0.279	0.179	0.321
El Pesc/La Piedra	0.173	0.238	0.164	0.136	0.173	0.236	0.244	0.246	0.160	0.157	0.304
Lechuza	0.075	0.105	0.096	0.096	0.066	0.154	0.137	0.119	0.063	0.086	0.178
Total F&W 17	0.797	1.136	0.844	0.642	0.857	1.229	1.034	1.244	0.914	0.953	1.579
Pt. Dume	0.070	0.104	0.094	0.078	0.154	0.113	0.092	0.169	0.042	0.050	0.164
Paradise Cove	0.223	0.244	0.259	0.109	0.346	0.244	0.223	0.086	0.127	0.024	0.165
Escondido Wash	0.278	0.321	0.267	0.104	0.248	0.243	0.281	0.095	0.084	0.059	0.164
Latigo Canyon	0.124	0.195	0.142	0.070	0.202	0.133	0.212	0.052	0.057	0.044	0.115
Puerco/Amarillo	0.064	0.115	0.126	0.069	0.153	0.105	0.130	0.034	0.027	0.002	0.100
Malibu Pt.	0.011	0.012	0.066	0.074	0.084	0.060	0.039	—	0.035	0.001	0.069
Total F&W 16	0.769	0.991	0.954	0.504	1.189	0.897	0.976	0.436	0.372	0.180	0.778
La Costa	—	0.001	0.001	—	0.003	0.003	0.001	—	—	—	0.0004
Las Flores	0.001	0.005	0.005	0.008	0.025	0.022	0.016	—	—	—	0.006
Big Rock	0.002	0.005	0.006	0.007	0.018	0.017	0.011	0.004	0.001	0.000	0.003
Las Tunas	0.005	0.019	0.015	0.007	0.030	0.029	0.012	0.004	—	0.001	0.007
Topanga	0.001	0.002	0.052	0.041	0.048	0.044	0.016	0.005	—	—	0.016
Sunset	—	0.004	0.008	0.007	0.008	0.010	0.010	0.010	0.015	0.003	0.014
Total F&W 15	0.009	0.035	0.087	0.069	0.131	0.123	0.064	0.022	0.017	0.004	0.046
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	1.758
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	1.021
Total F&W 14	2.140	2.692	1.760	1.591	1.825	1.476	0.732	2.160	1.850	1.624	2.779
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	0.547
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	1.143
Cabrillo	0.060	0.163	0.124	0.103	0.095	0.174	0.158	0.133	0.235	0.329	0.312
Total F&W 13	0.776	1.306	0.734	0.805	0.774	1.124	0.915	0.990	1.210	1.557	2.002
Total PV	2.916	3.998	2.494	2.396	2.599	2.600	1.647	3.149	3.060	3.181	4.781
POLA—POLB Harbor	0.213	0.151	0.277	0.397	0.495	0.337	0.196	0.359	0.359	0.531	0.565
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	0.119
Total F&W 10	0.302	0.246	0.438	0.816	0.890	0.765	0.561	0.404	0.395	0.563	0.684
TOTAL	4.793	6.406	4.817	4.427	5.665	5.614	4.283	5.255	4.757	4.881	7.869

Appendix B.4 Historical canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 1911 through 2018. 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.).

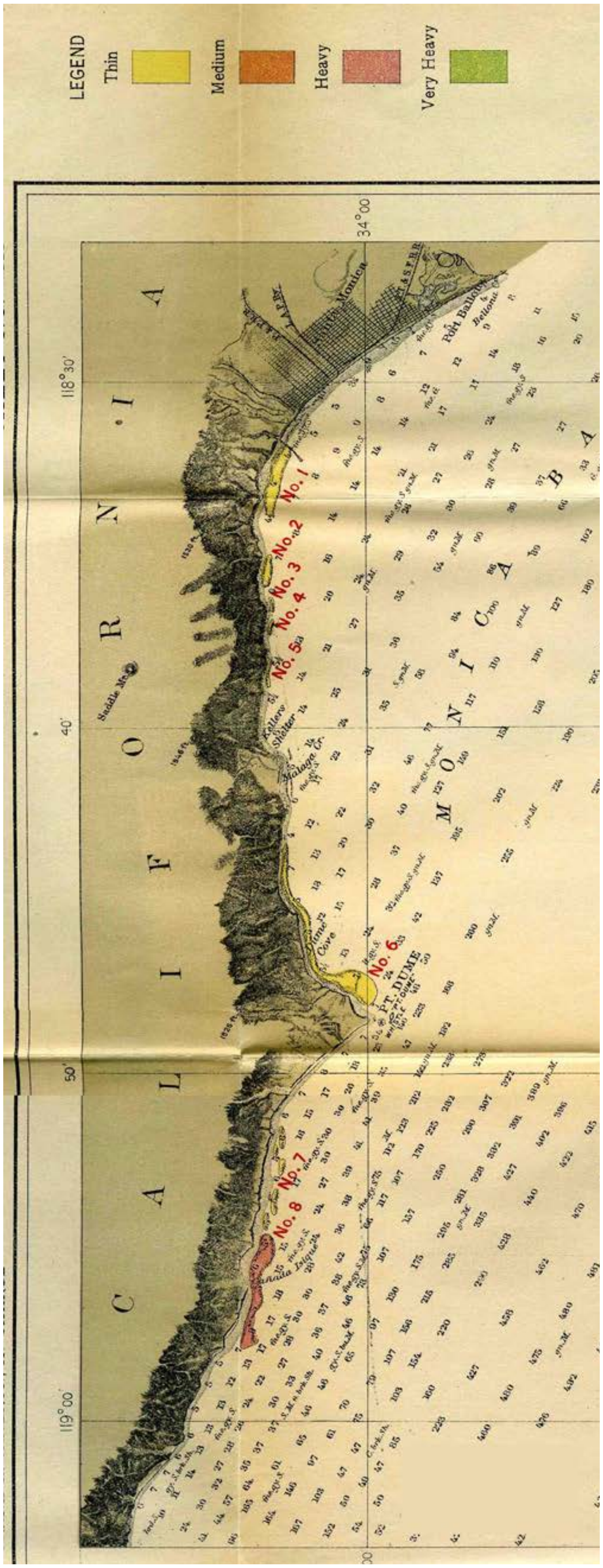
	Canopy Area (km^2)											
Kelp Bed	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
North Laguna Beach	0.028	0.022	0.028	0.042	0.055	0.034	0.029	—	—	—	—	0.001
South Laguna Beach	0.077	0.041	0.087	0.145	0.264	0.243	0.093	0.056	0.028	—	—	—
South Laguna	—	—	—	0.023	0.041	0.023	0.030	0.009	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.).

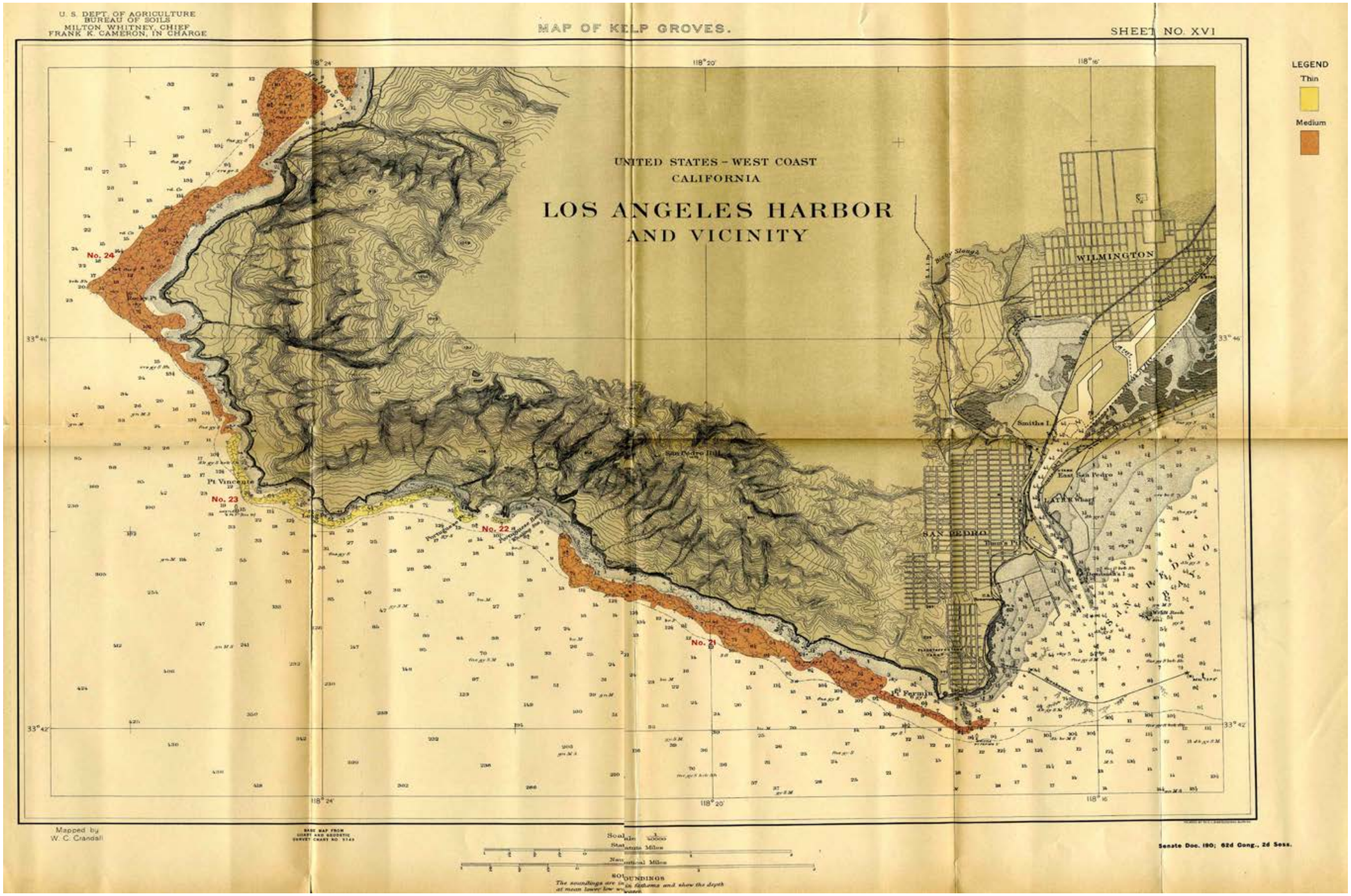
	Canopy Area (km^2)										
Kelp Bed	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
North Laguna Beach	—	—	—	—	—	—	0.0004	—	—	—	—
South Laguna Beach	—	—	—	—	—	0.005	0.0002	0.008	—	—	0.001
South Laguna	—	—	—	0.003	0.002	<0.001	0.004	0.009	0.003	—	0.004
Dana Point-Salt Creek	0.034	0.005	0.080	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.).

	Canopy Area (km^2)										
Kelp Bed	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
North Laguna Beach	0.002	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133
South Laguna Beach	0.025	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131
South Laguna	0.023	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003	0.048
Dana Point-Salt Creek	1.068	0.892	0.839	0.442	0.607	0.835	0.528	0.137	0.110	0.133	0.379
Capistrano Beach	0.071	0.071	0.124	0.010	0.056	0.099	0.034	0.007	0.012	0.0004	0.018
Total F&W 9	1.189	1.043	1.178	0.838	1.086	1.385	0.879	0.287	0.237	0.264	0.709
San Clemente	0.203	0.210	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229	0.335
San Mateo Point	0.487	0.545	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033	0.083
San Onofre	0.476	0.419	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087	0.127
Total F&W 8	1.166	1.174	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349	0.545
Horno Canyon	0.083	0.018	0.081	—	0.008	0.125	0.055	0.019	0.010	0.011	0.008
Barn Kelp	0.858	0.926	0.500	0.095	0.442	0.868	0.741	0.085	0.133	0.096	0.092
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	0.100
North Carlsbad	0.108	0.135	0.078	0.017	0.052	0.125	0.086	0.047	—	0.004	0.038
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	0.045
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	0.083
Leucadia	0.421	0.429	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010	0.053
Encinitas	0.346	0.205	0.128	0.124	0.260	0.231	0.112	0.113	0.009	0.003	0.033
Cardiff	0.484	0.520	0.213	0.395	0.459	0.590	0.299	0.318	0.024	0.003	0.005
Solana Beach	0.823	0.505	0.328	0.504	0.442	0.606	0.504	0.316	0.138	0.029	0.024
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	0.114
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	1.566
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	7.920
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	11.037

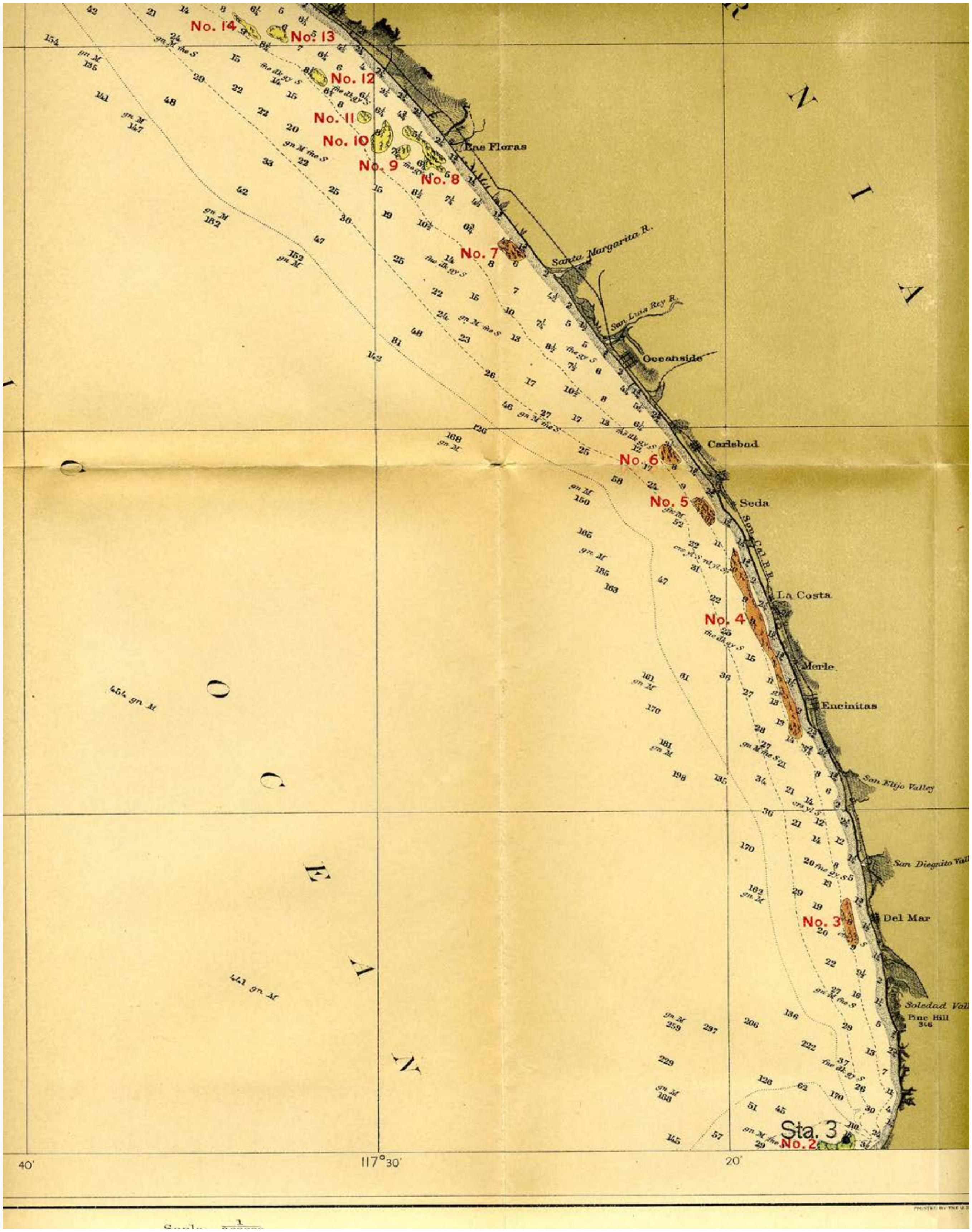


Appendix B.5 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.

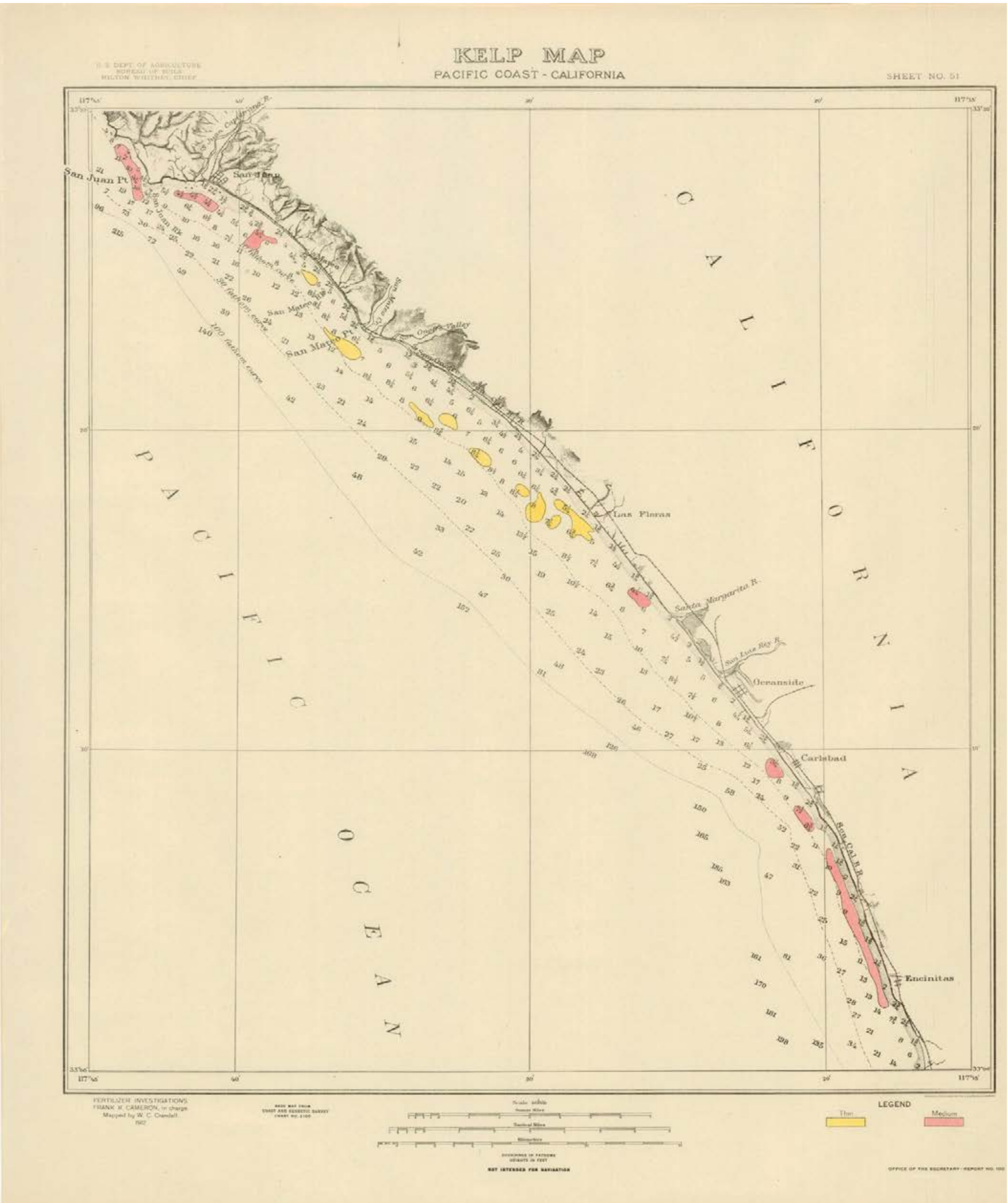


Appendix B.6 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.

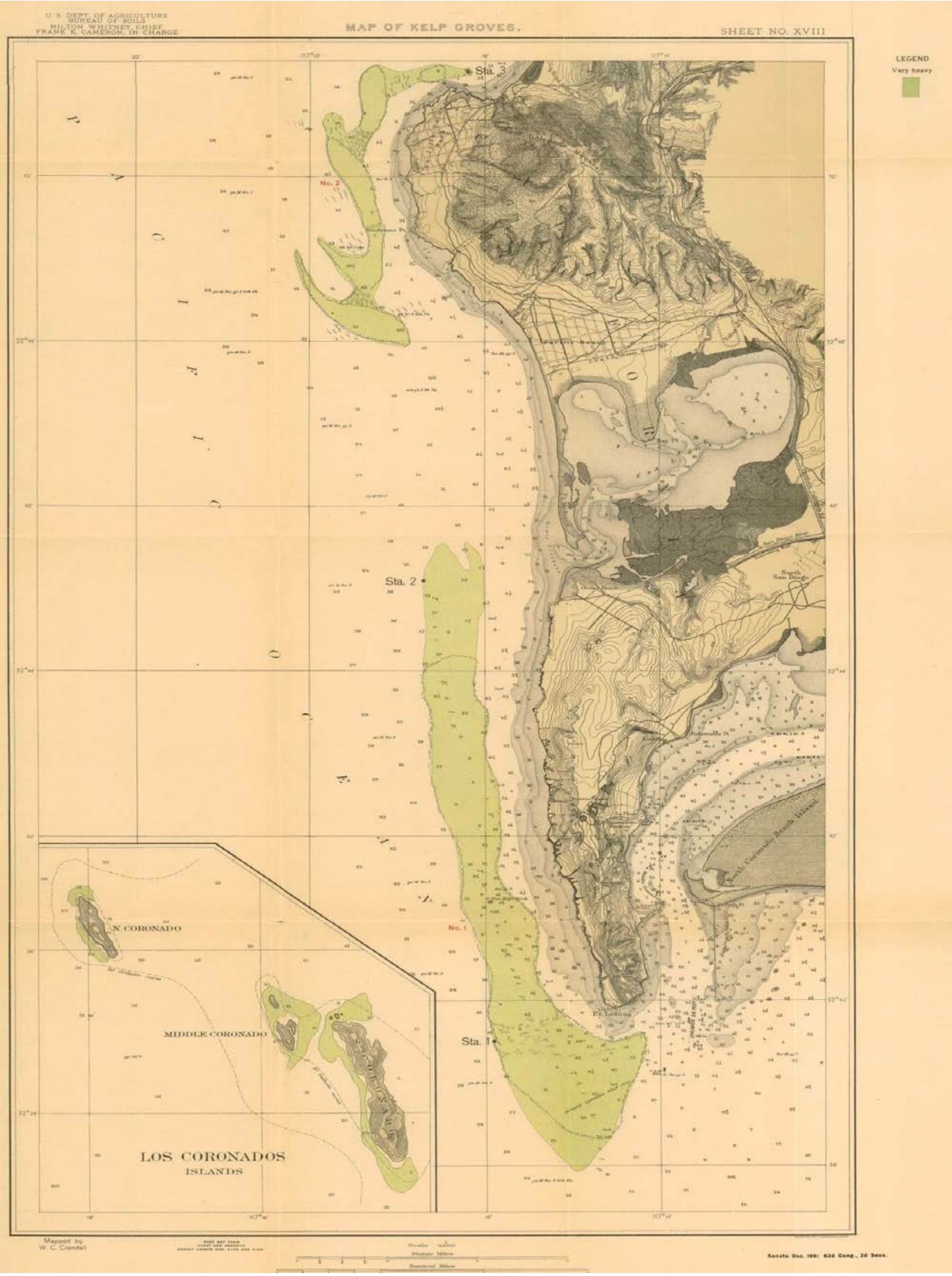
Appendix B.7 Crandall's 1911 kelp bed survey Newport to San Onofre.



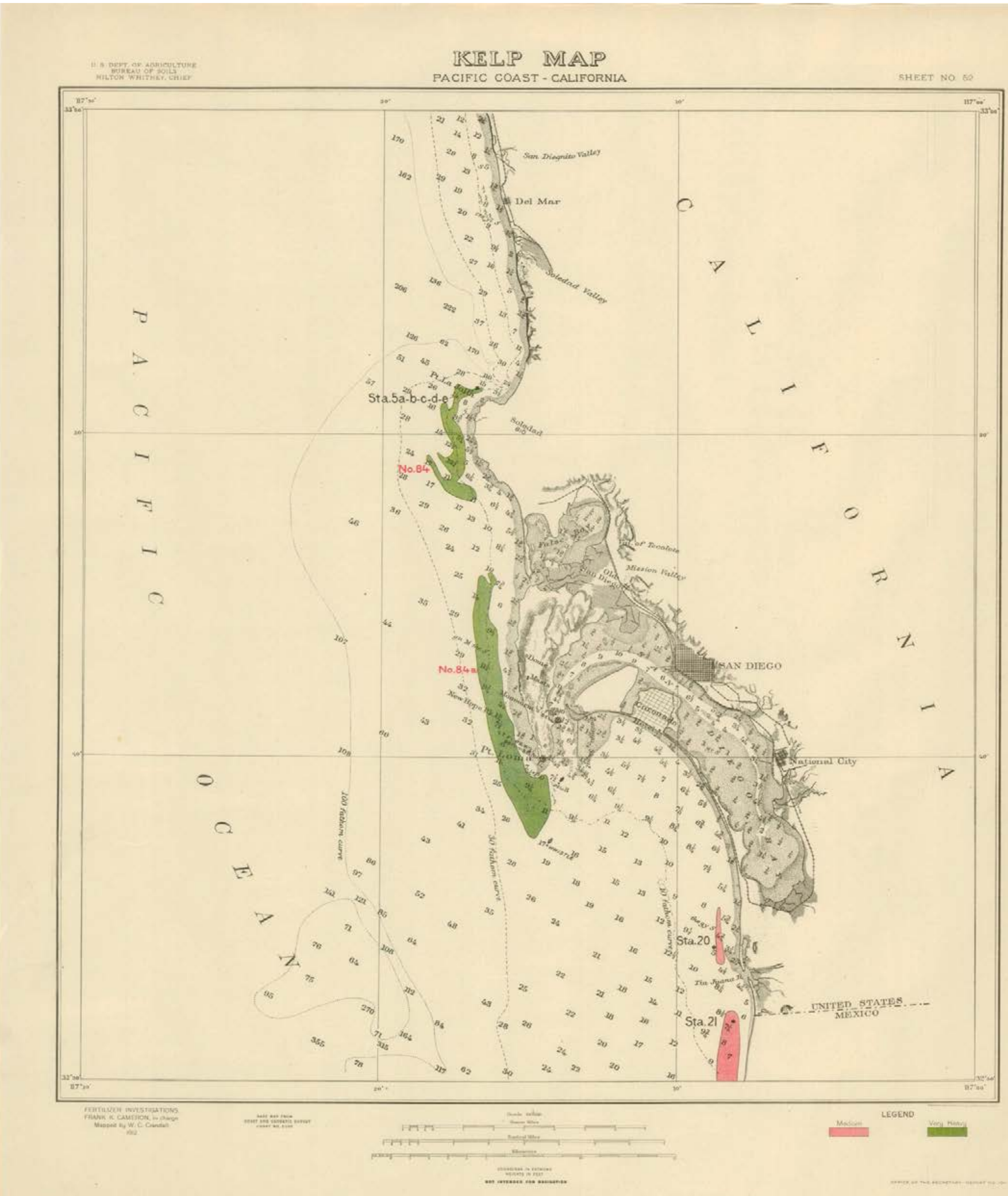
Appendix B.8 Crandall's 1911 kelp bed survey San Onofre to Del Mar.



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



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

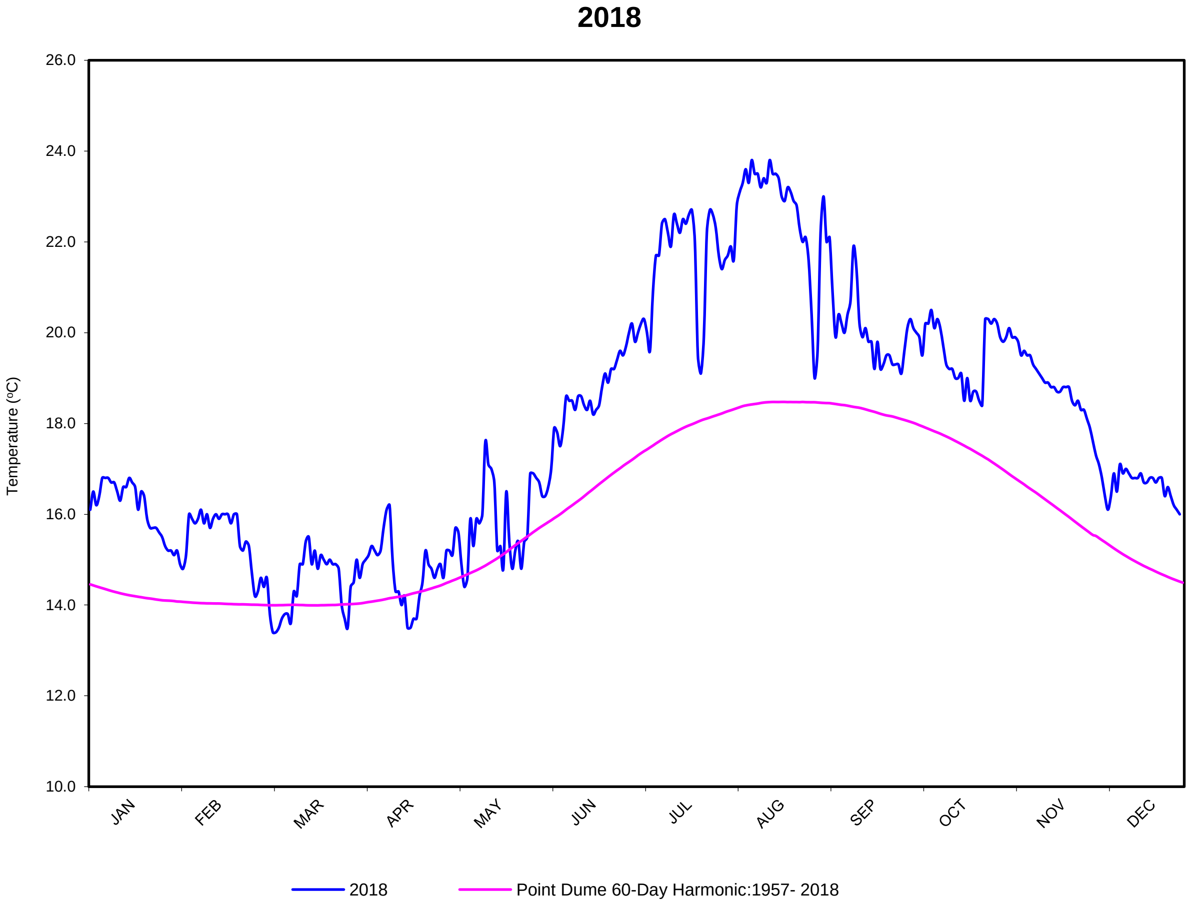


Appendix B.11 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

APPENDIX C

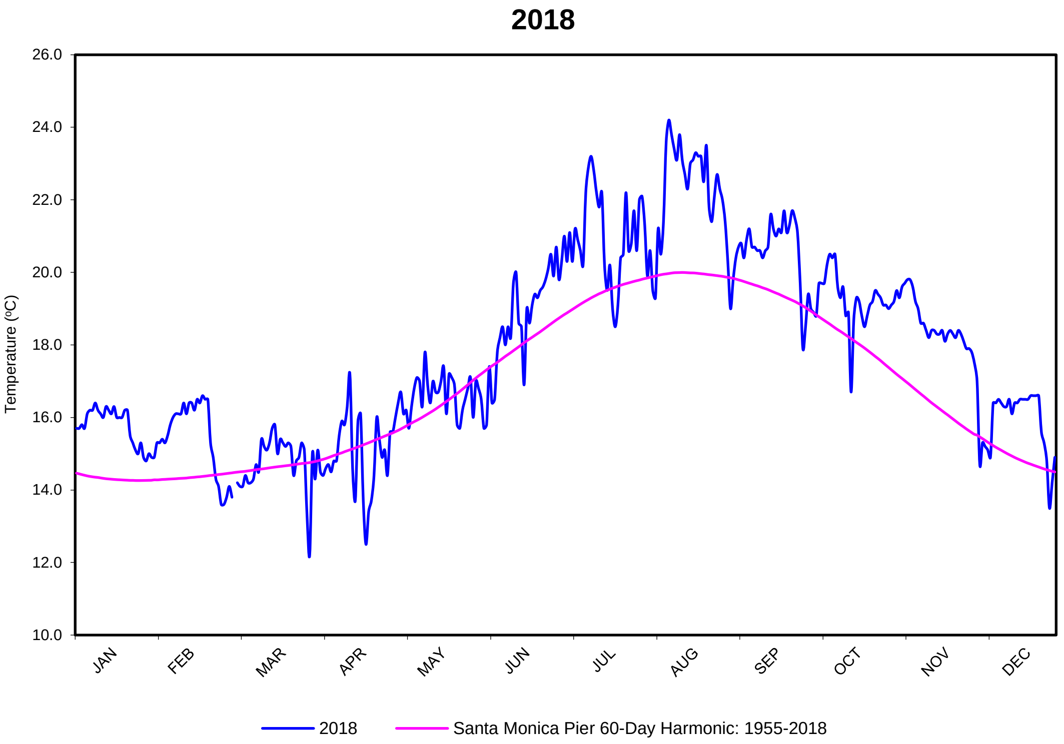
Sea Surface Temperatures

Point Dume
Sea Surface Temperature

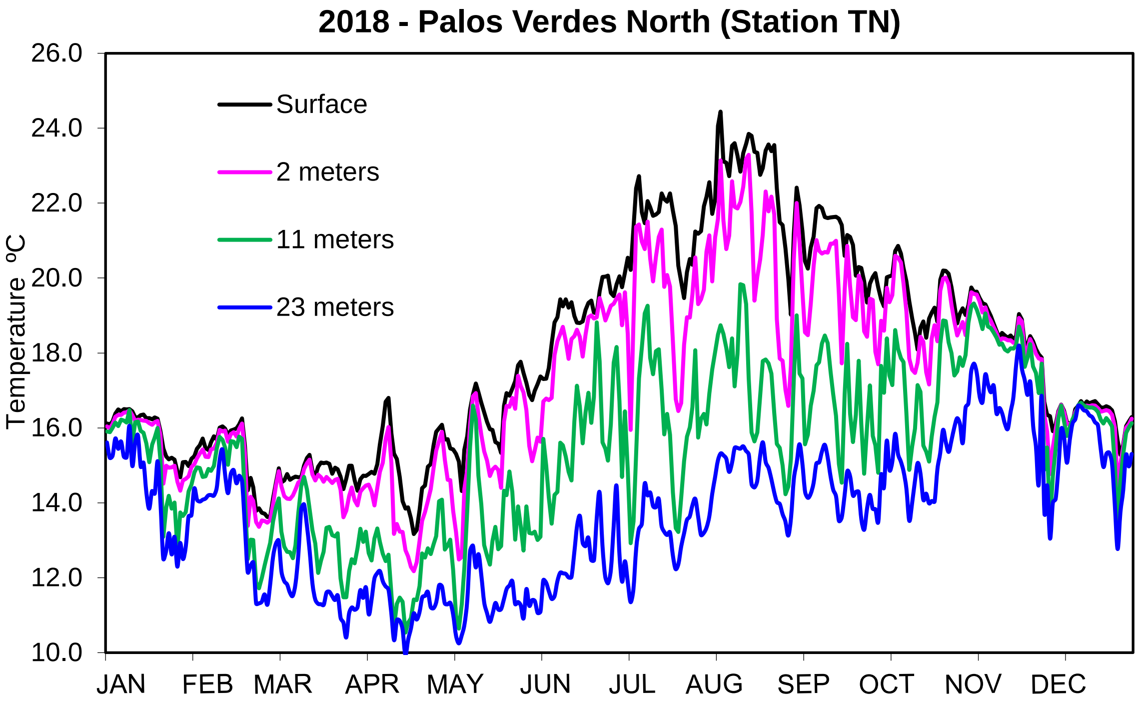


Appendix C.1 Daily sea surface temperatures (SST) at Point Dume for 2018.

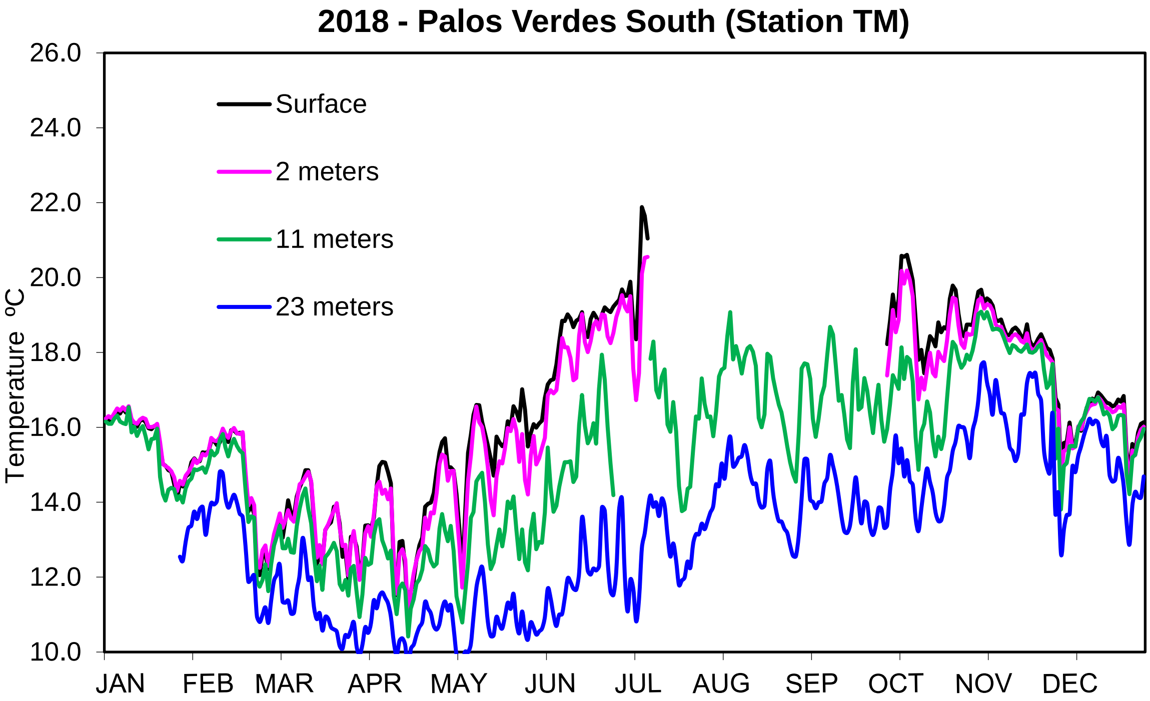
Santa Monica Pier
Sea Surface Temperature



Appendix C.2 Daily sea surface temperatures (SST) at Santa Monica Station Buoy for 2018.

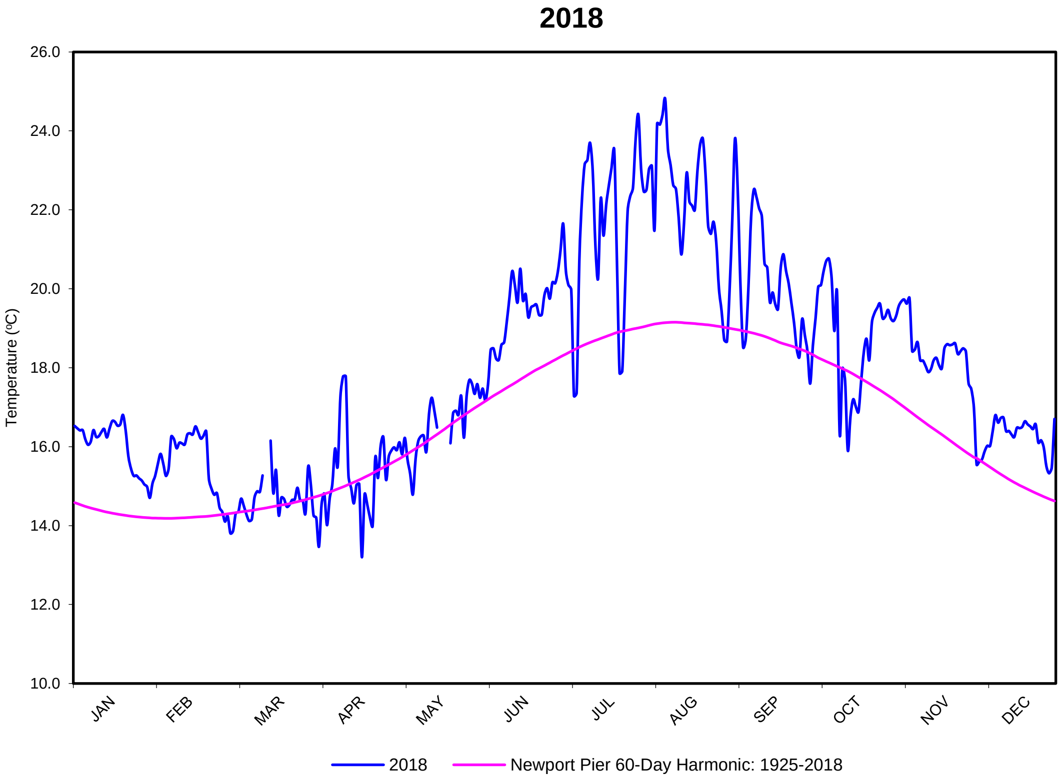


Appendix C.3. Daily sea surface temperatures (SST) at Station Palos Verdes North



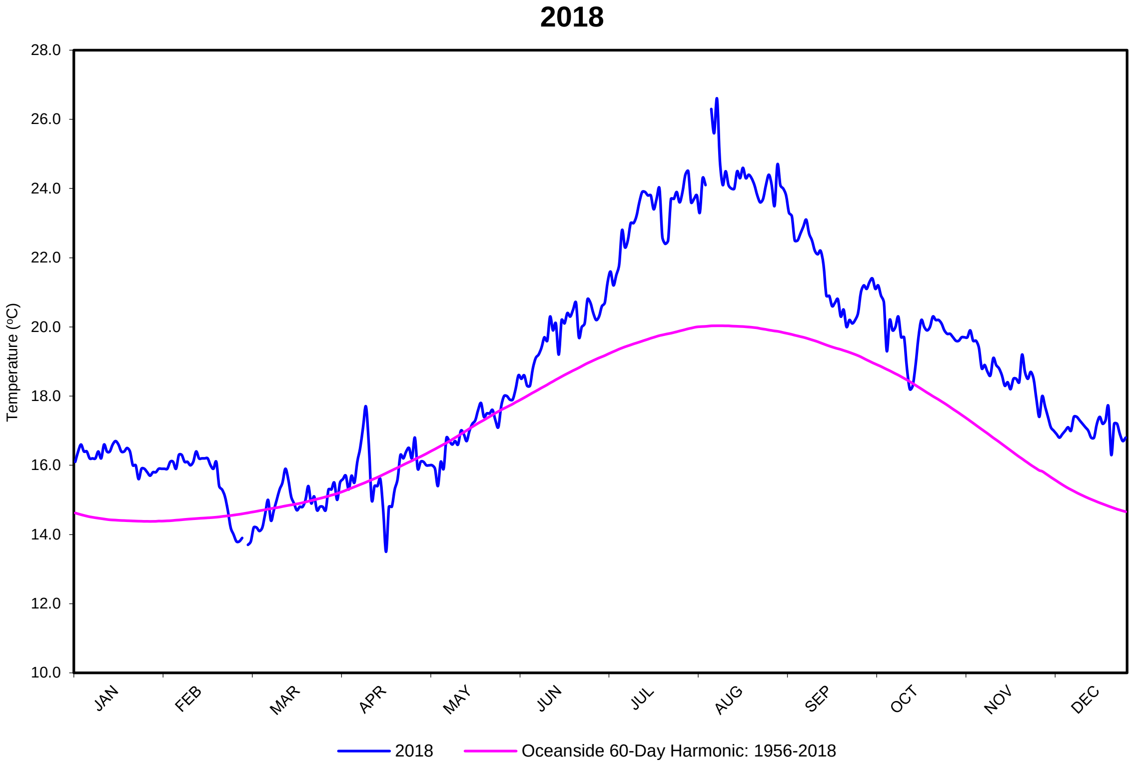
Appendix C.4. Daily sea surface temperatures (SST) at Station Palos Verdes South

Newport Pier
Sea Surface Temperature



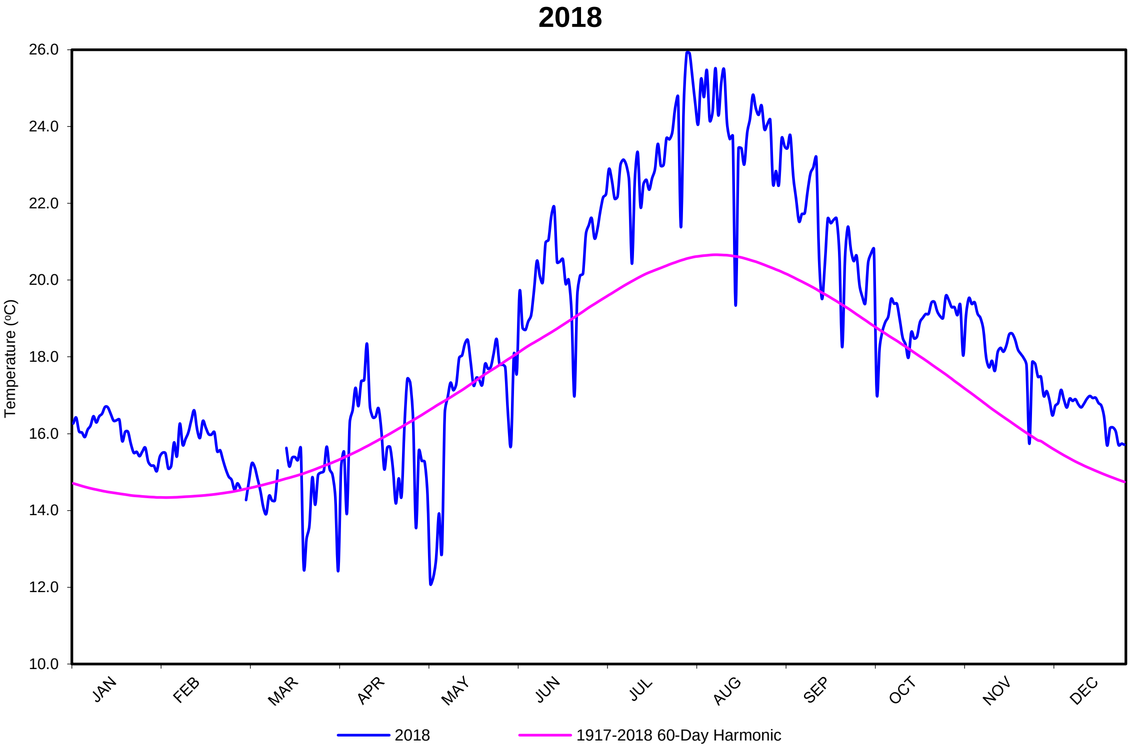
Appendix C.5 Daily sea surface temperatures (SST) at Newport Pier for 2018.

Oceanside
Sea Surface Temperature



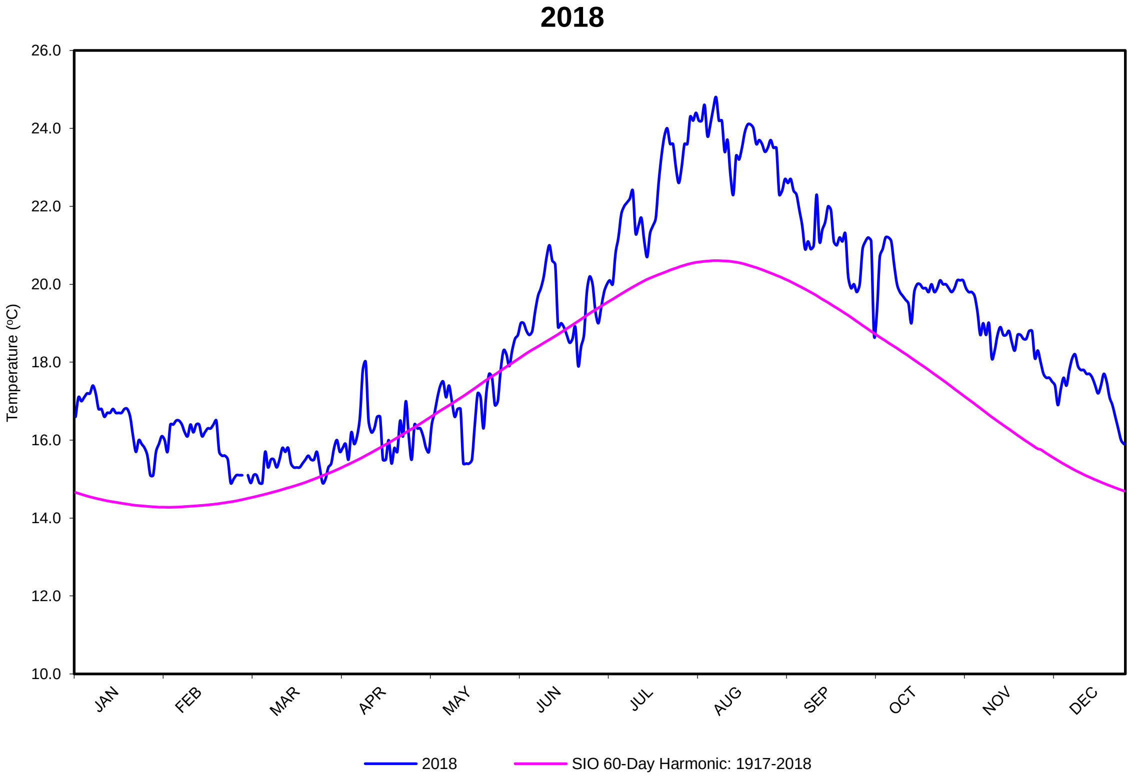
Appendix C.6 Daily sea surface temperatures (SST) at Oceanside for 2018.

Scripps Pier
Sea Surface Temperature



Appendix C.7 Daily sea surface temperatures (SST) at Scripps Pier for 2018.

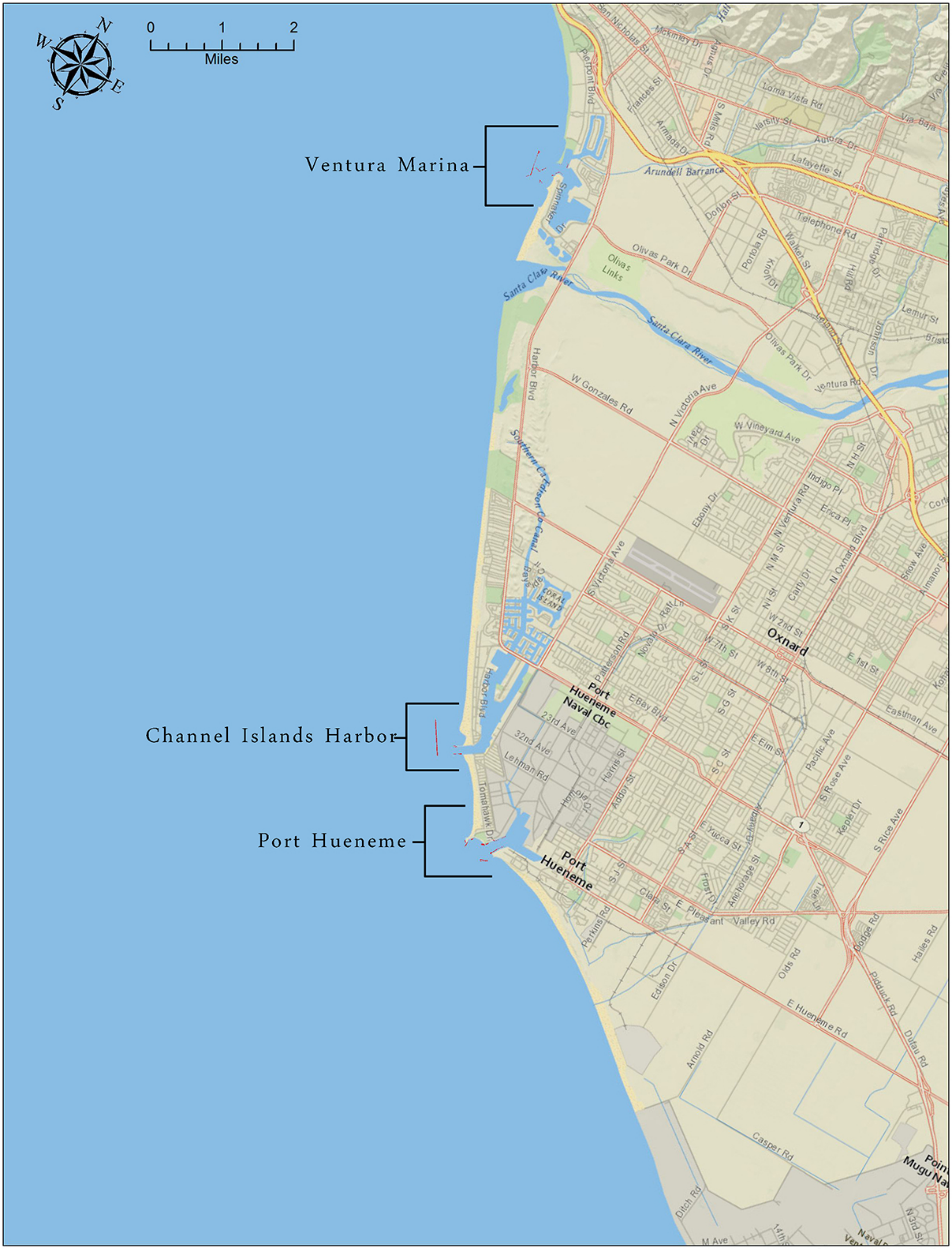
Point Loma South
Sea Surface Temperature



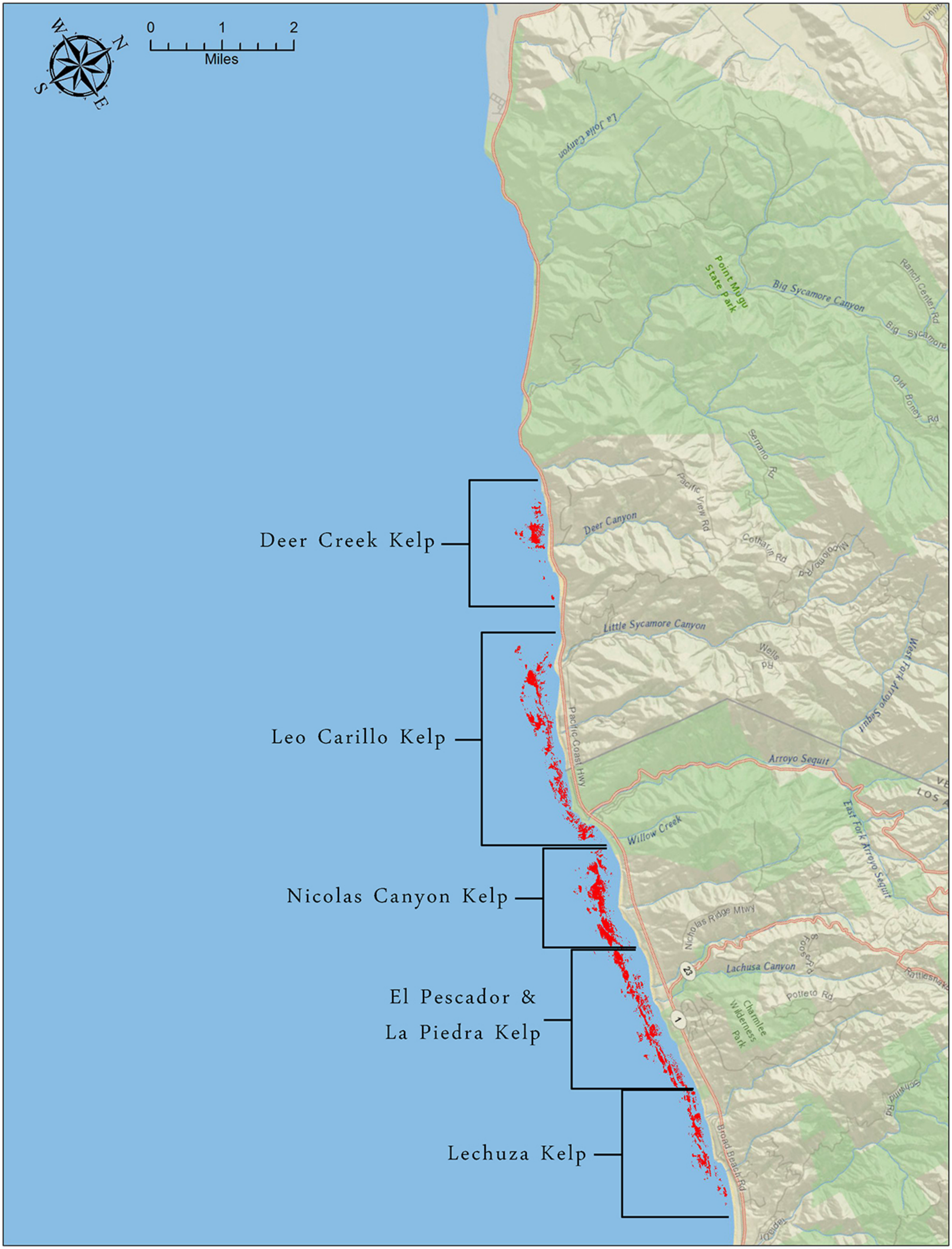
Appendix C.8 Daily sea surface temperatures (SST) at Point Loma South for 2018.

APPENDIX D

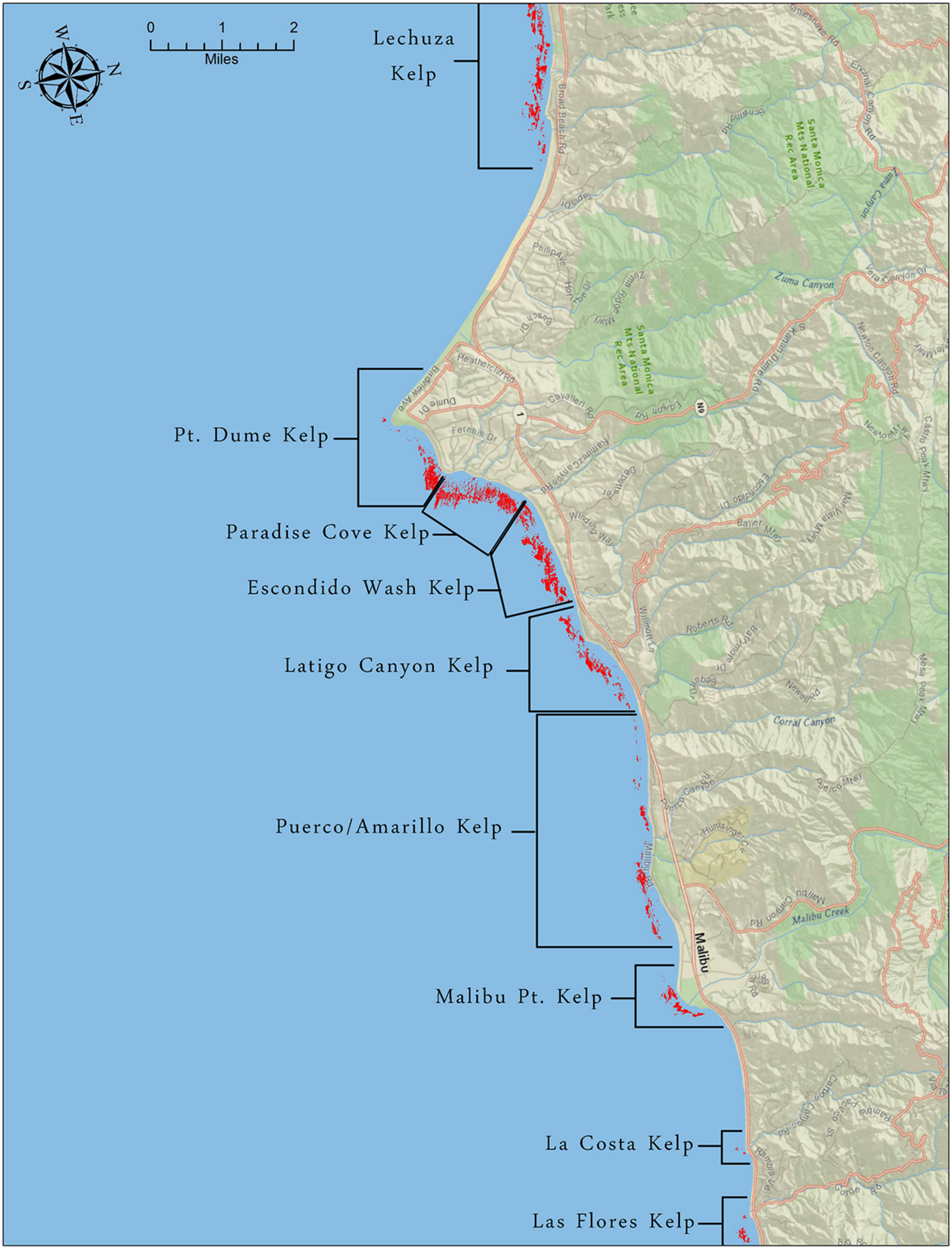
Flight Path
Flight Data Reports
Field Data Sheets


N
E
S
W
0
1
2
Miles
Ventura Marina
Channel Islands Harbor
Port Hueneme
Santa Clara River
Oxnard
Port Hueneme Naval Cbc
Port Hueneme
Olivas Links
Coral Island

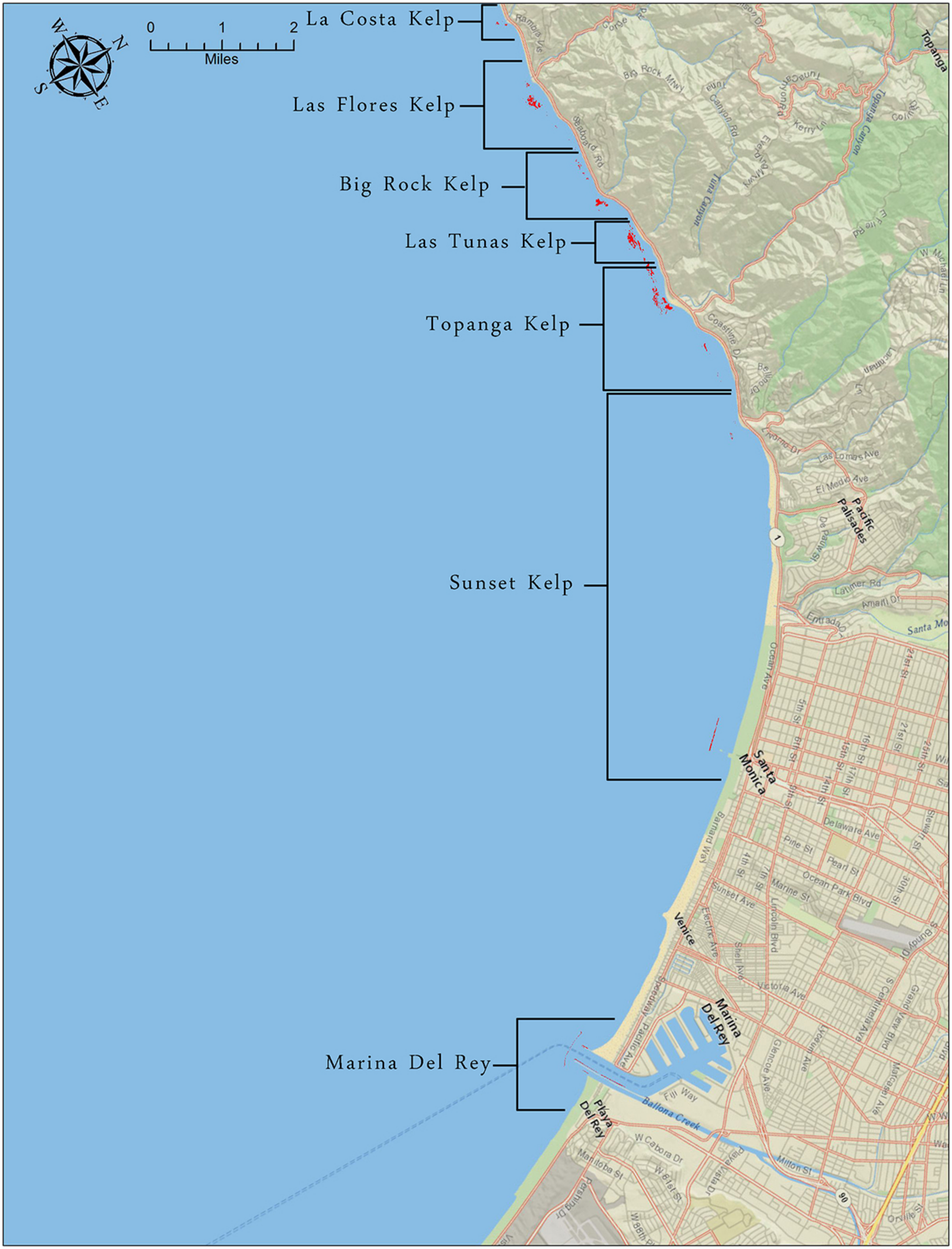
Appendix D.1


W
N
S
E
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
Decker Rd
Rattlesnake
Potrero Rd
Charmlee Wilderness Park
23
1
Broad Beach Rd
Encinal Rd

Appendix D.2

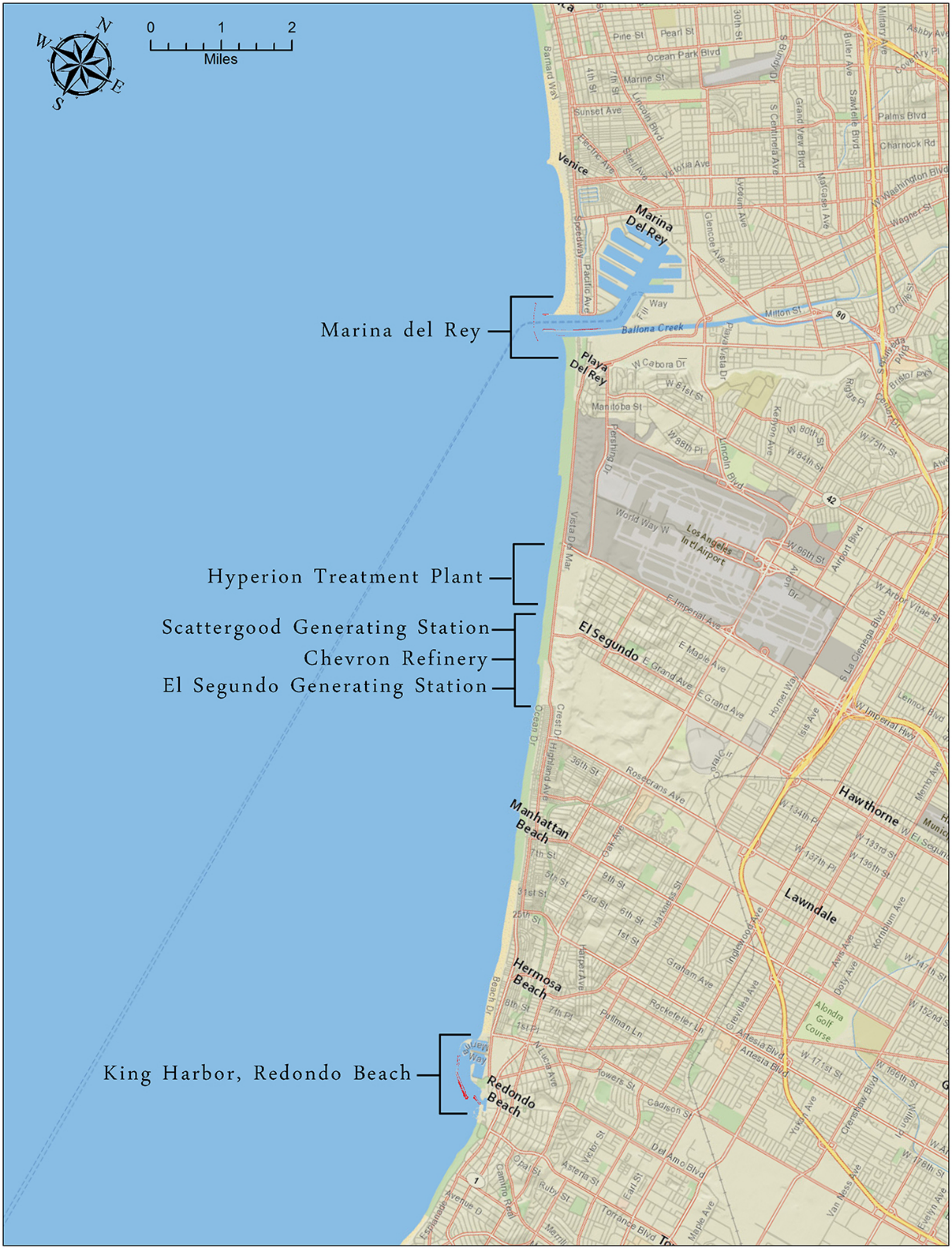

0
1
2
Miles
W
N
S
E
Lechuza Kelp
Pt. Dume Kelp
Paradise Cove Kelp
Escondido Wash Kelp
Latigo Canyon Kelp
Puerco/Amarillo Kelp
Malibu Pt. Kelp
La Costa Kelp
Las Flores Kelp
Malibu
Santa Monica Mts National Rec Area
Santa Monica Mts National Rec Area
Broad Beach Rd
Encinal Canyon Rd
Zuma Canyon
Vera Canyon Dr
Philip Ave
Horizon Dr
Zuma Ridge Mtwy
Busch Dr
Birdview Ave
Heathercliff Rd
Dume Dr
Fernhill Dr
Cavalleri Rd
Ramirez Canyon Rd
Winding Way
Escondido Dr
Newton Canyon Rd
Castro Peak Mtwy
Willmott Ln
Roberts Rd
Newell Rd
Corral Canyon
Puerco Canyon Rd
Puerco Mtwy
Huntsinger Cir
Malibu Rd
Malibu Canyon Rd
Malibu Creek
Mesa Peak Mtwy
Carbon Canyon Rd
Rambla Vis
Rambla Pacifico St
Corral Canyon

Appendix D.3



W
N
S
E
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
1
90

Appendix D.4



N
E
S
W
0
1
2
Miles
Marina del Rey
Hyperion Treatment Plant
Scattergood Generating Station
Chevron Refinery
El Segundo Generating Station
King Harbor, Redondo Beach
Venice
Marina Del Rey
Playa Del Rey
Los Angeles Int'l Airport
El Segundo
Manhattan Beach
Hermosa Beach
Redondo Beach
Hawthorne
Lawndale
Ballona Creek
90
42
1

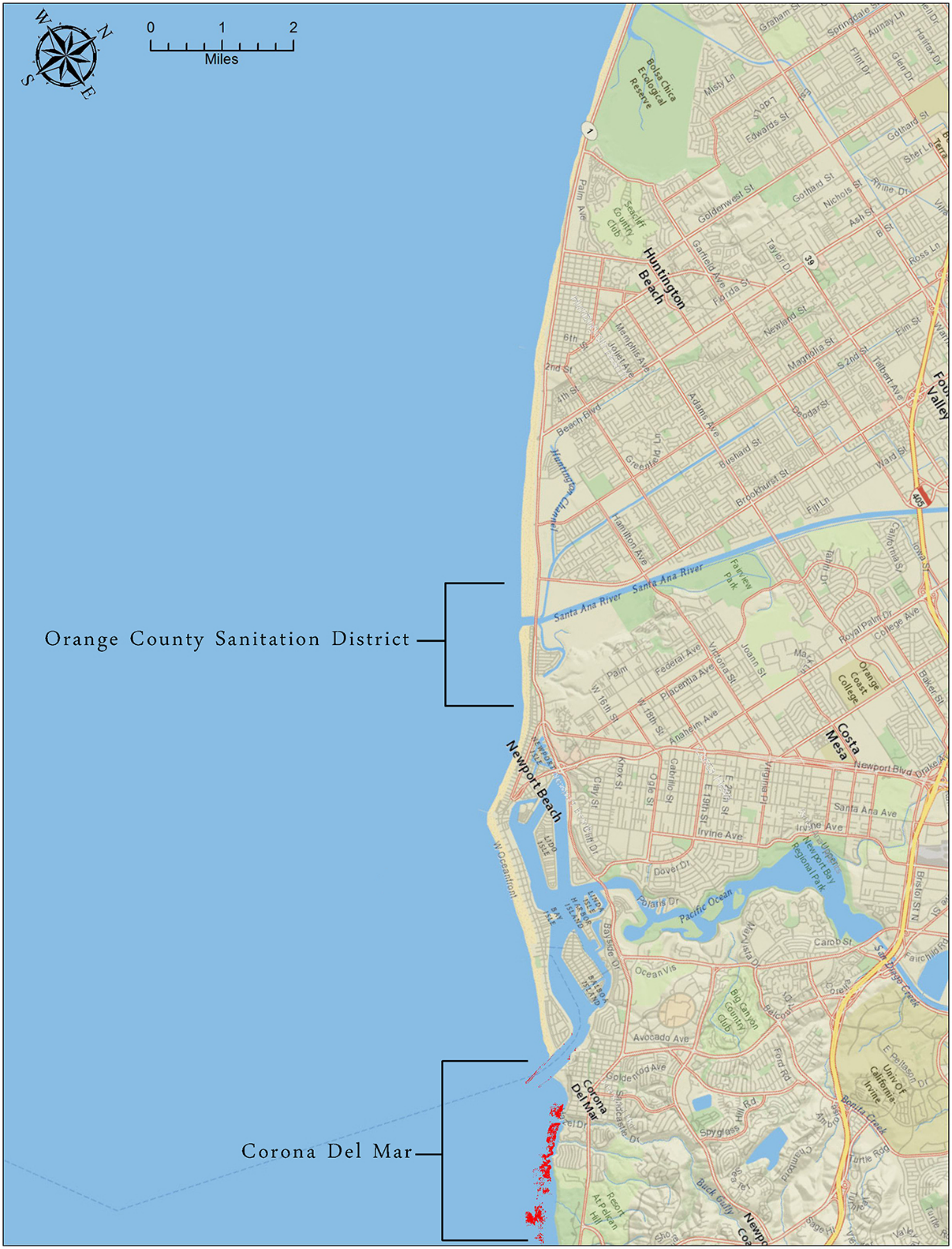
Appendix D.5


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

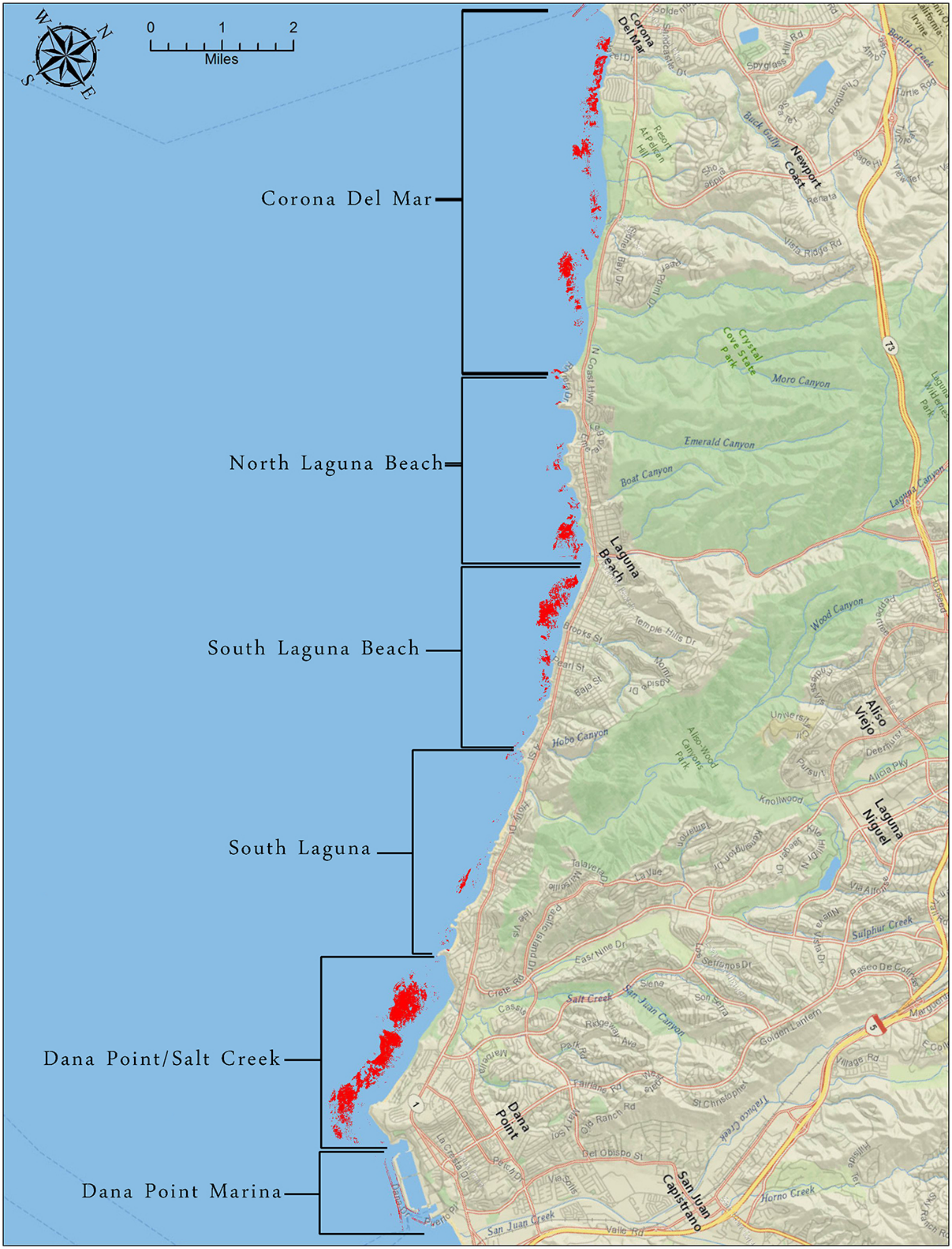
Appendix D.6


0
1
2
Miles
W
N
S
E
POLA/POLB
San Pedro
Wilmington
Los Angeles Harbor
Long Beach Harbor
Long Beach Harbor
Terminal Island
Los Angeles River
Island Grissom
Island White
Island Freeman
Island Chaffee
Pacific Ocean
Seal Beach
Surfside
Sunset Beach
47
103
1

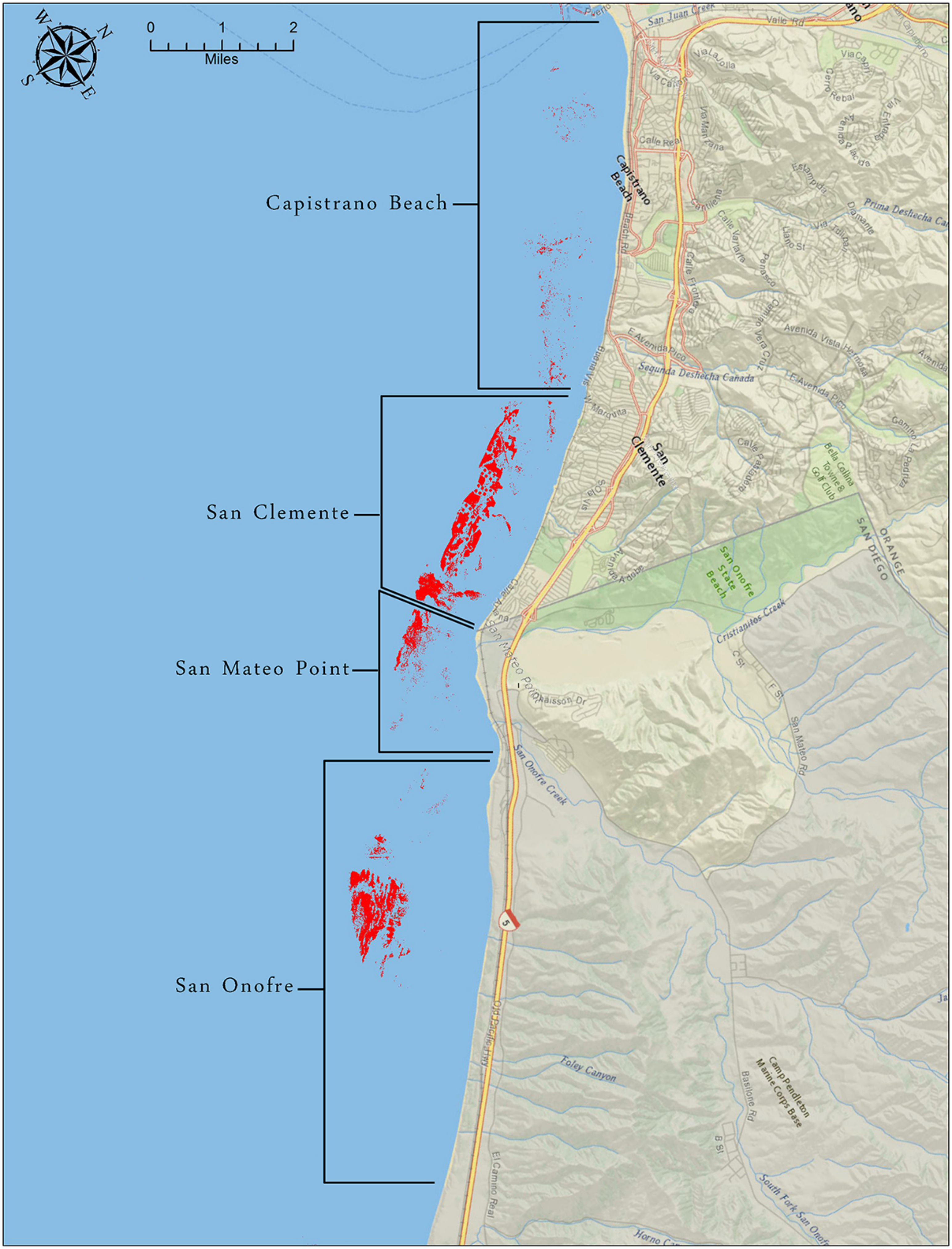
Appendix D.7


0
1
2
Miles
Orange County Sanitation District
Corona Del Mar
Huntington Beach
Newport Beach
Costa Mesa
Bolsa Chica Ecological Reserve
Santa Ana River
Pacific Ocean

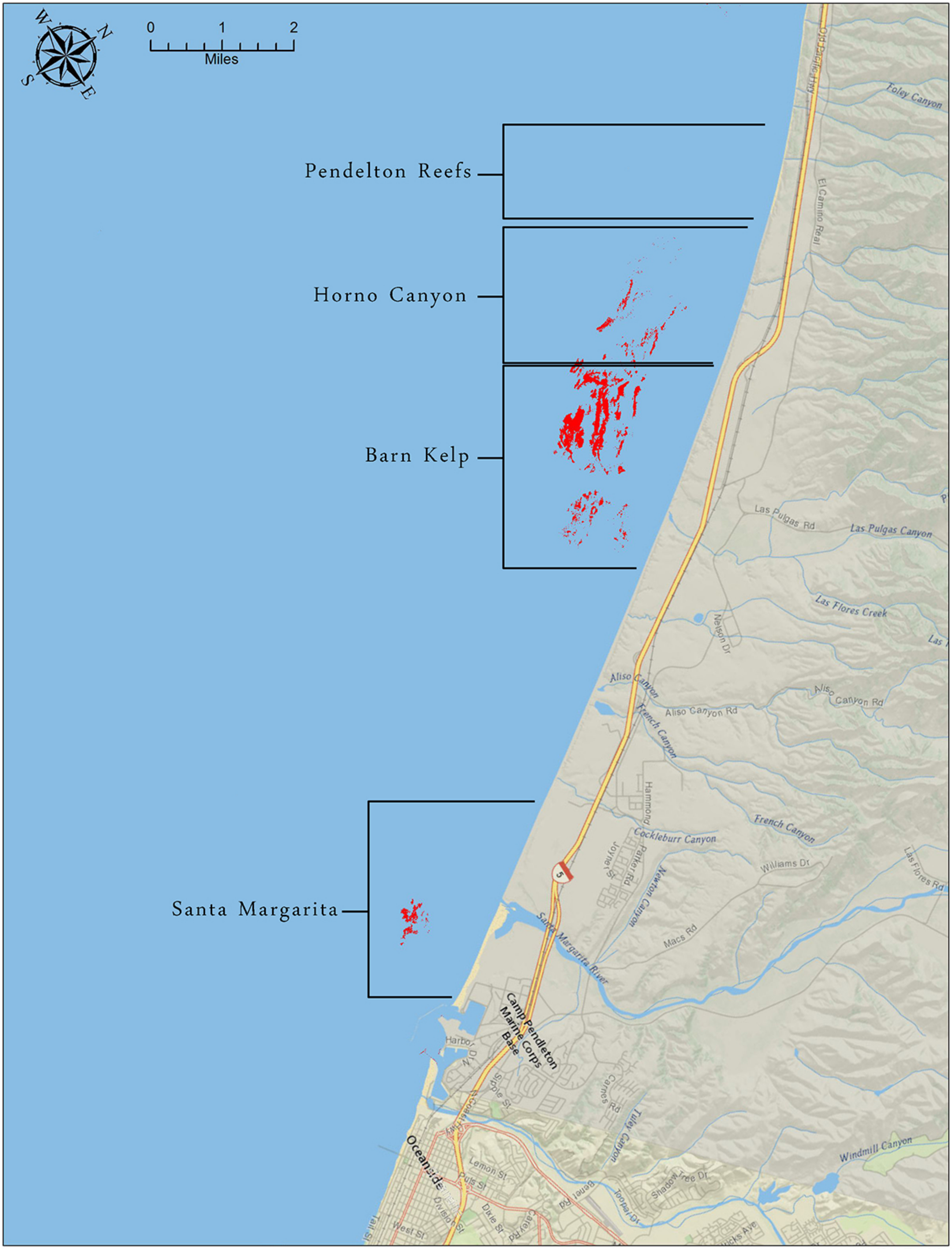
Appendix D.8


W
N
S
E
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
Laguna Beach
Aliso Viejo
Laguna Niguel
Dana Point
San Juan Capistrano
Moro Canyon
Emerald Canyon
Boat Canyon
Wood Canyon
Hobo Canyon
Aliso-Wood Canyons Park
Salt Creek
San Juan Creek
73
1
5

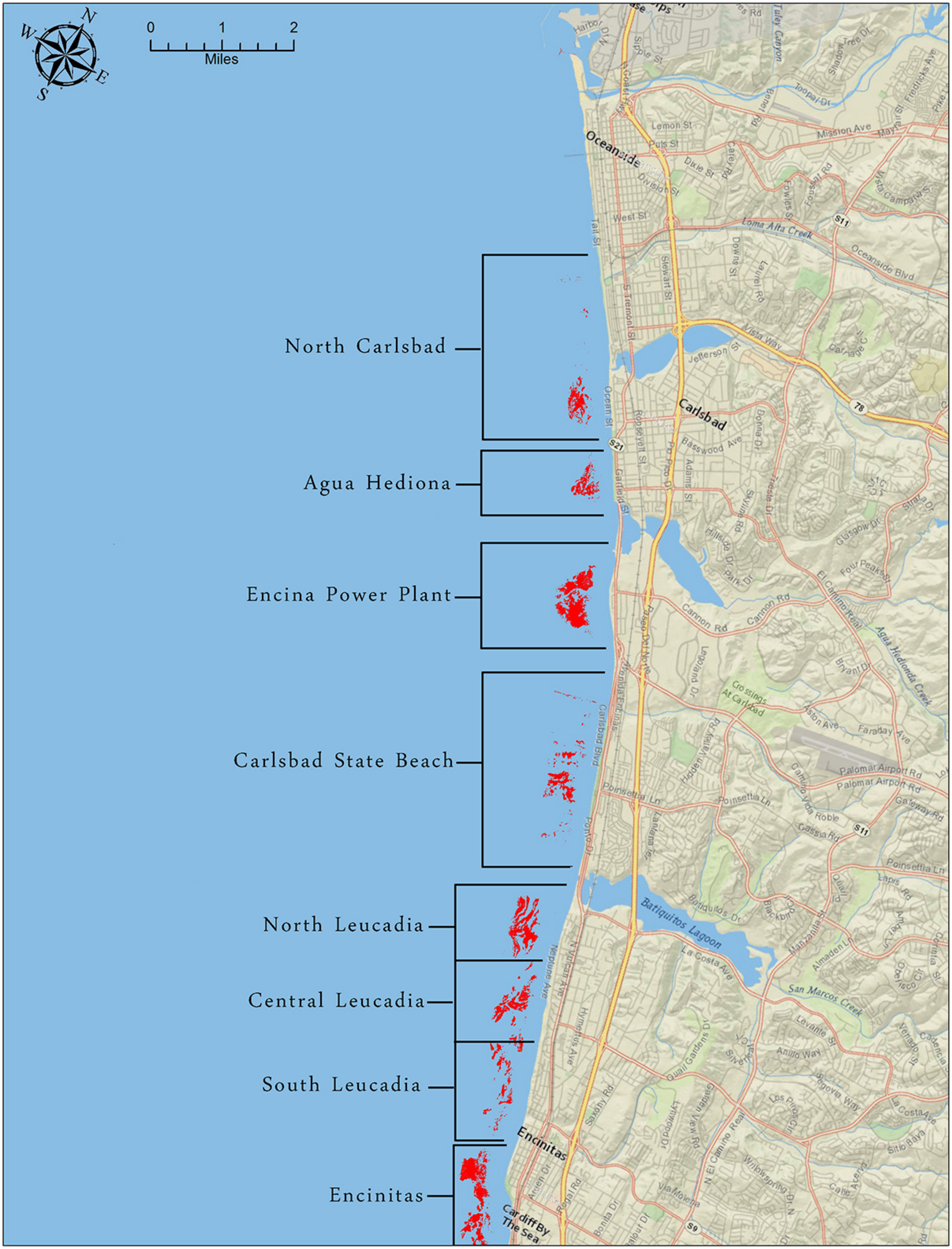
Appendix D.9



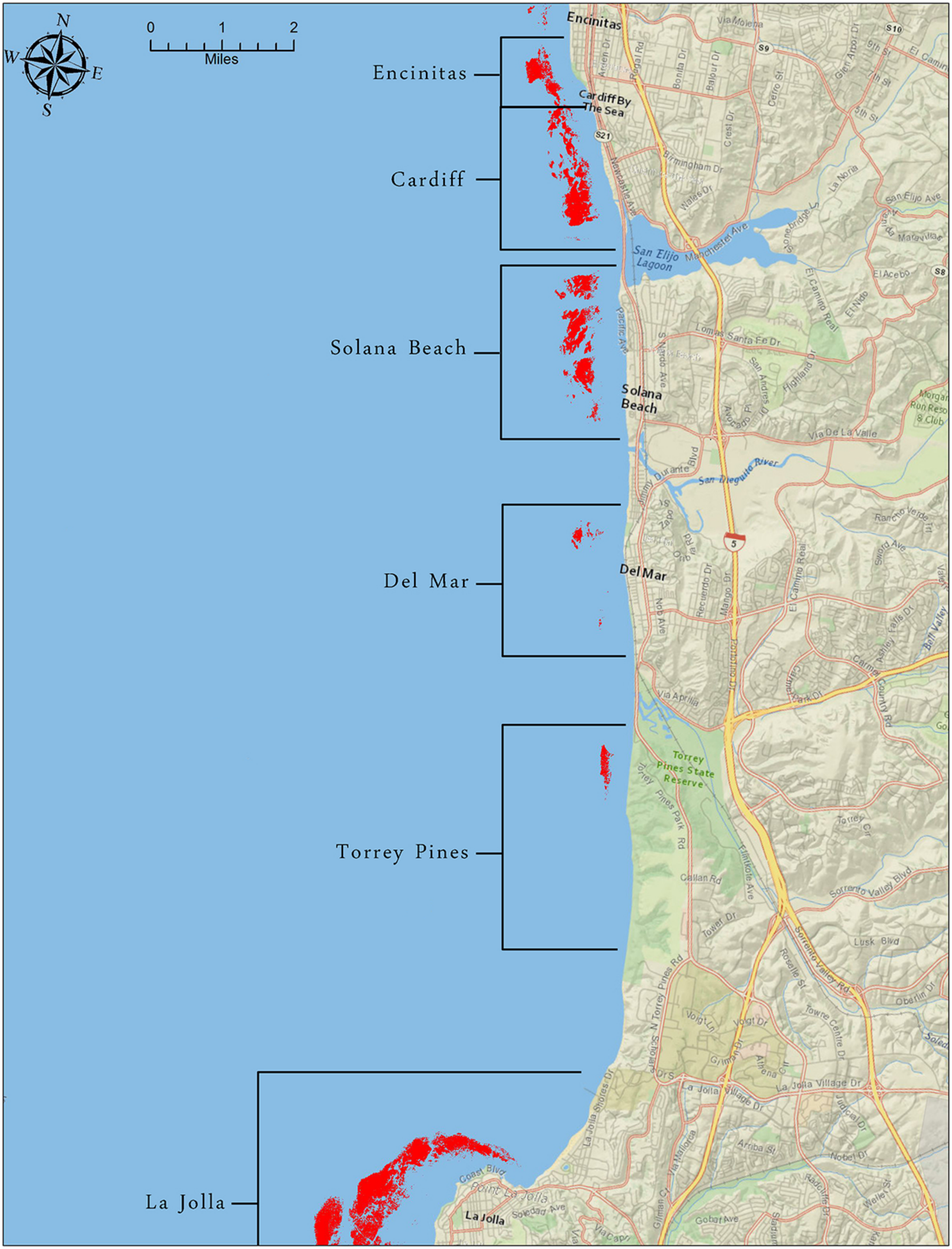
Appendix D.10



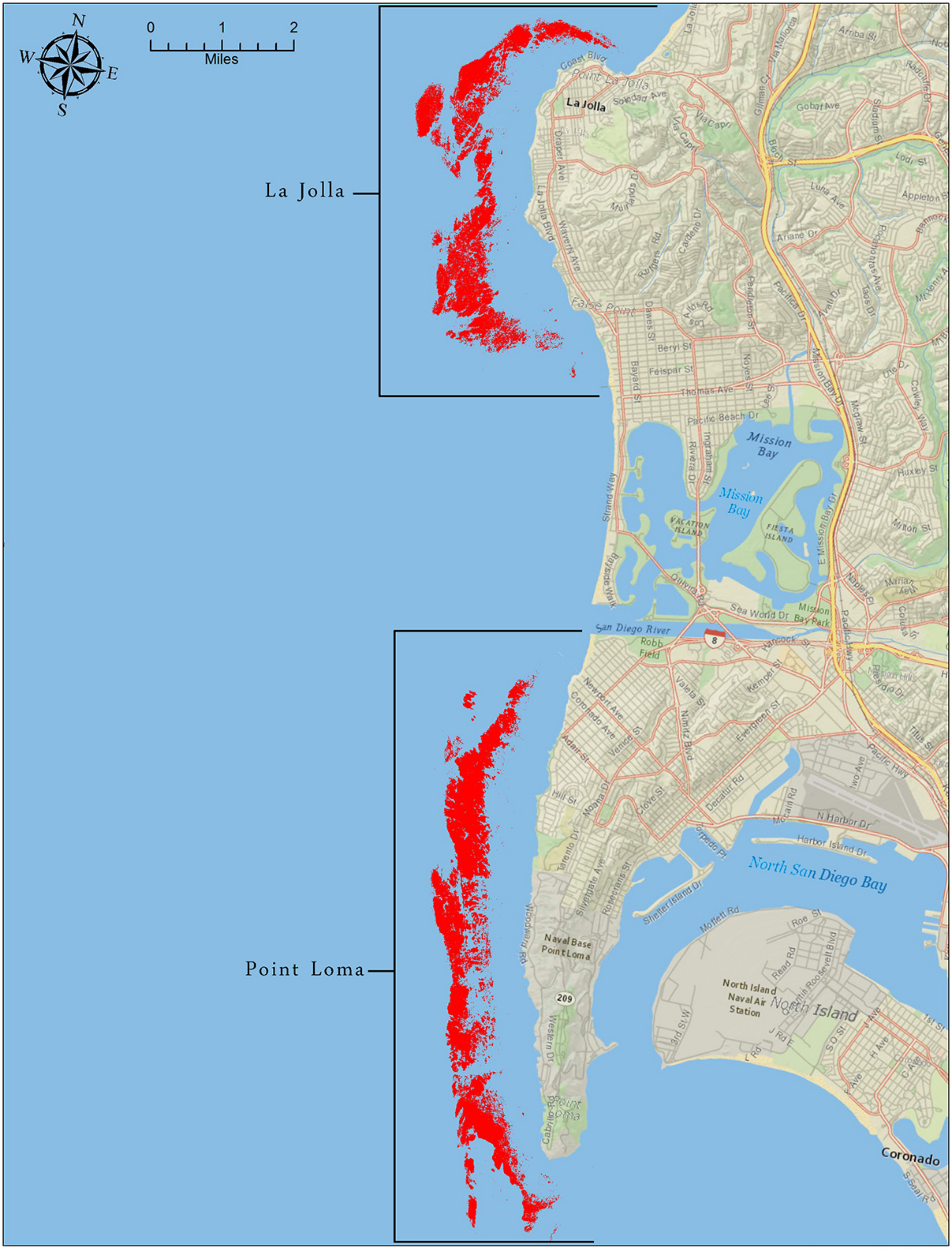
Appendix D.11



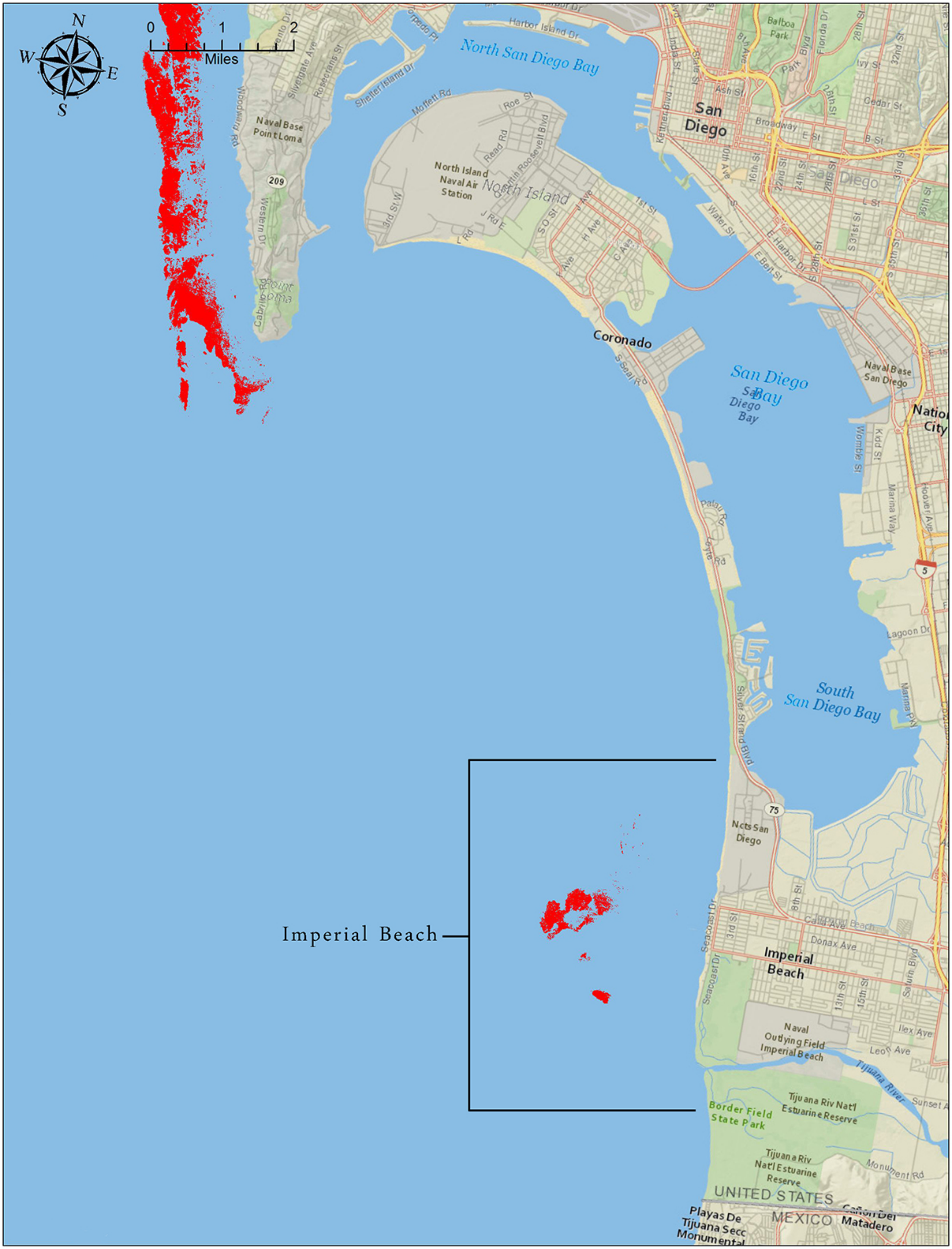
Appendix D.12



Appendix D.13



Appendix D.14



Appendix D.15

Appendix D. 16A. Flight record for
March 28, 2018

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:**	03/18
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	3/28/18
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	4/18

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 3/28/18**
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: March 28, 2018

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:	1431-1606
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.8' (-) to 1.0' (+) 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	Kelp canopies throughout the range showed significant increases in surface extent from that observed in the December 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. 16B. Flight record for
July 2, 2018

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:**	06/18
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	7/2/18
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	7/18

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 7/2/18**
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:		**July 2, 2018**			
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:	1513-1706
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	3.4' (+) to 2.8' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Good-Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach. Some small patches of fog were encountered from Ventura to Malibu, but no kelp canopies were obscurred. Solid fog was encountered from Malaga Cove to Point Vincente (about two miles of shoreline), and the kelp canopies were completly obscurred. Otherwise, clear skies prevailed throughout the range.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed significant increases in surface extent from that observed in the March 2018 survey.
Imagery Quality/ Comments	Good-Excellent Lens Note	Most surface kelp canopies were photographed within the above range, except from Malage Cove to Pt. Vincente (as noted). 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.

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

Signed: ____________________ Bob Van Wagenen, Director

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Appendix D. 16C. Flight record for
September 12, 2018

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:**	09/18
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	9/12/18
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	9/18

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 9/12/18**
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: September 12, 2018

	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:	1513-1706
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	3.0' (+) to 0.9' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach. Some small patches of fog were encountered from Ventura to Pt. Mugu, but no kelp canopies were obscurred. Otherwise, clear skies prevailed throughout the range.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed significant decreases in surface extent from that observed in the July 2018 survey, and were, for the most part non-existant within the surveyed range. High surface water temperatures, recently measured nearshore at 23 C (73 F) in the Carlsbad area, may have have played a part in the surface canopy reductions.
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range, and the image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent mapping and analysis 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. 16D. Flight record for
December 30, 2018.

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:**	12/18
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/30/18
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	3/19

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 12/30/18**
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:		**December 30, 2018**			
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:	1241-1411
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.7' (+) to 2.6' (+) 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	Kelp canopies throughout the range showed significant increases in surface extent from that observed in the September 2018 survey, where, for the most part, surface canopies were non-existant within the surveyed range.
Imagery Quality/ Comments	Excellent	All surface kelp canopies were photographed within the above range, and the image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent mapping and analysis 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:

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 33°35.338 117 52.2851

Date 28 Jan 19

Location Corona Del Mar

Time 1602

Wind/Direction

Current

Weather 80% Cloudy

UW Visibility ~10'+

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 Depth 26'

Subsurface None

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

Lat/Long: ① 33 34.557' ② 33 34.616'
① ② 117 51.147 117 51.330'

Date 28 Jan 11

Location Crystal Cove

Time 1545 / 1555

Wind/Direction

Current

Weather

UW Visibility ~10' +

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent ① 20 @ Surface ② 300m × 80m

Density Scattered

Tissue color Mm, DK Yellow-Light

% Frond comp. Senile ① 50% ② 50% Mature ② 30% Young ① 50% ① 20% Other

Disease N

Encrustation On older

Apical blades Y 5-15% both

Sediment on blades N

Remarks Depth - ② 37'

Subsurface ① None

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
Lat/Long: 33° 32.392' 117° 47.539'

Date 28 Jan 19
Location N. Laguna Beach
Time 1530
Wind/Direction 1-2 SW
Current
Weather 80%
UW Visibility
Swell Ht/Period 1-2 5ms

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 200m L x 100m W – extends further
Density 30%
Tissue color 50% Dk Yellow 51% light-med
% Frond comp. 10% **Senile** 50 **Mature** 4050 **Young** ____ **Other**
Disease N
Encrustation Y
Apical blades 20%
Sediment on blades N
Remarks Depth 35-45'

Subsurface Yes Extends further than surface

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

Lat/Long: ① 33° 29.968' 117° 44.800
② 33° 31.793' 117° 46.835'

Date 28 Jan 19

Location South Laguna

Time ① 1505 ② 1520

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent ① None ② 300m x 150m - longer subsurface

Density Medium 50%

Tissue color Dk Yellow 80%

% Frond comp. 10% **Senile** 80 **Mature** 10% **Young** **Other**

Disease 0

Encrustation 5%

Apical blades on subsurface Canopy @ 5%

Sediment on blades N

Remarks Depth 44'

Subsurface ① None ② Yes

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 Extends very sporadically to 25' depth.

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore

Lat/Long: 33° 27.429' 117° 43.284'

Date 28 Jan 19

Location Dana Pt.

Time 1443

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None (1 plant)

Density

Tissue color

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

Disease

Encrustation

Apical blades

Sediment on blades

Remarks 42' Depth

Subsurface None @ 38' maybe ?? @ 48' scattered profiles @ 10' tall ??

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
Lat/Long: 33 25.693' 117°32.944'

Date 28 Jan 19
Location Capistrano Beach
Time 1354
Wind/Direction
Current
Weather
UW Visibility
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent ~~None~~ → 1 Plant (5 stipes)
Density 0
Tissue color
% Frond comp. Senile Mature Young Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks Depth - 41'

Subsurface None

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

Lat/Long: 33 24.122' 117° 37.487'

Date 28 Jan 19

Location WNAR

Time 1345

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 0.5mi 300 x 150 m

Density 50-80% cover

Tissue color Dk Yell

% Frond comp. / Senile 50 Mature 50 Young ____ Other

Disease N

Encrustation N

Apical blades 5%

Sediment on blades N

Remarks Depth 45'

Subsurface large extent 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

Lat/Long: 33°23.384' 117°37.045'

Date 28 Jan 19

Location San Clemente

Time 1340

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 Depth 44'

Subsurface None

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

Lat/Long: 33° 22.641' 117° 36.138

Date 28 Jan 19

Location San Mateo

Time 1330

Wind/Direction 1-2 SW

Current

Weather M. Cloudy

UW Visibility

Swell Ht/Period 1-2' SW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 0.5 mi L x 300 m W

Density Scattered (10%)

Tissue color Dark Yellow (80%)

% Frond comp. ____ **Senile** 30 **Mature** 70 **Young** ____ **Other**

Disease N

Encrustation Yes 10%

Apical blades 50-80%

Sediment on blades N

Remarks 3-4 ft long. Depth - 48'

Subsurface Large extent 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

Lat/Long: 33°20.563' 117 33.430

Date 28 Jan 19

Location San Onofre Kelp

Time 1312

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 200m X 100m (4 larger subsurface)

Density Scattered (10%)

Tissue color Dark Yellow (90%)

% Frond comp. ~~0~~ **Senile** 10% **Mature** 90% **Young** **Other**

Disease N

Encrustation N

Apical blades Yes 80%

Sediment on blades N

4 Distinct patches of scattered Canopy

Remarks 3m long stipes @ site

Depth 42'

Subsurface Mature w/ encrustation

Matured regularly

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

Lat/Long: 33° 18.474 117° 31647'

Date 28 Jan 19

Location PAR

Time 1259

Wind/Direction

Current

Weather 95% Overcast

UW Visibility ~15' @ Surface

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

nodules to 35'

Depth - 44'

Subsurface None

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: Jennifer Smith
Lat/Long: 33°18.21' 117°30.397'

Date 28 Jan 19
Location Horno Canyon
Time 1130
Wind/Direction 1-2 S
Current
Weather M. Cloudy
UW Visibility
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 Metered occaissional plants 15-20' tall 45' depth

Subsurface
5-6 Plants upcoast giant kelp 2-3 stipes Extralimital

UNDERWATER OBSERVATIONS

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

Bottom
Tissue color med yellow
Encrustation n
Disease ~~s~~ n
Sediment on blades n
Sinking fronds n
Grazed tissues n
Sporophyllis —
Juvenile fronds 2 (5.5'H) + 3ft (single stipe)
Holdfasts —
Old holdfasts 12
Recruitment —

Seahare Aply.
Cowrie

Community
Litter
Turf algae Red Alga (Acrosorium)
Turf invert.
Shrub algae
Large Invert. 2 purple urchins
Fishes 0
Disease
Sed. on rocks
Urchin status

Bottom characteristics
Laminaria high density
Pterigophora

80% cobble 20% sand
shell hash

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: Shannon Eminhizer

Lat/Long: 33°18.211' 117°30.397'
33°19.133' 117°31.092' Alt #9
None

Date 28 Jan 19

Location Horno Canyon

Time 1130

Wind/Direction 1-2 S

Current

Weather M. Cloudy

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

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color Dark Yellow

Encrustation ~~20%~~ 30%

Disease –

Sediment on blades yes – 15%

Sinking fronds –

Grazed tissues 25%

Sporophyllis ~~卌 ||~~ -1 ~~kelp~~ Lam 1 juv. kelp ~ 5 ft.

Juvenile fronds 卌|| ~~卌卌~~ ||| 15 ptero

Holdfasts ~~2~~

Old holdfasts 卌

Recruitment 0

Community

Litter –

Turf algae –

Turf invert. –

Shrub algae –

Large Invert. – 1 snail - dots on it | white stripe

Fishes –

Disease –

Sed. on rocks –

Urchin status –

Bottom characteristics

20% Sand, 70% Rock | cobble, 10% shell

REMARKS No fish, 1 kelp ~ 25 ft tall, rest ~ 1 M
~6 20-30 ft. kelp just behind our transect | extralimital

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 33° 17.197' 117° 29.182'

Date 28 Jan 19

Location Barn Kelp

Time 1235

Wind/Direction 1-2 SW

Current

Weather M. Cloudy (90-95%)

UW Visibility

Swell Ht/Period 1-2 SW

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'

Subsurface None

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

Lat/Long: 33° 14.834' 117° 26.546
836' 450'

Date 4 Jan 19

Location Santa Magarita

Time 1444

Wind/Direction 3kn W

Current

Weather Sunny

UW Visibility

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 ~ 35' depth

Subsurface None

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
Lat/Long: 33° 05380' 117° 19.51'

Date 4 Jan 19
Location Carlsbad State Park
Time 1225
Wind/Direction 3kn W
Current
Weather Sunny
UW Visibility
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 None

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

Lat/Long: 33° 08.673' 117° 21.089'

Date 4 Jan 19

Location Agua Hedionda

Time 1405

Wind/Direction 3 kn W

Current

Weather Sunny

UW Visibility

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 2 Plants

Density

Tissue color Dk Yellow

% Frond comp. ______ **Senile** 100% **Mature** ______ **Young** ______ **Other**

Disease None

Encrustation None

Apical blades None

Sediment on blades None

Remarks 26'

Subsurface Mutered numerous scattered single plants @ 15' tall

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

bserver: R. Moore

Lat/Long: 33° 09.342' 117° 21.752'

Date 4 Jan 19

Location N. Carlsbad

Time 1412

Wind/Direction 3 kn W

Current

Weather Sunny

UW Visibility

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 Very Scattered subs. @ 10' fa4

NDERWATER 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

EMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 33° 07.494' 117° 20.445'

Date 4 Jan 19

Location Encina Power Plant

Time 1300

Wind/Direction 2 kn W

Current @ 0.5 kn

Weather Sunny

UW Visibility 10 meters

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

Purple Urchin

Subsurface Cystoseira

90% Shelf Rock 2% Sand 18% Cobble

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation NONE

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom Juv 1

Tissue color med yellow on 2 plants obs.

Encrustation n

Disease n

Sediment on blades n

Sinking fronds –

Grazed tissues –

Sporophyllis –

Juvenile fronds 1 plant @ 30cm

Holdfasts

Old holdfasts 10 + 15 = ㉕

Recruitment 1 - single blade plant

Kelp Bass - 6

Sheephead - 1

Community

Litter

Turf algae Red (Acrosor)

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

Strongyl. purpur - 1 + 4 = ⑦

Lobster - 1 + 3 = ④

S. Francisc. - 1 = ①

Shale reef (flat) w/ cobble & sand patches. (see % notes above)

REMARKS Red turf algae dominant Egregia Present (@ 8-10 plants extralimital) in "tufts" + Gigartina

JUVENILE MACROCYSTIS

Red Urchin

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: Shannon Eminhizer

Lat/Long: 33° 07.494' 117° 20.445'

Date 4JAN 19

Location Encina PP

Time 1300

Wind/Direction

Current

Weather

UW Visibility 10 meters

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

Lobster = ~~||||~~ |||
Herm crab = 1
SNAIL = 2

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 ~~||||~~ || = ⑦

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert. ||

Fishes ||

Disease

Sed. on rocks

Urchin status |||

Bottom characteristics

(1) Sheephead + Kelp bass (2)

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 33'03190 117° 16.495'
33°03.896' 117° 16.749' batch of u/w kelp

Date 4 Jan 19
Location Leucadia
Time 1200
Wind/Direction 2 kn W
Current
Weather Sunny
UW Visibility 15-20'
Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None ① ② / 50 x 100' ③ – 33° 04.402' / 117° 18.789'
Density
Tissue color
% Frond comp. ______ **Senile** ______ **Mature** ______ **Young** ______ **Other**
Disease
Encrustation
Apical blades
Sediment on blades
Remarks 38' Depth

Subsurface 10-20 metered @ 10-15' tall Several just subsurf 50/50 Senile/Young
@

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 @ 3rd L/L's @ 200 x 200 yds single plants @ sffc 2-3m frond length } N. Leu.
widely scattered

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore

Lat/Long: 33° 02.196' 117° 18.111'

Date 4 Jan 19

Location Encinitas

Time 1150

Wind/Direction 2kn W

Current

Weather Sunny

UW Visibility

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None

Density 1 plant

Tissue color —

% Frond comp. 100% **Senile** ____ **Mature** ____ **Young** ____ **Other**

Disease

Encrustation

Apical blades

Sediment on blades

Remarks

Subsurface Scattered 10-20 indiv 10-20' tall

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

Lat/Long: 33° 01.046' 117° 17.390'

Date 4 Jan 9

Location Cardiff

Time 1150

Wind/Direction 2' W

Current

Weather Sunny

UW Visibility

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 33' deep

Subsurface Several single 10-15' tall on meter

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
Lat/Long: 32° 59.748' 117° 17.086'

Date 4 Jan 19
Location Solana Beach
Time 1142
Wind/Direction 2 kn W
Current
Weather Sunny
UW Visibility
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 41' Dep

Subsurface Maybe small patches @ 5-10' tall

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
Lat/Long: 32° 57.564' 117° 16.577'

Date 4 Jan 19
Location Del Mar
Time 1130
Wind/Direction 2kn W
Current minimal
Weather Sunny
UW Visibility
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 None

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
t/Long: 32° 53.545 117° 15.644'

Date 4 Jan 19
Location Torrey Pines
Time 1105
Wind/Direction 2kn W
Current
Weather Sunny
UW Visibility
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 45' Depth

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

MARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

bserver: R. Moore

Lat/Long: 32° 50.998' 117° 17.431'

Date 4 Jan 19

Location La Jolla North

Time 1040

Wind/Direction 2 kn W

Current minimal

Weather Sunny

UW Visibility 20'

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent in/off @ 100 yds & extends to Central & wider.

Density Scattered canopy

Tissue color 20% Dk Yellow 40% Med 40% Light Y

% Frond comp. 40% Senile 40% Mature 20% Young ____ Other

Disease None

Encrustation Yes 50%

Apical blades Yes @ 10%

Sediment on blades None

Remarks 2-4m Fronds Depth 60' see below

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 Central extends out to 70' scattered solid @ 60' & towards shore to KJN

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 32° 48.214' 117' 17.990'

Date 4 Jan 19

Location La Jolla South

Time 1020

Wind/Direction 2kn W

Current Minimal

Weather Sunny

UW Visibility 20'

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 1/4m in/off 200yd NS

Density Solid

Tissue color 20% Dk Yellow 80% Med

% Frond comp. 1% **Senile** 80% **Mature** 19% **Young** ______ **Other**

Disease None

Encrustation 5% Bryoz

Apical blades Yes 5%

Sediment on blades None

Remarks 2.5m Frond Length Depth 55' (see below)

Subsurface New growth visible

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 From above L/L @ S edge, bed continues upcoast solid canopy @
Stays inshore @ 55' depth. Meter some occaissionally to 70' until @ Cutr

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moon

Lat/Long: 32° 43.405 117° 16.268'

Date 4 Jan 19

Location Pt Loma N

Time 0950

Wind/Direction 2 kn W

Current

Weather Sunny

UW Visibility

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent Very scattered inshore of 55'

Density

Tissue color

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

Disease

Encrustation

Apical blades

Sediment on blades

Remarks Very scattered canopy inshore of 55' Depth 60'

Subsurface All w/i 10' of surface broken tips mature to senile some encrustation

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 Red Crabs @ 1 mile S of PLN canopy thin but lots of subsurface young
No klp @ W/L 70' moderate 60' @ 20' tall (10-40')

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 32°39.629' 117°15.465'

South border?

Date 4 Jan 19

Location Pt. Loma South

Time 0950

Wind/Direction 2 W

Current

Weather Sunny

UW Visibility

Swell Ht/Period 2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent Along P.L. shoreline

Density Solid shallow, @ 50%

Tissue color Dark Yellow 98%

% Frond comp. 1% **Senile** 2% **Mature** 97% **Young** – **Other**

Disease None

Encrustation 5%

Apical blades 5%

Sediment on blades None

Remarks 90% Dk Yellow 1-3m fm surface 65' deep

Subsurface Yes

Some bull kelp

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 Shallower than @ 70' depth Most outer edge 55'-60'

along entire PL Bed

Scattered/Patchy offshore of inner strip PLS to PLN

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R. Moore

Lat/Long: 33° 34.560' 117° 09.475'

Date 4 Jan 19

Location Imperial Beach

Time 0850

Wind/Direction 2-3 kn NE

Current

Weather Sunny

UW Visibility

Swell Ht/Period 2-3' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None

Density

Tissue color

% Frond comp. Senile Mature Young Other

Disease

Encrustation

Apical blades

Sediment on blades

Remarks rough

High Tide +6.43@ 0735

Low tide -0.88 1446

Subsurface Nothing Metered

Depth - 33'-45'

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

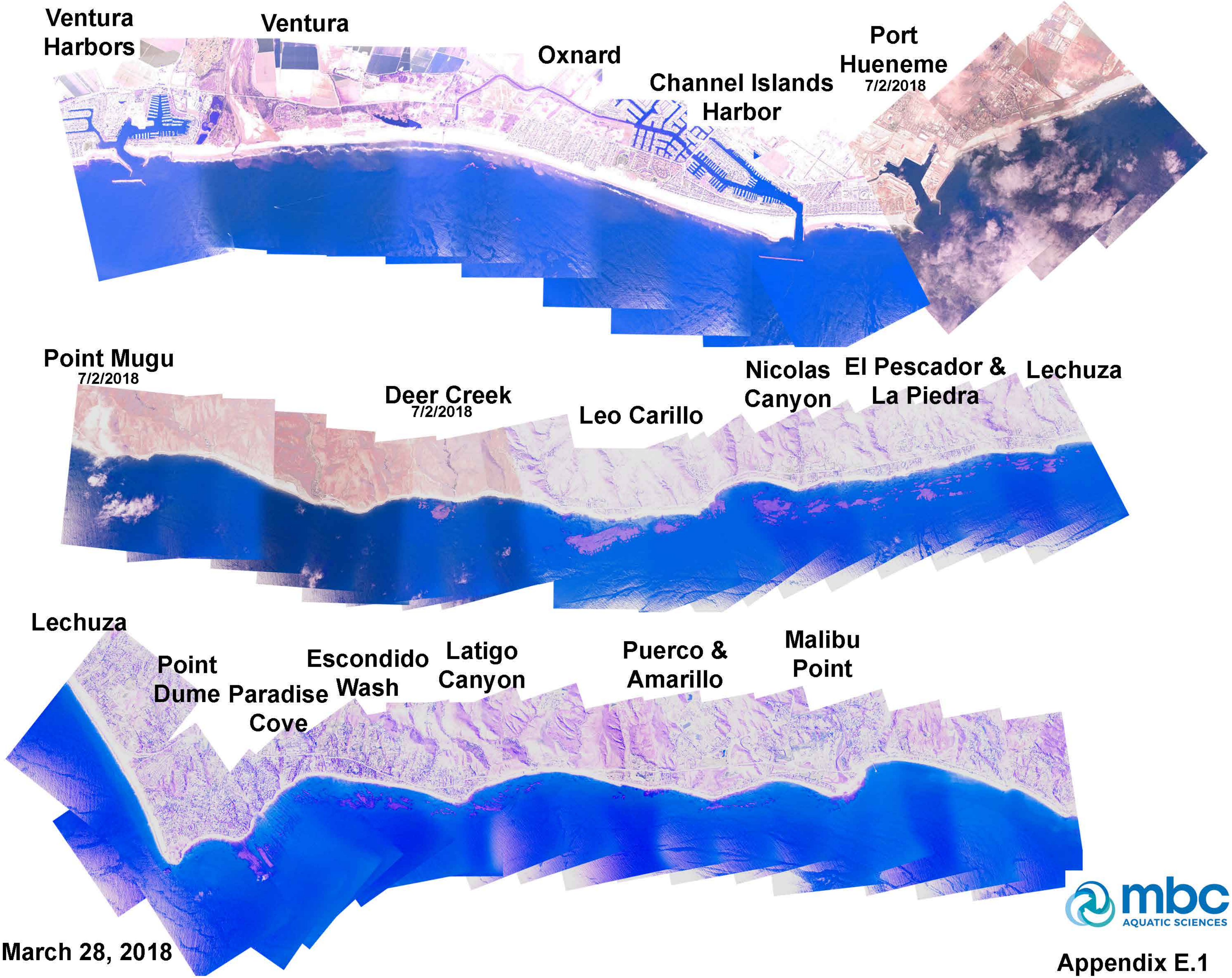
Urchin status

Bottom characteristics

REMARKS Drove through shallow area hard bottom - metered nothing 33'-45'

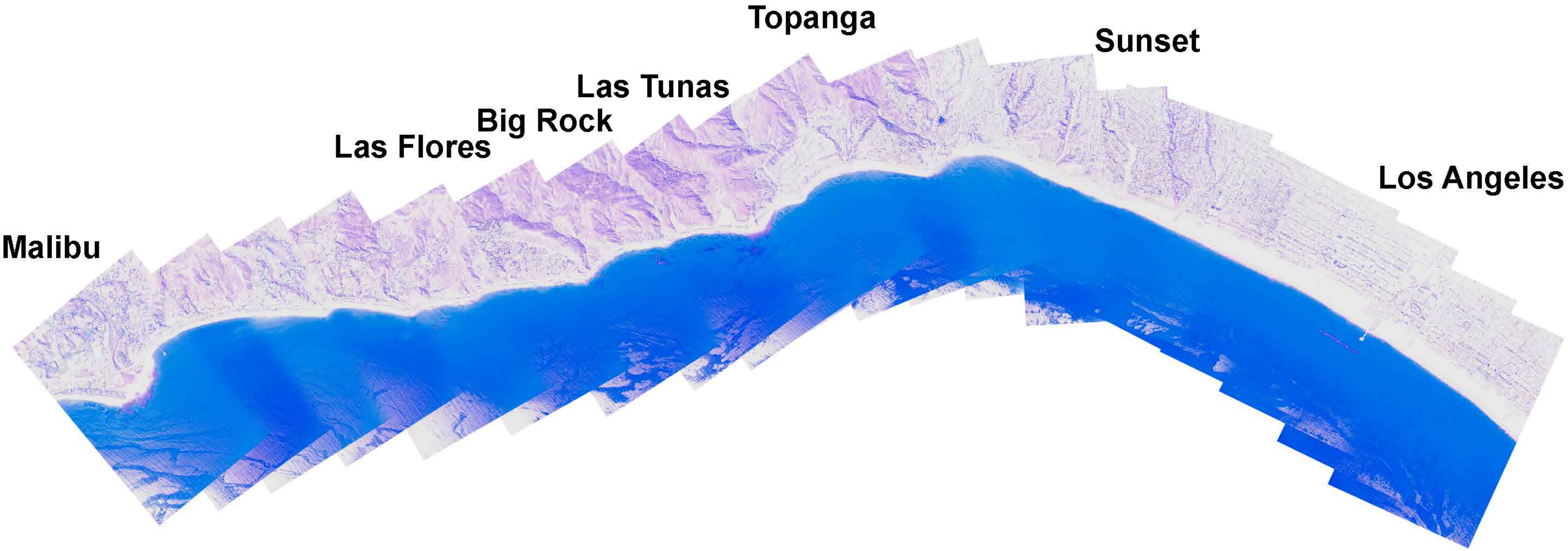
APPENDIX E

Kelp Canopy Aerial Photographs



March 28, 2018

Appendix E.1



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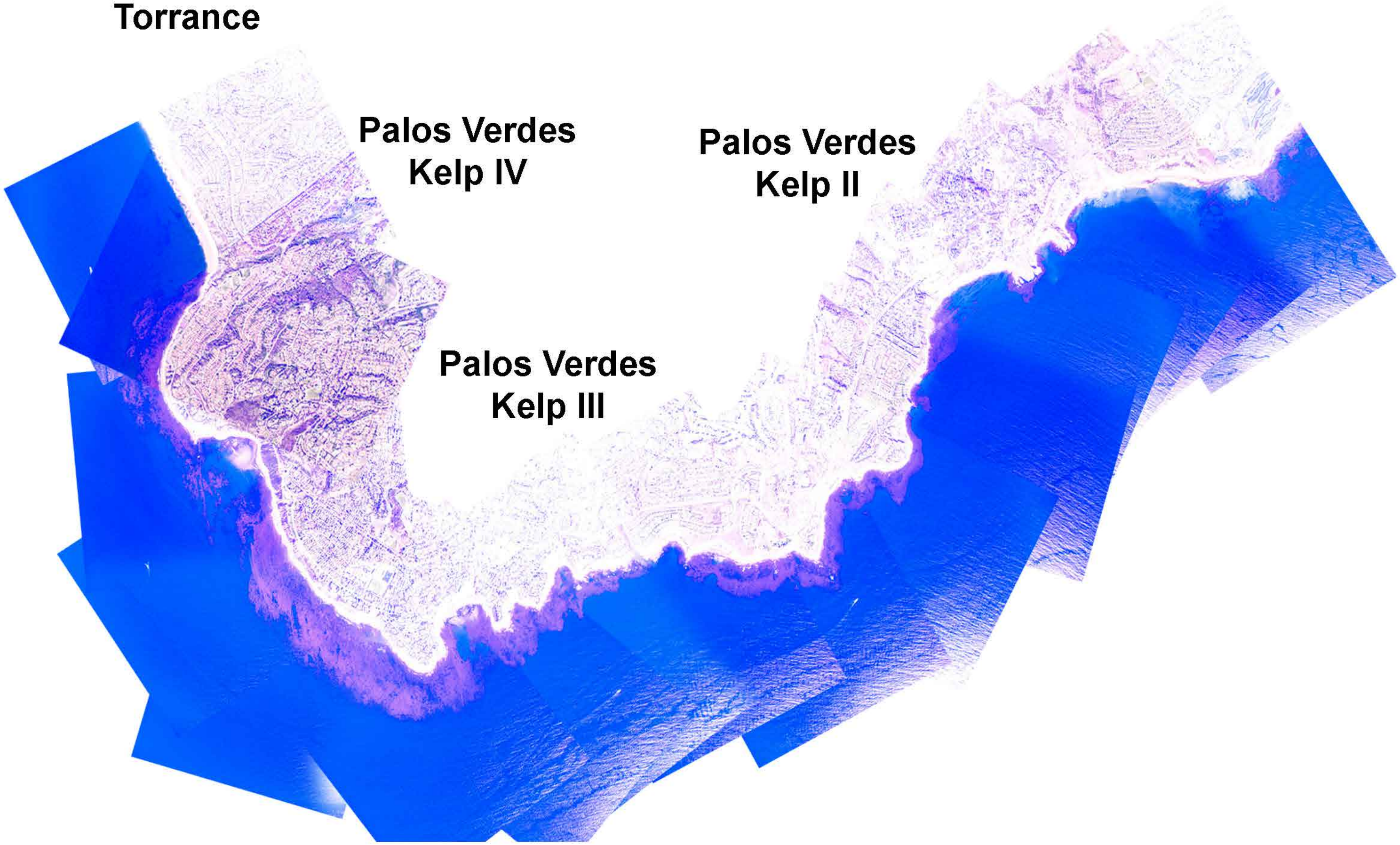
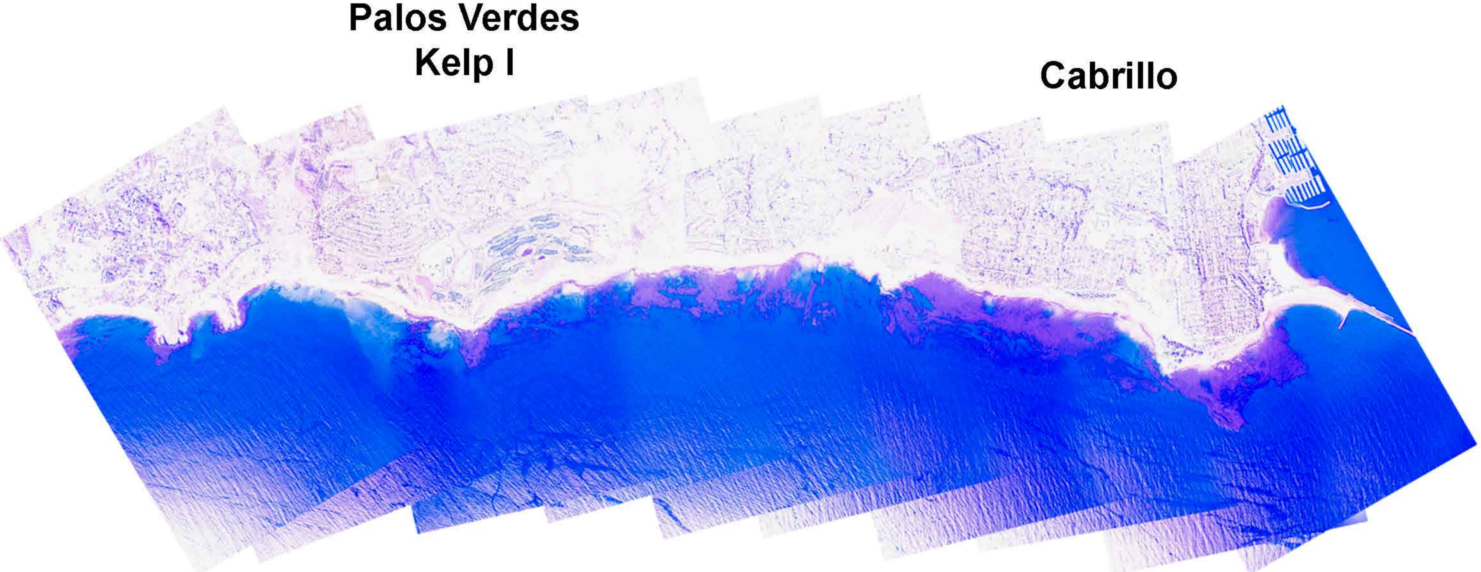
March 28, 2018

Appendix E.2

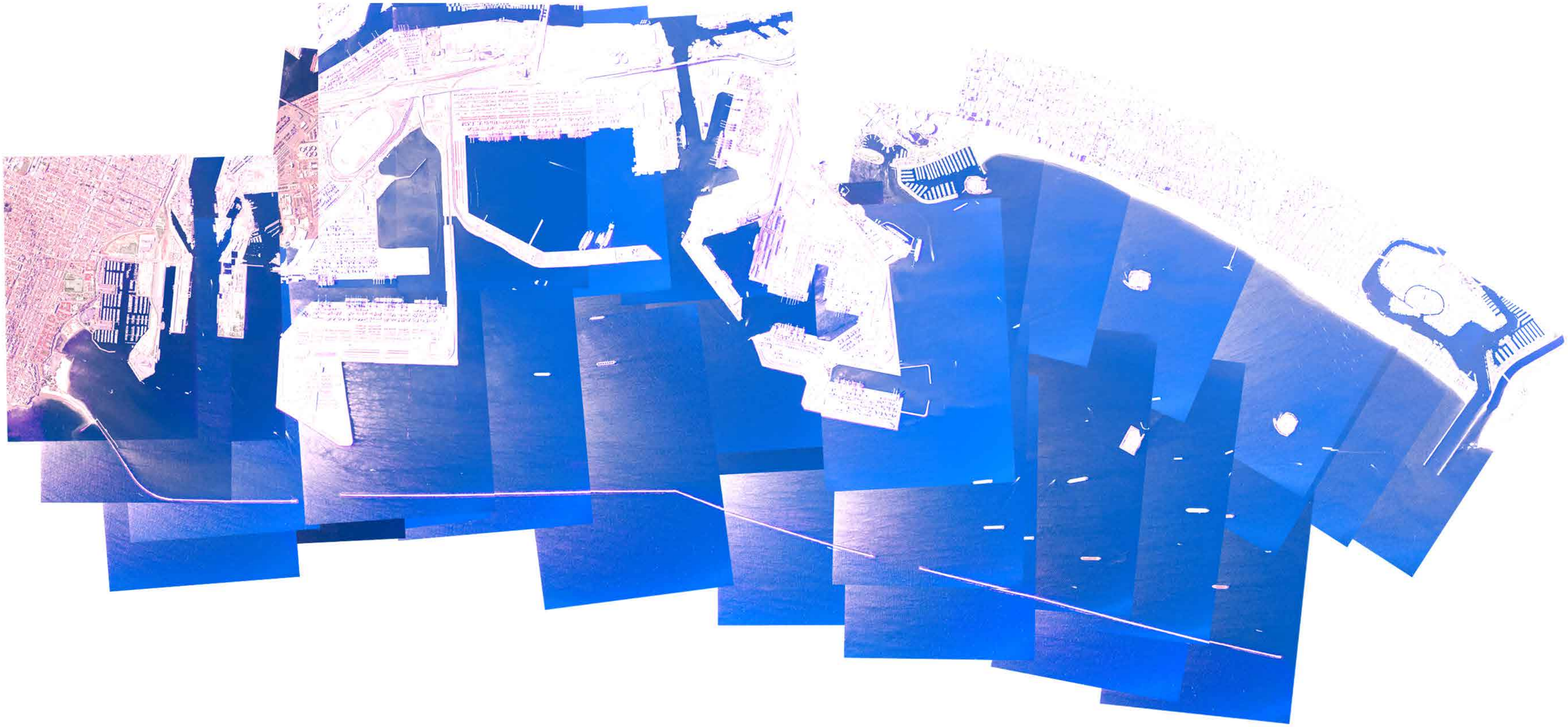




March 28, 2018

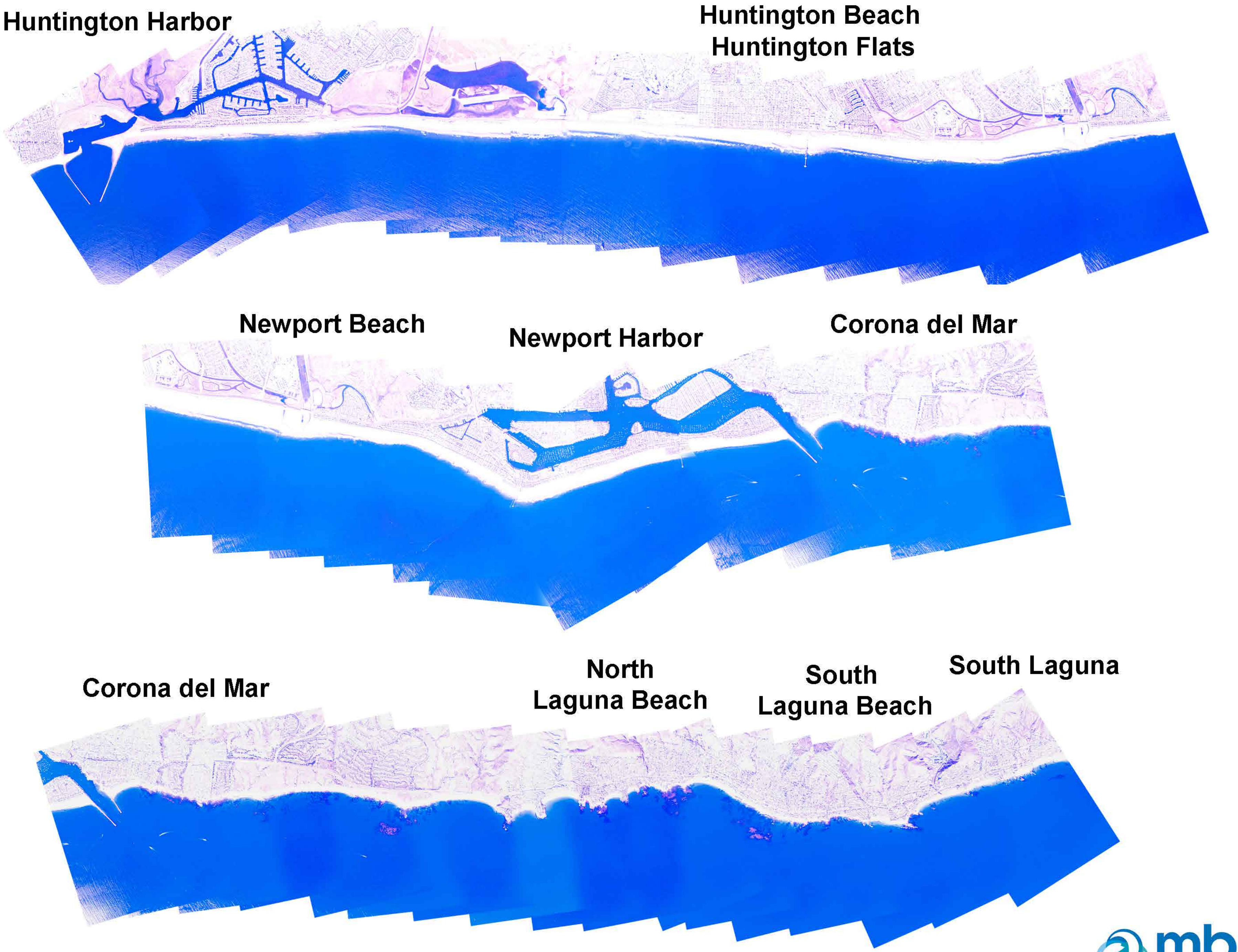
Appendix E.3

POLA/POLB Harbors



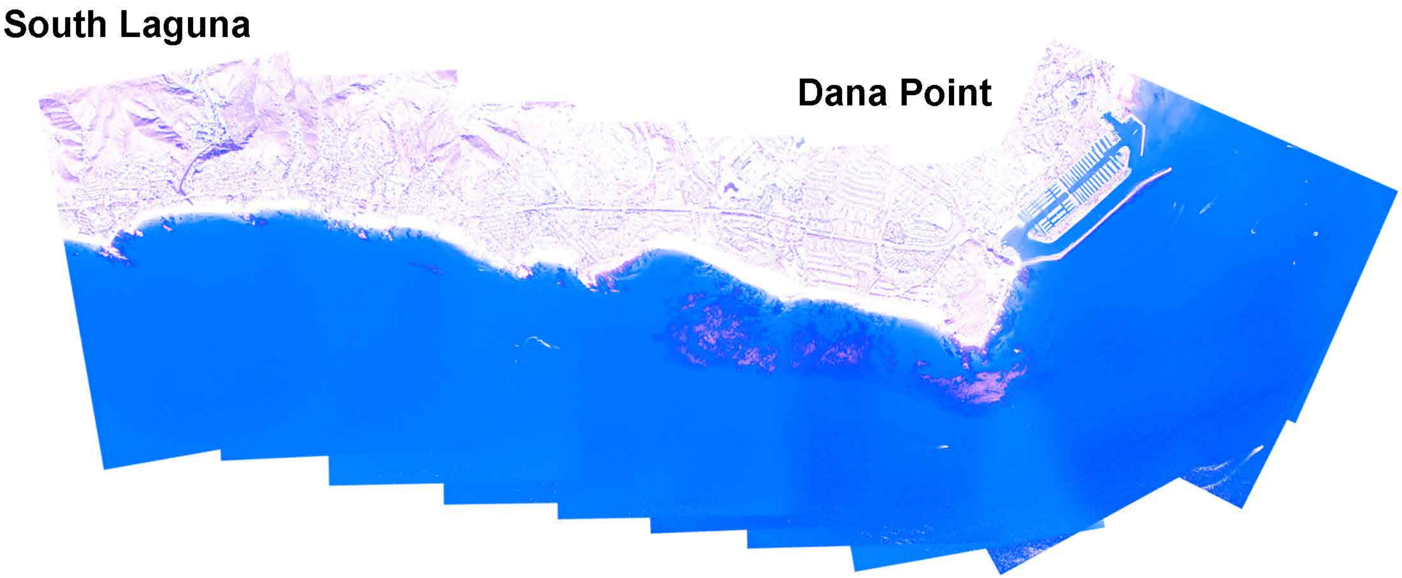
July 2, 2018

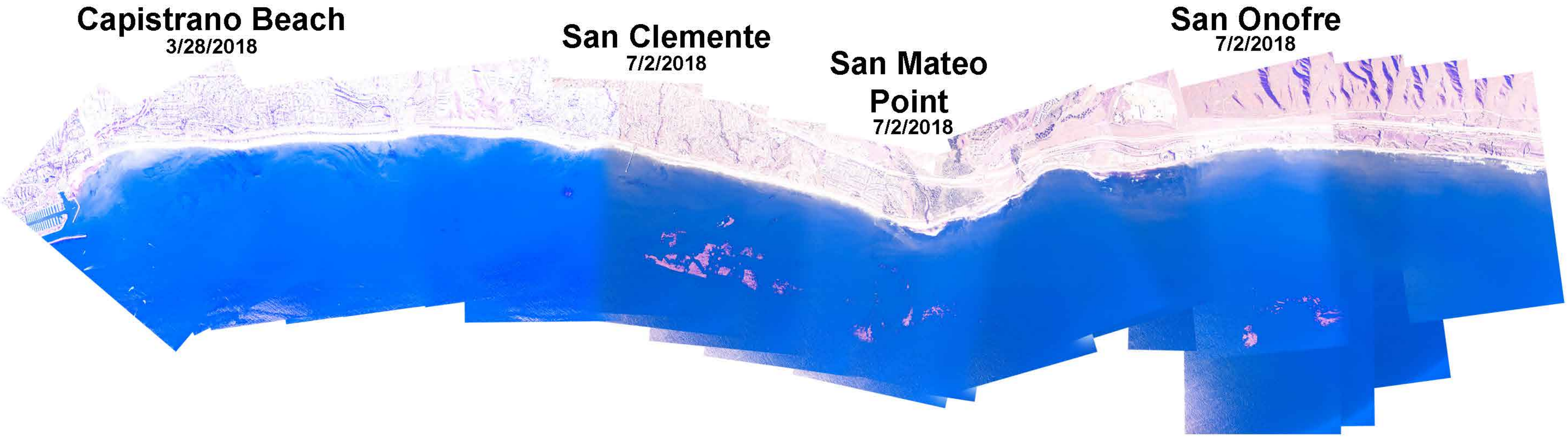
Appendix E.4



March 28, 2018

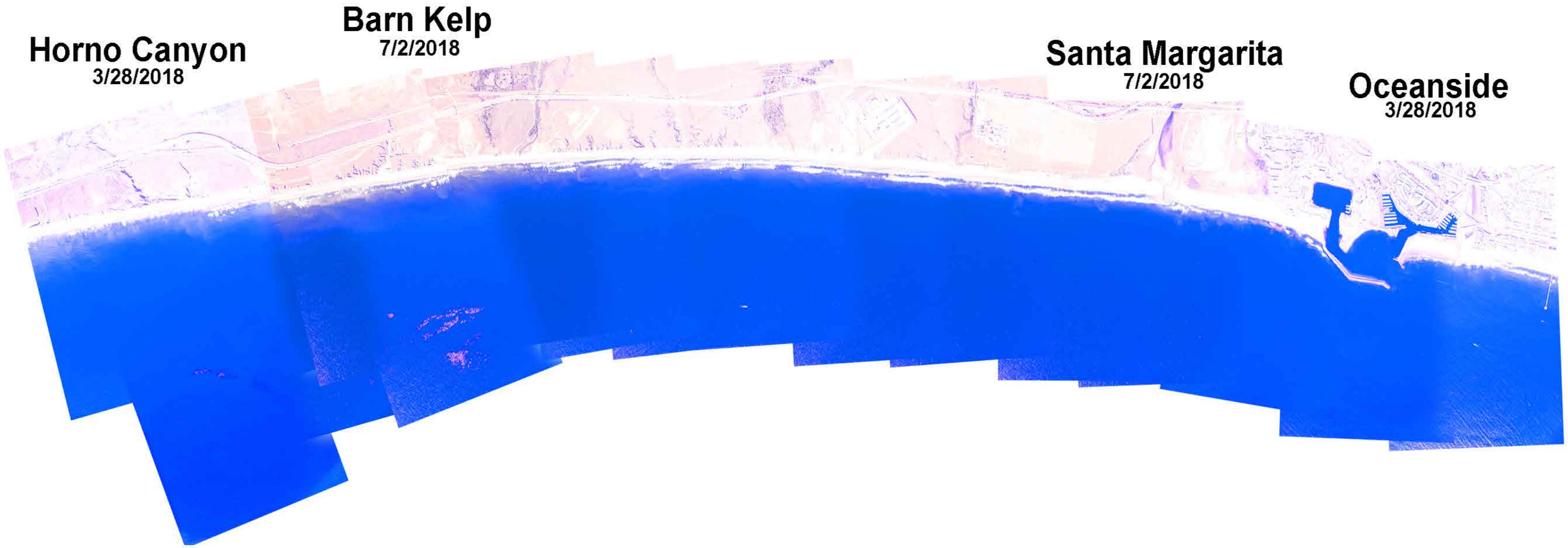
Appendix E.5

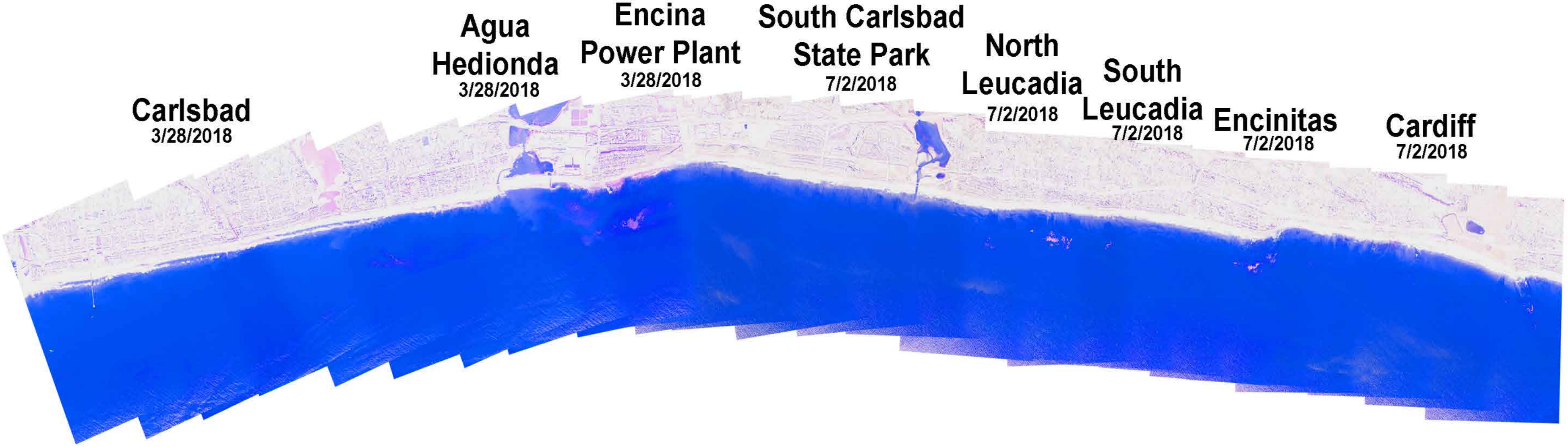




March 28, 2018

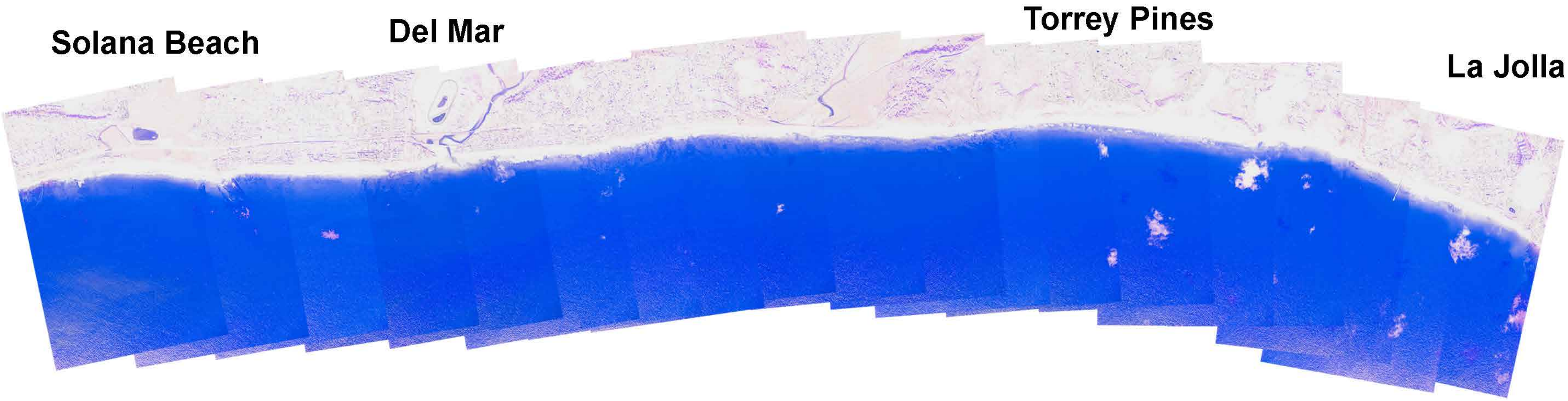
Appendix E.6

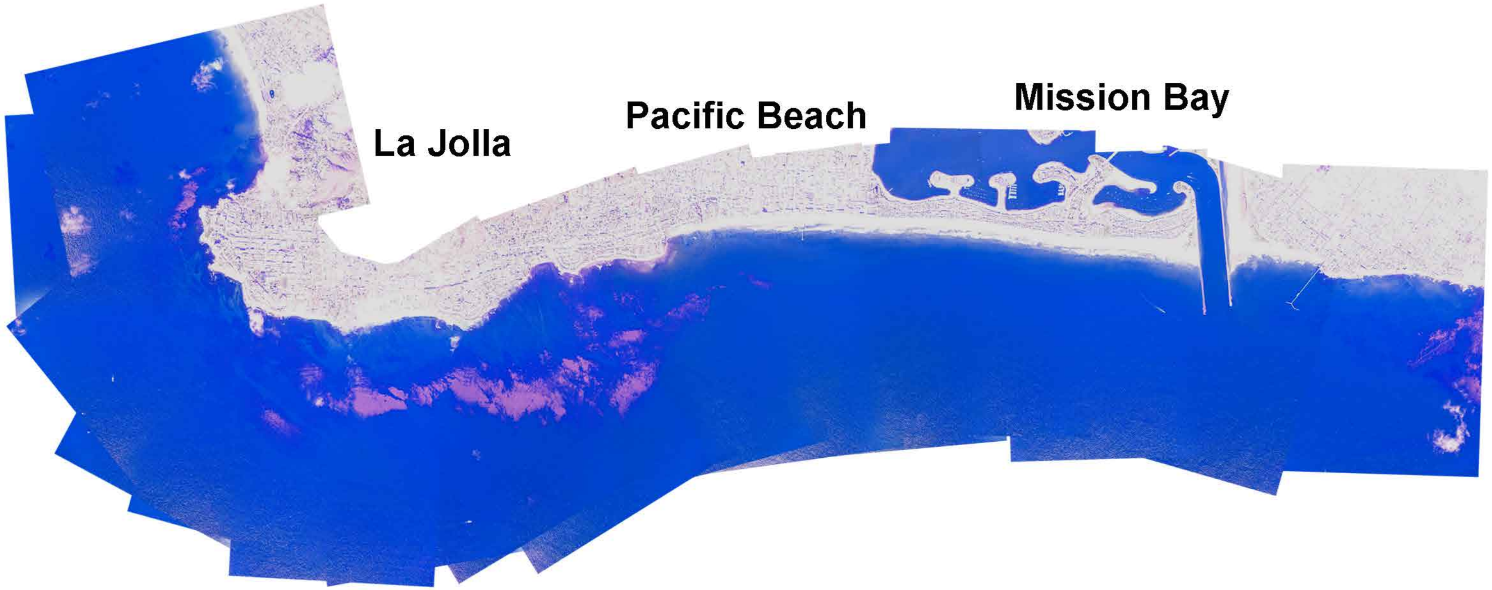




mbc
AQUATIC SCIENCES

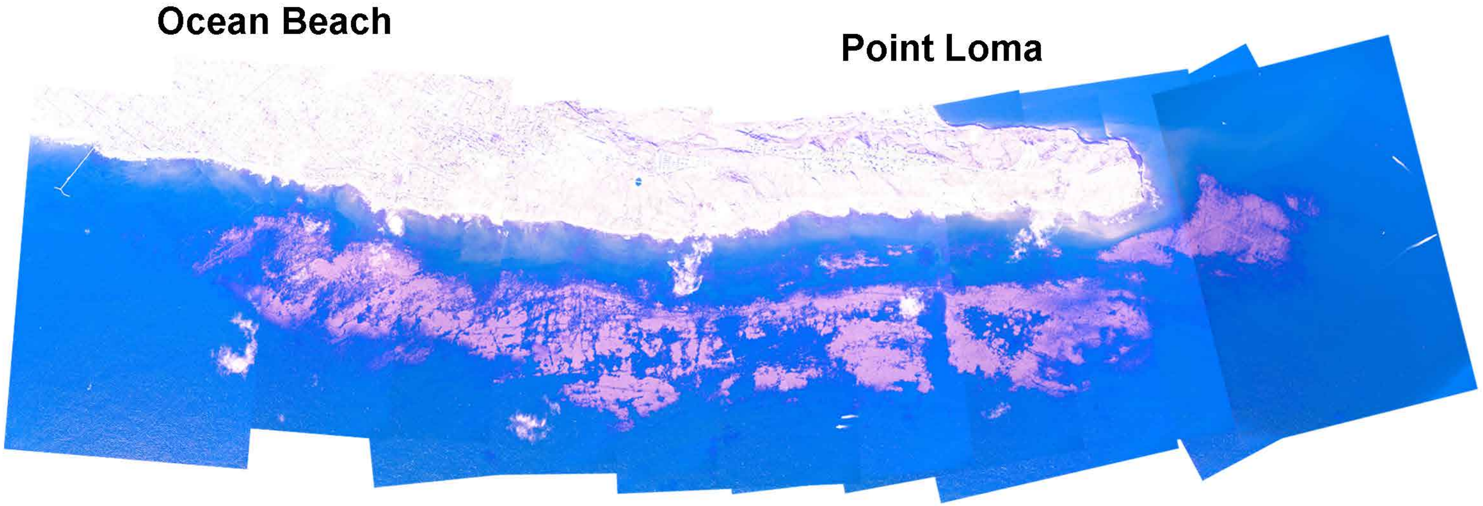
Appendix E.7

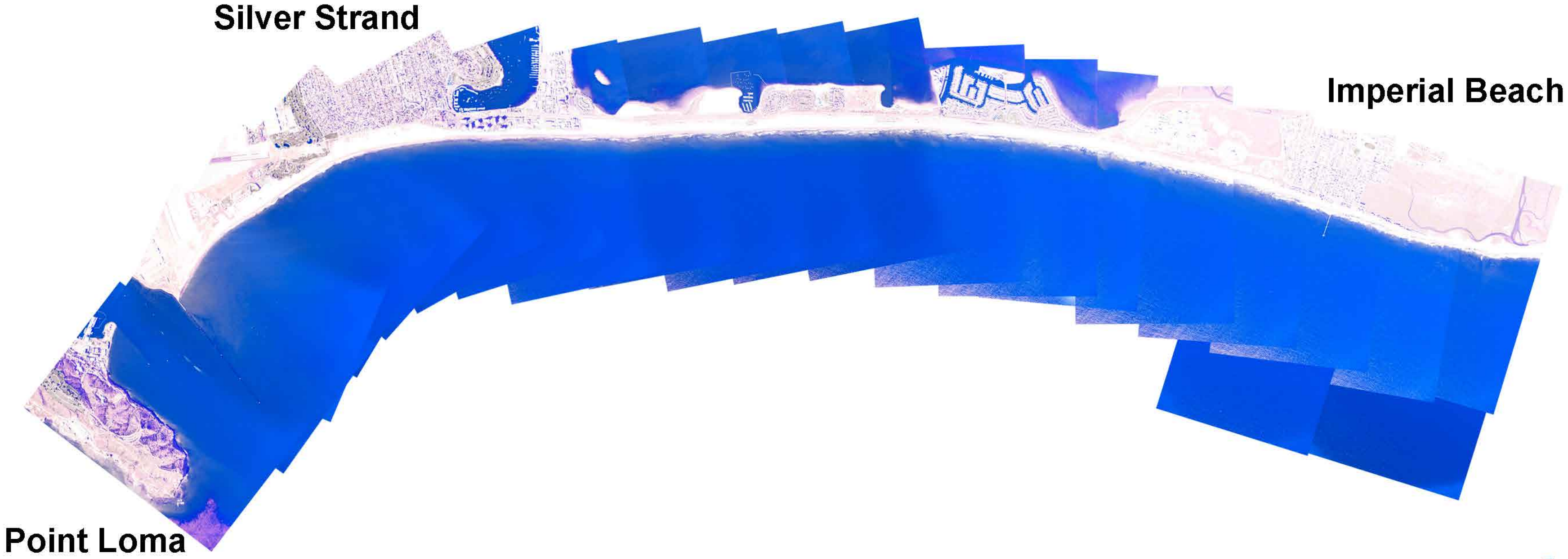




July 2, 2018

Appendix E.8





July 2, 2018

Appendix E.9